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LABOUR PROTECTION AND CIVIL DEFENSE

Textbook

Recommended by Academic Council of Igor Sikorsky Kyiv Polytechnic Institute as a textbook for undergraduate students

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Textbook

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LABOUR PROTECTION AND CIVIL DEFENSE

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ABSTRACT. General safety issues, identification and classification of potential hazards, their properties as well as methods and means of protection against their impact, basics of sanitary and hygienic working conditions, methods of prevention of occupational diseases, threats leading to emergencies, the nature of their manifestations and effects on humans and economic objects, methods and means of civil protection of the population and territories in case of an emergency, the principles of first aid have been set out. Particular attention is paid to the issues of personal and collective safety at work, in everyday life and during emergencies and martial law. Designed for students of higher educational institutions acquiring technical specialties within the framework of the complex discipline "Labour protection and civil defense", related to issues of safety at work, in everyday life and emergencies.

CONTENTS

INTRODUCTION

You have in your hands a training manual on the discipline "Labour Protection and Civil Defense" ("LP and CD"). Its concept was formed as a system of views based on fundamental scientific and theoretical positions, as well as practical approaches to thorough training of specialists in the field of automation and instrumentation in the field of professional, civil and household security. According to this concept, the discipline "LP and CD" is considered as an interdisciplinary synthetic set of additional knowledge and skills, the need and demand of which are dictated as general socially significant upbringing, educational and purely professional goals.

If you look at the whole as the development of science and technology affects on human society, then on the one hand, it promotes the safety of human life and at the same time leads to the emergence of a whole range of new dangers, increasing the risk, injury and death of people.

The reasons for increasing the level of danger are:

- complication of technological equipment and processes;
- errors in design and operation;
- neglect safety by human;
- non-acquaintance or conscious violation of labour safety rules.

Today, the safety, health and even life of a large number of people depend on the safety of technology and equipment, the technically competent use of them, the timely adopted, often the only correct solution. The ability to provide appropriate security requirements at the infrastructure and organizational level can only be provided by specialists with an appropriate level of training in this field. It should be emphasized the urgency and importance of forming competences in higher education in the field of civil defense in the conditions of increasing socio-political tension in certain countries, regions and the whole world, the intensification of conflicts on the economic, political, religious, national grounds etc.

Since the further development of civilization is inevitably linked with the expansion of production, and as a result, with the emergence of additional types of hazards that concern each individual and society as a whole, one of the urgent tasks of the present is to further increase the scientific, educational and educational level of the population, his ability and ability to carry out a comprehensive assessment of the degree of threats and the effectiveness of the level of protection. On the other hand, a person is an integral part of the socio-economic environment. The peculiarities of Ukraine's development now require rapid and effective steps towards radical reforms in all spheres of activity, including in the sphere of training of security personnel, which have determined the necessity of solving this task for our country.

One of the basic security axioms is the regulation that "absolute safety for a person does not happen". Proceeding from this, a definite view and approach to the issues of forming the structure and content of the "LP and CD" as a discipline related to the field of knowledge about the danger, the threat of which can affect on each person and requires adequate protection against them (hazards) in conditions of domestic and industrial activity, in a social environment.

This field of knowledge is based on the security sciences, which have a common basis. Thus, labour protection, as the main component of the discipline of safety for engineering specialties, includes legal and organizational foundations, industrial sanitation, industrial safety and fire safety at work. Civil defense, as a basis for the preservation of the population and infrastructure in emergency situations, provides protection against catastrophes, natural disasters, wartime etc.; in its turn, fire safety implies the safety of the natural environment, public and residential buildings, agricultural lands, transport vehicles.

Thus, "LP and CD" is an integrated educational discipline of humanitarian and technical direction that studies the general patterns of potential dangers, their properties, issues of monitoring and risk analysis, the basis of sanitary and hygienic working conditions and methods of preventing occupational diseases, threats leading to emergency situations, the nature of their manifestations and actions on people, animals, plants and objects of the economy, ways and means of civil defense of the population and territories in the event of an emergency situation personal and collective security in everyday circumstances and during emergencies and martial law, the principles of providing first-aid care.

The object of studying the discipline "LP and CD" are dangerous and harmful processes, phenomena and substances that arise during the interaction of a person with objects of life, primarily in the industrial sphere, in emergency, military and everyday state, and the danger posed by them and means and measures aimed at eliminating this danger.

The subject of the discipline "LP and CD" is the legislative, regulatory, socio-economic, engineering and sanitary and hygienic bases of safety of life, labour protection and civil defense as a system of personal, social and state protection.

Purpose of the discipline "LP and CD":

formation of future specialists awareness of the need and competencies to solve in the primary positions the typical tasks of all areas of professional activity with the obligatory observance of the requirements of occupational safety, responsibility for personal and collective security in everyday conditions and during emergencies, special and martial law.

According to the results of studying the bachelor's degree in corresponding specialties should be able to solve typical professional tasks taking into account the requirements of labour protection and civil defense and have the following competencies:

– use the regulations of legislative acts and normative legal documents on labour protection and civil defense in their professional activities;

– to evaluate sanitary and hygienic conditions and the level of safety of work at separate workplaces and in industrial premises;

– to perform in the primary position professional functions, duties and powers on labour protection, industrial and civil security.

– to identify harmful and dangerous factors in the domestic and social environment, to use the basic methods of preserving life and health, including in emergency situations (ES).

The purpose of the educational function is to provide knowledge of the personal safety of a person and the safety of those around him that meet modern requirements.

The purpose of the educational function is to form a scientific outlook, an active social position, and creative thinking in solving production and life problems that pose a danger to human life and health.

The purpose of the psychological function is to form a psychological readiness for safe operation in the conditions of a modern technogenic environment and the readiness to purposeful actions and protection in the conditions of danger.

The task of the discipline "LP and CD" is to make students, by results of training, to demonstrate the following results:

– knowledge:

- socio-economic, legislative, regulatory and organizational foundations of labour protection and civil defense;
- modern problems, main tasks and principles of human security;
- basic regulations of occupational hygiene and industrial sanitation;
- organizational and technical foundations of industrial and fire safety;
- duties and procedures in emergency and military situations.

– abilities:

- identification of harmful and dangerous factors in the environment;
- to evaluate the hygienic characteristics of working conditions in the workplace;
- select and operate modern collective and individual protection measures;
- assess the level of fire and explosion hazard of premises and ensure compliance of fire prevention measures, means and devices of fire protection with regulatory requirements;
- carry out and issue instructions on occupational safety at work;
- perform the necessary actions in the event of incidents and accidents;
- qualify for emergency and emergency situations, special and military conditions;
- to ensure the effectiveness of evacuation measures.

Section I. SAFETY OF LIFE - SUSPENSION OF SUSTAINABLE DEVELOPMENT

1.1. Categorical and conceptual apparatus for life safety

1.1.1. Model of human life

Life – is one of the forms of the existence of matter, characterized by the exchange of substances, the ability to reproduce, develop, grow, different forms of movement, as well as the ability to adapt to environmental changes.

Life is the highest form of the existence of matter in comparison with other forms such as physical, chemical, energy, wave, etc.

Life can be seen as a consistent, orderly metabolism and energy. An inalienable property of all living things is ***activity***.

Occupation – a specific human form of activity, interaction between people and people with the environment in order to meet the material, cultural and spiritual needs and changes and transformation in the interests of the human environment.

Types of occupation: production; household; scientific; sports, etc.

Life and occupation are interdependent and mutually complementary. Life can not exist without occupation and vice versa. Man constantly interacts with the environment, transforms the environment, and it, in turn, affects on the livelihoods of the person himself. That is, the interaction of man with the surrounding environment occurs in the presence of direct and inverse relationships.

Vital activity – is a form of life`s organization and purposeful activity, in which all human needs and inquiries are fully or partially provided.

Activities are usually carried out in the presence of certain sources that can harm the person, systems that provide human life, products of its activities, etc.

Potential source of harm – phenomena, processes, objects, properties that can under certain conditions cause damage to human life, systems that provide its life, products of its activities etc.

The condition of the environment, provided that there are no potential sources of harm, can be considered safe. But such a state of the environment can only be imagined theoretically. In reality, human activity occurs in the presence of sources that can harm.

Therefore, under security means a balanced (according to expert judgment) state of man, society, state, natural, human-made systems, etc.

The structure of vital activity – the interconnection between life, which is a system of protection, with the environment can be represented by the following scheme (Fig. 1.1).

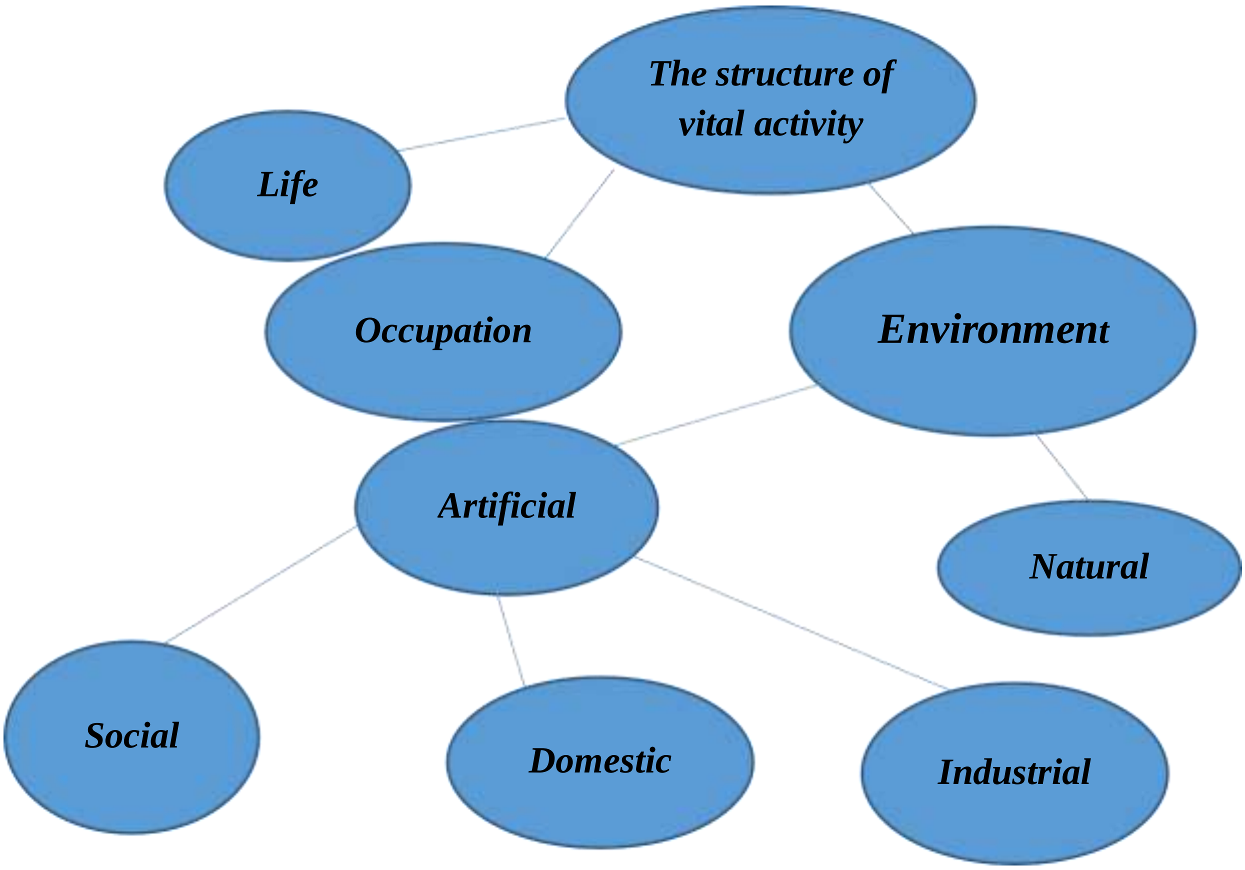


Fig. 1.1. The structure of vital activity

Human life safety (HLS) – is a complex condition in which the probability of carrying out a negative risk to a person is minimal in all conditions of its activity.

Danger** – **is a negative property of living and inanimate matter that is capable of causing damage to the very matter itself, namely people,

the natural environment, material values, it is a violation of normal living conditions and activities of people in a separate territory or object.

It is impossible to study the features of a person, collective or society, not taking into account their place in the environment and the environment of this environment. Therefore, HLS studies human beings and their environment in the system "man - living environment". Beyond this system, people are the subject of studying anthropology, medicine, psychology, sociology and many other sciences. An environment surrounding a person outside this system is studied by astronomy, geography, geology, biology, ecology, etc.

The "human-living environment" system is a multilevel and complex system; it usually includes a large number of variables, among which there is a large number of relationships. It is known that the more variables and relationships between them has a system, the more difficult these communications are subjected to the mathematical treatment and deduction of universal laws.

Human is one of the elements – the subject of this system, in which the term "human" means not only one being, an individual, but also a group of people, a collective, inhabitants of a locality, a region, a country, a society, and mankind in general. The latter determines the level of the system "human – LE".

Living Environment (LE) – the second element of the system "human – the living environment", its object. The living environment is part of the universe, where the person is or can be present at the present time and functioning systems of its life support. In this sense, it has no permanent in time and space boundaries, its boundaries are determined primarily by the level of the system, that is what in this case is understood under the term "human".

Human life environment consists of natural, social, or socio-political and technogenic environments.

Life safety – an integral part of the characteristics of the strategic direction of human development; defined UN as "Sustainable Human Development" (Sustainable Human Development).

Multi-level HLS system is shown in Figure 1.2.

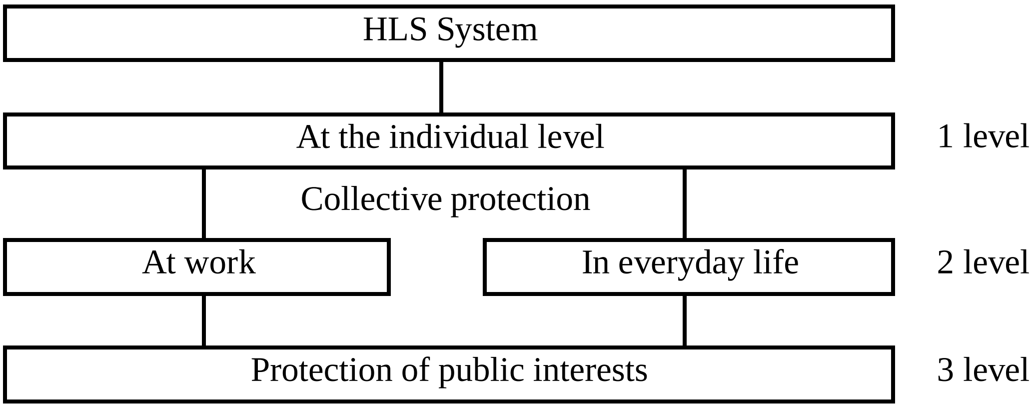


Fig. 1.2. Multi-level HLS system

Sustainable development – is a development that leads not only to economic, but also to social, cultural, spiritual growth, promotes humanization of the mentality of citizens and enrichment of positive universal human experience.

The concept of sustainable human development is the basis of the science of human security.

Its main areas are:

1. Safety of the vital activities of any country’s population is provided not by means of arms, but by the long-term process of sustainable human development.

2. The safety of human life and health should be regarded as a component of the development of the material, production, social, political, cultural, spiritual and everyday spheres of society’s life.

3. For most people, a sense of security is associated with problems of everyday life (nutrition, warmth, stability, clothing, medical care, work, salary, education, etc.) and it should be satisfied.

4. Human security is a general category that characterizes the provision of human life in any country.

1.1.2. Theoretical foundations of life safety

Life safety – is a basic factor for sustainable human development. As was said above, security is the absence of a threat to anyone or something; and danger is a system, an object, a mechanism, a process, a phenomenon, their dangerous parameters, characteristics, properties, which under certain conditions can bring harm to the health and life of a person, society; poses a threat to the environment.

Dangers are divided into:

– potential (hidden);

– permanent (constant, continuous);

– total.

Sources of danger over time change, some become more important, others – less. Previously, the source of danger was the phenomena of nature, representatives of the biological world, various natural processes and phenomena. As civilization develops, man-made (created by man) danger, and the level of threat increases. At the present stage of development, man-made hazards occupy a prominent place.

Causes of danger – a coincidence of circumstances, resulting in the emergence of danger and there are negative consequences: nervous shocks, injuries, illness, disability, sometimes death.

There is a chain: "cause – danger – consequences". Eliminating the cause can eliminate the manifestation of danger and, consequently, the consequences.

Life safety –these are the conditions, norms of life and work of people, the parameters of the environment on which, with a certain probability, the manifestation of hazards with negative consequences is excluded. It is also a system of knowledge that ensures the safety of human being in the production and non-production environment and the development of activities for the security of the future, taking into account the human impact on the living environment.

Today, the following security systems really exist:

– system of environmental protection (biosphere);

– system of personal and collective security of a person in the course of his labour activity;

– the system of state security;

– a system of global security.

You can identify a number of important life safety issues:

– support of parameters of a living environment in the limits necessary for a life;

– providing the population with all types of energy resources (electricity, gas, oil products, coal, etc.);

– providing the population with all norms and parameters of artificial environment: housing, public transport, public buildings, sports complexes, medical institutions, etc.;

– provision of food by the population as a physiological basis of life; if mankind does not develop new types of food and does not adapt to them in time, then after a while it will be on the verge of famine or chemical poisoning;

– the availability and rational use of drinking (fresh) water in the interests of life;

– liquidation (processing or use) of waste of production, life activity.

Comprehensive analysis of the system shows that this system can function effectively for a long time only if it is able to protect itself from the dangers of any origin. The system of life safety should have in its composition a subsystem that would provide protection both for individual elements and for the system as a whole. In other words, every person, individual social groups of people and all humanity, together with the environment, needs protection.

1.1.3. Methodological basis of life safety

Life safety as a relatively new branch of science, created in our time at the junction of natural sciences, humanities and engineering, uses the methods of these sciences, while developing their own methods. Having developed on the basis of the achievements of the sciences of man, society, nature, LS began to create their own methods, using the accumulated experience. On the other hand, the complex nature of BC ***requires*** the use of a set of methods of other sciences.

The main methodological principle of LS is the system-structural approach, and the method used in it, – system analysis.

***System analysis** – is a scientific method of knowledge, which is a sequence of actions to establish structural relationships between variables or elements of the system under investigation.*

Under the system refers to a set of interconnected elements that interact with each other in such a way that a certain result (goal) is achieved.

Under the elements (constituent parts) systems understand not only material objects, but also the relations and connections between these objects. Any device is an example of a technical system, and a plant, animal or person is an example of a biological system. Any group of people or groups – the community – are social systems. *A system, one of which elements is a person, is called **ergatic**.*

The complexity of studying the systems "human – the living environment" is also conditioned by the fact that these systems are multilevel, contain positive, negative and homeostatic feedback and have many endangered properties. Systems have their properties, which are not and cannot even be in the elements that make up it. *This essential feature of systems, which is called as an **emergent**, is the basis of system analysis.*

Life safety solves the following tasks:

- identification of danger (name, type, category), determination of its physical essence (mechanical, physical, chemical, social) and sources;
- determination of the level of danger (its risk);
- prevention and prevention of dangers;
- clarification of the nature of the damaging factors, parameters, properties, characteristics;
- taking measures to protect people and reduce the negative consequences of manifestations of hazards;
- localization of negative consequences of the manifestation of hazards and ensuring the safety of people and the environment.

One of the main areas of LS provision is the identification of sources of danger.

Potentially hazardous object (PHO) – is an object, the accident on which may lead to emergency [1].

Potentially hazardous areas (PHA) – are territories within which there are PHOs, hazardous substances, domestic and industrial wastes that can form a zone of emergency due to the accident.

Potentially hazardous processes (PHP) – are technological, biochemical, hydrotechnical and other processes that pose a threat to people and the environment.

The main measures to prevent the emergencies and reduce the negative effects of their manifestation include:

- systematic monitoring of the technological state of the PHO and timely detection of events that may lead to emergencies;
- control of the parameters of the natural environment in the industrial zone;
- compliance with the relevant norms and rules for the placement, construction and operation of PHO;
- creation of material reserves, forces and means in the case of emergency;
- application of various sanctions to the violators of the LS;
- legal regulation of all aspects of security;
- increase of the level of professional training of the personnel.

The principle of systemicity considers phenomena in their mutual connection as an integral set or complex. The purpose or result achieved by the system is called the system-building element.

System analysis in life safety – is a scientific method for identifying and recognizing the dangers that arise in the system of "human – living environment" or at the level of its component components, and their impact on the state of health, health and human life.

In the study of security problems they need to be studied without distinction from environmental, economic, technological, social, organizational and other components of the system to which they are included. Each of these elements affects the other, and they all are in complex interdependence.

System-structured approach to phenomena, elements and interconnections in the system "human-living environment" is not only a basic requirement for the development of theoretical principles of LS, but above all an important means to improve the activities aimed at ensuring healthy and safe conditions of human existence. System-structured approach is needed not only to study the security level of a system (industrial, domestic, transport, social, military, etc.) but also to determine the impact of individual factors on the security situation.

1.1.4. From human security to national security and human security

Human security – is an integral part of the characterization of the strategic direction of mankind, defined by the UN as "sustainable human development", which leads not only to economic but also to social, cultural and spiritual growth, which promotes humanization of the mentality of citizens and enrichment of positive universal human experience. People create a society that the state has to protect, so there is such a concept as the security of society.

Social security (societal security) – is a general term for identifying efforts to overcome modern threats to the security of society. The concept of "security of society" was formed as a result of the awareness of the phenomena of identity and cohesion of society as sources of instability. Ensuring human security, and, accordingly, society, forms the concept of national security.

National security – is the protection of vital interests of a person and a citizen, a society and a state in which sustainable development of society is ensured, timely detection, prevention and neutralization of real and potential threats to national interests.

Objects of national security are:

– a person and a citizen – their constitutional rights and freedoms;

– society – its spiritual, moral, ethical, cultural, historical, intellectual and material values, information and environment, natural resources;

– the state – its constitutional system, sovereignty, territorial integrity and inviolability.

The subject of the system “human – a living environment” can be both an individual and any community to which this person is a member. In turn, social communities can be constituent parts of other communities, and, in turn, they are even more numerous. As a rule, one can always speak of a certain hierarchy of social communities. In some cases, this hierarchy is rigidly defined and regulated. In other cases, it exists, despite the lack of such regulation.

Consider an example of such a hierarchical structure of human communities, based on the principle of human residence.

A union of two people can be considered as the minimum community. As a rule, this is a family. But it can also be two students living together at the hostel. We call such a community a micro-group belonging to a larger collective-dwelling house (dormitory). Living conditions in individual homes are largely determined by the quality of communal services provided by the housing department or other similar structure of the neighborhood in which the building is located. Thus, the inhabitants of the neighborhood can be considered as members of one large team, which we will call a microcosm. The micro-district is an integral part of the city, and, consequently, the population of the city – is a social community of a higher hierarchical level in relation to those that were considered before. Even higher hierarchical communities are the people of the region, the country, the continent and, finally, humanity.

Similarly, we can consider examples of other hierarchical structures constructed according to another principle – production, educational, etc. For example, a student group, a team of faculty, a university, a student city, a country. The maximum number of members of the micro-group, usually 20–30 people, but may be larger. Since any social group or person who in one case is a subject of the system, in the other time is only an integral part of another entity of another system, and the one in turn enters the subject of a higher level, then there exist the system “human – living environment” of different levels. The levels of these systems are determined by the level of their subjects. So, based on the above example, we can talk about the level of the system “human – living environment” from one person, family, residents of a residential building, microdistrict, settlement etc.

For systems of different levels, not only the subject but also the object is the living environment, since its boundaries are determined by the members of the social community, the subject of the system, or may be present at this time. From the level of the system "human – living environment" also depends on the classification of danger to the appropriate category.

For an individual, that is, when we talk about the system "human – living environment" with one person, all other people and any communities are elements of the living environment, namely the social environment.

For the global system, "human – living environment", all people are components of the common human community, and the living environment consists of the natural – the Earth and the outer space surrounding it, and the man-made environment created by mankind in the history of its existence.

For systems of any other level, it is always necessary to determine which people and communities are the internal constituents of the community for which the system "human – living environment" is considered, and which are elements of the social environment surrounding this community.

National security of Ukraine is ensured through the implementation of a well-balanced state policy in accordance with the doctrines, concepts, strategies and programs adopted in the established manner in the political, economic, social, military, environmental, scientific and technological, information and other spheres.

1.2. Sources of danger, damaging, dangerous and harmful factors

1.2.1. Taxonomy, identification and quantification of hazards

Taxonomy of hazards – is the classification and systematization of phenomena, processes, information, objects that are capable of causing harm (at the moment it is not yet fully developed). An example of a taxonomy of hazards can be such a division:

- by origin (natural, technogenic, socio-political, combined);
- by localization (space, atmospheric, lithosphere, hydrosphere);

- for consequences (diseases, injuries, death, fires, pollution);
- for damage (social, technical, environmental);
- in the field of manifestation (domestic, industrial, sports, road transport);
- on time manifestations (impulse, cumulative);
- by the nature of the action on the person (active and passive (the latter are activated by the energy that the bearer itself is the person who is exposed to acute, stationary elements, pits, deviations, irregularities of the surface etc.)).

Identification of hazards – finding the type of danger and establishing its characteristics, necessary for the development of measures to eliminate or eliminate the consequences.

In order to determine the severity of the danger, the categories of severity of danger are used (I – catastrophic, II – critical, III – limiting, IV – insignificant), which determine the quantitative significance of the relative severity of the probable consequences of hazardous conditions and the level of probability of danger (A – frequent, B – probable, C – random, D – remote, E – never will happen), which is a qualitative reflection of the relative probability that an unwanted event occurs as a result of an unsolved or uncontrolled hazard.

Quantification of hazards – the introduction of quantitative characteristics to assess the degree (level) of danger.

The most commonly quantified risk assessment is the degree of risk.

Numerical, ballroom and other methods of quantization are used. The degree of danger may be the number of victims, degree of destruction, damage to the environment, losses associated with hazards.

1.2.2. Types of dangers

In order to eliminate or at least reduce the damage that is in danger, they are regulated by state regulatory documents. Table 1.1 shows the types of hazards, their features and the list of documents that regulate them.

Table 1.1. The types and signs of various hazards

Kind of hazards	Signs
Bacteriological	Presence of dangerous microorganisms (bacteria, viruses, rickettsia, fungi, simpler)
Biological	Presence of dangerous macroorganisms, as well as storage and landfills of biological waste, sewage treatment facilities
Explosive fire	The presence of gaseous, liquid and solid substances, materials or mixtures thereof, as well as oxidizing agents that are capable of exploding and burning under certain conditions
Fire	Presence of gaseous, liquid and solid substances, materials or mixtures capable of supporting combustion
Hydrodynamic	Presence of hydraulic structures (dams, dams, sluices) for the accumulation and storage of significant volumes of water and liquid substances
Radiation	Presence of radioactive substances and materials, other sources of ionizing radiation
Physical	Presence of sources of electromagnetic, ionizing, light, acoustic or other fields of an unfavorable range or power. Dynamic danger associated with the presence of sources of high velocities, including variables (vibrations)
Chemical	Presence of toxic, harmful, potent poisonous substances, pesticides, chemical means of plant protection and mineral fertilizers
Ecological	Possibility of unfavorable influence on the environment of man-made and natural factors, as a result of which the adaptation of living systems to the habitual conditions of existence

1.2.3. Classification of hazards

The most successful classification of hazards is the classification by source of origin, according to which all hazards are divided into 4 groups: natural, man-made, socio-political and combined (Figure 1.3.). The first three groups belong to the elements of the living environment, which surrounds the person – natural, technological and social. The fourth group includes natural-man-made, natural-social and socio-man-made hazards, the sources of which are a combination of different elements of the living environment.

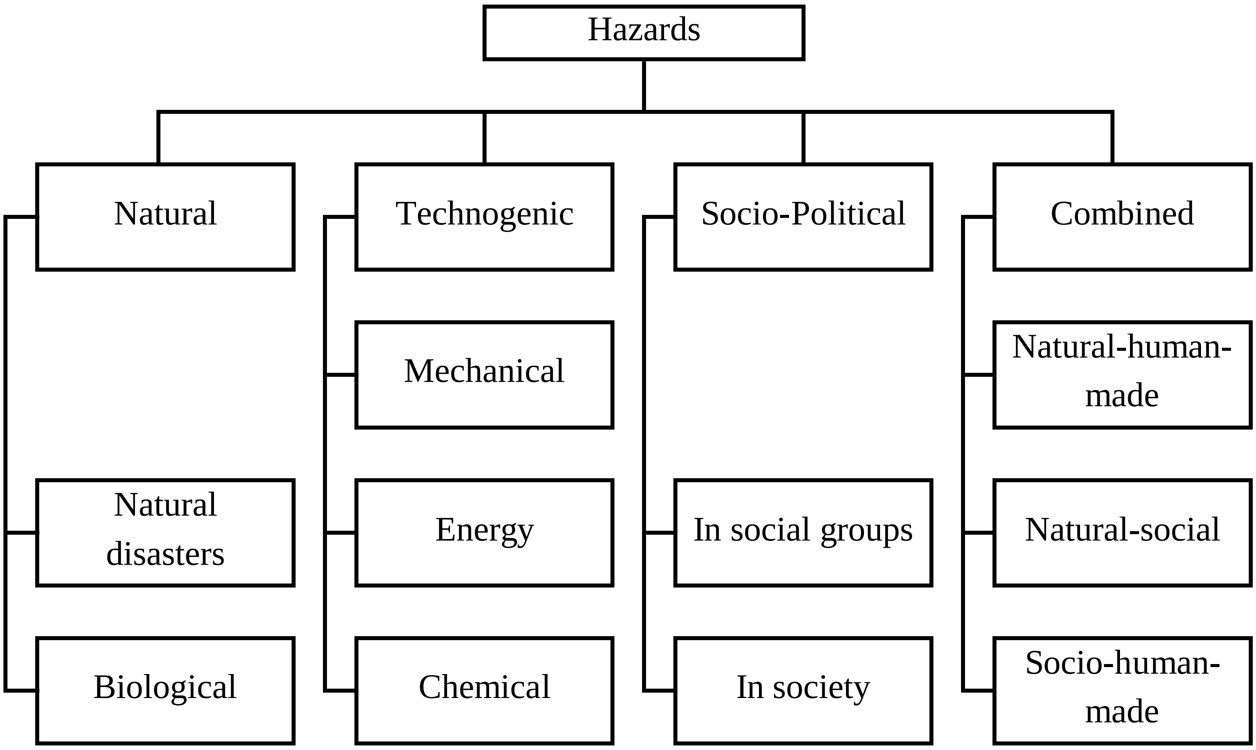


Fig. 1.3. Classification of hazards by sources of origin

Natural sources of danger – are natural objects, natural phenomena and natural disasters that can cause damage to people or endangers human life or health (earthquakes, landslides, villages, volcanoes, floods, snow avalanches, storms, hurricanes, showers, hailstones, fogs, icebergs, lightning, asteroids, solar and cosmic radiation, dangerous animals, plants, fish, insects, mushrooms, bacteria, viruses, infectious diseases).

Technogenic hazards – are the dangers associated with the use of vehicles, the operation of lifting and transport equipment, the use of flammable flammable and explosive substances and materials, electric energy, chemicals, various types of radiation (ionizing, electromagnetic, vibroacoustic), processes, occurring at elevated temperature and pressure. The sources of man-made hazards are the corresponding objects that give rise to them.

Social dangers – are the dangers caused by the low spiritual and cultural level (vagrancy, prostitution, drunkenness, alcoholism, tobacco smoking). The sources of these dangers are unsatisfactory material conditions, poor living conditions, strikes, uprising, conflict situations on the international, ethnic, racial or religious grounds.

The sources of political dangers – are conflicts at the interethnic and interstate level, spiritual oppression, political terrorism, ideological, inter-party and armed conflicts, and war.

The greatest number of hazards are ***combined risks***.

Natural-human-made hazards: smog, acid rain, dust storms, soil erosion, soil fertility, desertification, landslides, villages, earthquakes and other tectonic phenomena that triggered human activity.

Natural-social dangers: drug addiction, the epidemic of infectious diseases, sexually transmitted diseases, AIDS.

Socio-technological dangers: occupational diseases, occupational injuries, mental disorders and diseases caused by productive activities, mass mental deviations and diseases caused by influence on consciousness and subconsciousness by mass media and special technical means, substance abuse.

1.2.4. Safety in the "human-equipment-environment" system

Sources of danger are natural processes and phenomena, elements of an industrial environment, human actions that endanger the danger.

Under ***the astonishing factors*** are those factors of the living environment, which, under certain conditions, harms both people and life-support systems of people, leads to material losses.

Harmful factors are called such factors of the living environment, which lead to deterioration of well-being, reduced capacity for work, disease and even death as a consequence of the disease.

Dangerous factors are called factors of the living environment, which lead to injuries, burns, frostbite, other damage to the body or its individual organs, and even to sudden death.

Hazardous and harmful factors are often hidden, implicit or difficult to detect or recognize. This refers to any dangerous and harmful factors, as well as sources of danger that give rise to them.

Solar radiation, which is necessary for the existence of almost all living organisms on Earth, including humans, can be the cause of skin diseases. An attractive children's toy can release harmful substances, and a passenger who peacefully drowses in the cabin of an airplane can be a terrorist.

In each case where the source of danger is more obvious, for example, an explosive, a weapon, a car, an active volcano, a collapsing house, we are talking about the presence of a source of danger, but this does not always mean the presence of a dangerous situation, that is, events in which the danger is manifested or created a real possibility of its manifestation.

The main groups of the damaging, harmful and dangerous factors in the system "human-equipment-environment":

- mechanical (rotating objects, flying, falling, moving);
- physical (atmospheric pressure, relative humidity, air temperature, gas composition of air, radiation background and other indicators if they are beyond the norm);
- chemical (poisonous and potent toxic substances, toxic substances in doses exceeding the maximum permissible concentrations of MAC);
- biological (flora and fauna, in interaction with which a person can get severe negative consequences or die);
- psychophysiological (fatigue, stress, nervous breakdown, occupational disease caused by harmful environmental factors: monotony of labour, vibration, noise, insufficient lighting, etc.);
- social (overtime work, crime, time zone change, etc.).

Human factor (HF) – is a set of physiological, psychophysiological, anthropometric and professional characteristics, which in one way or another contribute to the emergence of dangers. From 40 % to 80 % of the dangers arise as a result of human activity.

Human factor – is a multi-valued term that describes the possibility of human adoption of erroneous solutions in specific situations. Designers are trying to predict, prevent and reduce the consequences of such human behaviour. The expression human factor is used as an explanation of the causes of disasters and accidents that caused damage or sacrifice.

Any person inherent in limiting opportunities or mistakes. Not always the psychological and psycho-physiological characteristics of a person correspond to the level of complexity of solvable problems or problems. Lack of full confidence in the success of the future action, doubts in the possibility of achieving the goal of the activity generate emotional tension, which manifests itself as excessive anxiety, intense human experience of the process and the expected results. Emotional tension leads to a deterioration in the organization of activity, overexcitement or general inhibition and stiffness in behaviour, increasing the likelihood of false actions. The emergence of tensions contribute to such individual characteristics of man, as excessive vulnerability, excessive zeal, lack of general endurance, impulsivity in behaviour.

The source of errors can be reduced attention in a familiar and calm environment. In such a situation, a person relaxes and does not expect any complication. Errors in the performance of one or another action may also be related to an unsatisfactory mental state of a person. At the same time, humans have depressed mood, increased irritability, slow reactions, and sometimes, on the contrary, unnecessary excitement, fuss, unnecessary talkativeness. The reason for human error can be the lack or lack of information support, especially in extreme situations and in the absence of time for decision-making.

In our time not only the protection of man from production and the environment, but also protection of the environment from man and production is relevant. Directions of manifestations of hazards arising from a human factor can be represented by the following scheme (Fig. 1.4.):

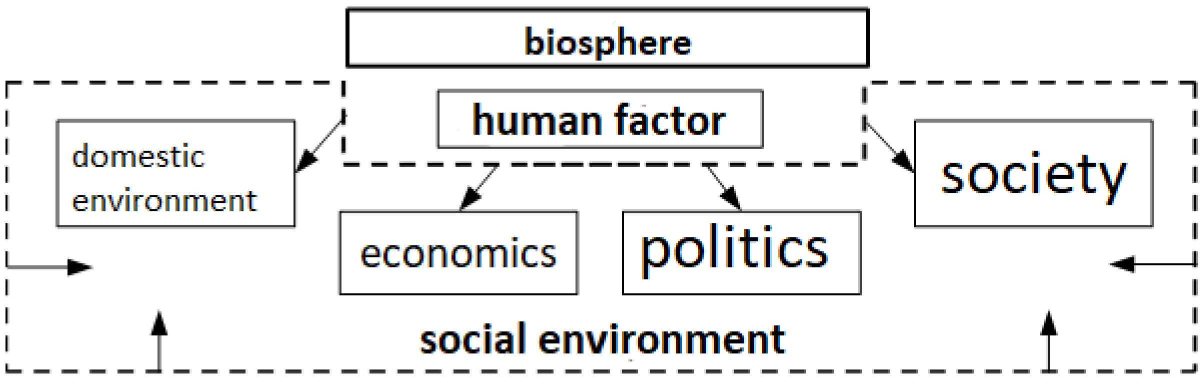


Fig. 1.4. Directions of manifestations of emerging hazardsas a result of the human factor

The human factor is the reason:

- 80–90 % of violations of the regime of the TPP;
- 70–80 % of accidents in transport;

- 50–65 % of aircraft crashes;
- more than 50 % of accidents in everyday life.

The "human-technician-environment" system guarantees the achievement of the following objectives:

- obtaining the result of life necessary for a person;
- ensuring the safety of human life;
- prevention of manifestations of the affected and reducing the action of dangerous and harmful factors to acceptable values, which do not contribute to loss of efficiency and degradation of human health;
- reducing the dangerous impact of human life on the environment and attracting the necessary protective measures;
- ensuring the stability of the operation and protection of people under the influence of various emergency factors.

1.3. Dangers that can lead to an emergency

1.3.1. Global problems of humanity

Global problems of mankind – are the problems of anthropogenic origin, which concern all countries, the vital interests of all peoples of the world, are characterized by dynamism and need to be solved for joint actions of the world community.

From their solution depends on further progress of mankind and the preservation of civilization. They are interconnected, affect both the surface of the earth and the oceans, the atmosphere of the planet, the near-Earth and outer space, leading to great economic and social damage.

Global human problems cover all aspects of life such as environmental, economic, energy, health and medical technology, space and space technology, political, industrial, and public. Consequently, they can be described as follows.

Ecology: land degradation, modern environmental problems, ozone holes, greenhouse effect, the problem of regulating industrial emissions, the problems of ecosystem destruction, ecological disasters, the problems of geoactivity, the problems of heliosactivity, the problems of the world economy.

Economics: exhaustion of factors of production, global competitiveness, economic paradigm, integration and disintegration of markets (integration education in Europe, Asia, America), costly production, new models of economic development, redistribution of goods between traditional and emerging economies, resource potential of modern society.

Energy: the energy crisis, the safety of nuclear power plants and nuclear facilities, the development and implementation of alternative energy sources.

Health: birth control and demographic programs in developing countries, oncology, AIDS, sanitary and veterinary control against pandemics and their threats (avian influenza, swine flu).

Space and space technology: space debris and space pollution.

Politics: arms control, nuclear technology control, overcoming of regional and world tensions, mutual adaptation, harmonization of national and international politics.

Industry: post-industrial development model, third industrial revolution.

Society: hypothesis of the second demographic transition, increase of uncontrolled migration, overpopulation, food problem, unemployment, poverty, export of democracy, rapprochement of nations (assimilation), socio-economic development, civilization development, technological revolution.

These are the main complex problems of mankind, and the development of civilization on the planet constantly generates new and new. Commitment to drug addiction, crime, terrorism, dies traditional spiritual values. Better technically arming, a person does not become morally morally. This, probably, lies behind the causes of all the global problems of humankind.

1.3.2. Natural hazards

In our time, a person is able to fly to the moon, to Mars, we know a lot about other planets, but the forces of nature of our own planet are still not conquered by us. In our civilized, technically developed time, mankind remains dependent on natural phenomena, which are often of a catastrophic nature. Volcanic eruptions, earthquakes, droughts, mudflows, snow avalanches, floods cause the death of many thousands of people, causing tremendous material damage.

Natural danger – is an event of natural origin or a result of natural processes that, in its intensity, scale and duration, can affect people, objects of the economy and the environment.

Natural hazards include: natural disasters, natural radiation (cosmic rays, sources of earth radiation), falling from the cosmos of the body, atmospheric electricity and biological hazards.

Natural disasters are natural phenomena that are of an extraordinary nature and lead to a violation of the normal activities of the population, the death of people, the destruction and destruction of material assets.

According to the localization, natural disasters are divided into: geophysical and geological processes and phenomena, meteorological, hydrological, biological, natural fires.

According to experts, annual losses from natural disasters in the world amounted to 30 billion dollars. The biggest losses from all natural disasters caused by floods, including tsunami-induced (40 %), tropical cyclones (20 %), and earthquakes and droughts in the third and fourth places (15 %). Hurricanes and earthquakes are the cause of most deaths.

On the territory of Ukraine, almost all spectrum of dangerous natural phenomena and processes of geological, hydrogeological and meteorological origin may arise.

Natural radiation – is a source of terrestrial radiation and cosmic rays.

Sources of terrestrial radiation are: long-lived radionuclides of potassium-40, rubidium-87, uranium-238, thorium-232, lead-210, polonium-210, radon gas and others found in various rocks of the earth. In this earth's radiation in different parts of the globe is not the same and depends on the concentration of radionuclides in one place or another. The most dangerous of all natural sources of radiation is the invisible, which does not taste and smell of heavy radon gas (7.5 times heavier than air). In nature, it is found in the form of radon-222 (from the decay of uranium-238) and radon-220 (from the collapse of thorium-232). However, products of decay of radon are more dangerous than the gas itself. Other natural sources of radiation are: coal (at burning), thermal water, phosphate (at extraction and as fertilizer) and other substances.

Cosmic rays usually come to us from the depths of the universe, but some definite part of them is born on the Sun during solar flares. Cosmic rays can reach the surface of the Earth or, interact with its atmosphere, causing repeated radiation and resulting in the formation of various radionuclides. At the same time, the northern and southern poles get more radiation than equatorial regions, due to the presence of a magnetic field of the Earth, which is rejected by cosmic rays (charged particles). In addition, with an increase in the height, the ozone layer of the air, which plays the role of the screen, decreases as a result of which the level of irradiation with cosmic rays increases. Radiation protection is a strict dosing of the reception of solar radiation by place, time and state of health, restriction of activity in zones of high radiation.

Falling space bodies

Asteroids – are cosmic bodies whose diameter ranges from 1 to 1000 km. In space, there are about 300,000 asteroids and comets, and about 300 of them can cross Earth's orbit. The probability of a collision of asteroids with the Earth is estimated 10-5-10-8.

The meteorite (from the Greek μετέωρος, "suspended in the air") is a solid body of heavenly origin that fell to the surface of the Earth from outer space.

It is believed that during the day falls 5–6 tons of meteorites, or 2000 tons per year. In addition, for a day on the earth's surface falls from 300 to 20,000 tons of meteorite dust.

To draw attention to the threat, the UN General Assembly has designated June 30 as the World Asteroid Day.

Regular sky surveys began to detect near-Earth asteroids that threaten to collide with our planet.

Atmospheric electricity

Lightning – is a gigantic electric spark discharge in the atmosphere between the clouds (75 %) or between the cloud and the earth (25 %), which is usually a bright flash of light and accompanying its thunder.

Thunder – is a sound phenomenon in the atmosphere that accompanies the lightning bursts. Thunder is a fluctuation of air under the influence of a very rapid increase in pressure on the lightning path.

Lightning has a considerable length, the sound from different parts of it and its reflection from the clouds and from the surface of the earth reaches the human ear at the same time. The volume of thunder rumbling can reach 120 decibels, it can be heard at distances of up to 15–20 kilometers, so ***if an observer sees lightning but does not hear the thunder, the thunderstorm is at least 20 kilometers away.***

In the process of formation of rainfall in the cloud, the electrification of droplets or ice particles occurs. As a result of strong upward flow of air in the cloud, separate regions are formed, charged with different charges. When the intensity of the electric field in the cloud or between the lower charged region and the ground reaches a breakdown value, lightning arises.

Lightning are the following types:

– ***linear*** – lightning in the form of a winding line, from which leaves a lot of branches, is the most widespread;

– ***vague*** – lightning that has no contours and occurs with an instant flash;

– ***a ball*** – a spherical discharge that exists in the atmosphere for a certain time, is the most dangerous kind of lightning.

Biological dangers – are flora, fauna and pathogenic microorganisms, in interaction with which people can get severe negative consequences or die.

Dangerous flora: poisonous and toxic plants, mushrooms.

Poisonous plants – are plants that contain toxins and / or chemicals that pose a serious risk of illness, injury or death of humans or animals.

About 10 thousand types of poisonous plants are known in the world, of which 250–300 species grow in Ukraine. Poisonous substances (plant toxins, plant poisons) can be found in the whole plant as a whole, or in different parts of it – in the aboveground: leaves, flowers, fruits, seeds, bark and underground: rhizomes, roots, bulbs, and tubers.

The toxic substance of poisonous plants are various compounds, which belong mainly to alkaloids, glucosides, organic acids, resins, essential oils, toxoalbumin and other chemical compounds.

By degree of toxicity plants are divided into:

– poisonous (seeds, bark and roots of white acacia, elderberry, lily of the valley, hellebore white, ivy, etc.);

– very poisonous (digitalis, oleander, crow's eye, aconite, etc.);

– deadly poisonous (black hawthorn, cicut, belladonna common, common stomach, wolf berries, etc., some species of mushrooms).

To prevent poisoning, never eat, taste or even touch plants and mushrooms unless you are sure they are safe.

In the first manifestations of poisoning as soon as possible seek qualified medical assistance. Because the more toxins get into the blood, the more severe the poisoning will be.

Fauna: insects, fish, amphibians, reptiles, predatory animals.

Among animal organisms, poisonous forms occur more often than in plant organisms. Poisons produced by certain or other organisms are chemical factors involved in interspecies interactions. Examples of the use of chemicals for attack or defense can be found at all stages of evolutionary development.

Danger to humans may include: wounded wild boar, lynx, brown bear, wolf, and animals infected with rabies (foxes, wild dogs).

There are no special methods of protection against the adverse effects of poisonous animals. You need to be able to distinguish them among others, to know their properties and symptoms of exposure to the human body and to avoid contact.

There are no special methods of protection against the adverse effects of poisonous plants and animals. You need to be able to distinguish them among others, to know their properties and symptoms of exposure to the human body and to avoid contact.

Pathogenic microorganisms: viruses, bacteria, fungi, mycoplasma, rickettsia and protozoa.

Distribution among people, animals, plants of pathogenic microorganisms, bacteria, viruses, which under certain conditions cause mass infectious diseases:

– epidemics (plague, cholera, flu);

– epizootics (foot and mouth disease, anthrax, avian influenza);

– epithophytosis (phytophthora, mildew).

Infectious disease – is a disease by pathogenic microorganisms, which is transmitted from a sick person or animal to a healthy person. Infectious diseases are manifested in the form of epidemic cells.

Epidemic morbidity or endemic – is a permanent registration of a specific area of morbidity that is characteristic of the area. ***Exotic morbidity*** is observed at the import of pathogens into a territory free of this infectious disease.

Sporadic morbidity – is the usual level of morbidity that is inherent in the corresponding disease in a given locality.

An epidemic explosion – is called a time-limited and abrupt rise in morbidity in a defined area, which is associated with simultaneous infections of people.

The incidence – is determined by the ratio of the number of diseases for a certain segment, time to the number of residents of the area, the city in the same period.

Mortality – is the number of deaths from this disease, which is defined by the coefficient of 100 thousand, 10 thousand and 1000 people, covered by epidemic surveillance.

Mortality is the percentage of deaths from the number of patients with this infectious disease.

The pathways of transmission of the pathogen – are defined elements of the environment or their combination, which ensure the transfer of the pathogen from source to surrounding people in specific epidemic conditions. The main ways of transmission of pathogens to infectious diseases are people: airborne, food, water, transmission, contact.

All infectious diseases of people are divided into 4 groups: intestinal infections, respiratory infections, blood infections, infection of external surfaces.

In order to successfully combat infectious diseases, even in peacetime, in many cases it is necessary to carry out mass vaccinations in a very short time.

Disinfection – is the destruction or removal of pathogenic microbes from the environment.

Disinsection – the destruction of insects and ticks harmful to humans – pathogens of infectious diseases.

Deratization – the destruction of rodents, which can be a source or carrier of infections.

Knowledge of biological hazards, their properties, competent behaviour of people in places of these dangers will help to avoid negative consequences of the influence on the human body.

1.3.3. Technological hazards

Technogenic hazards – are the dangers associated with the operation of technical devices and systems.

Thermal power plants

The share of thermal power plants accounts for 35 % of the total pollution of water and 46 % of the air. They throw out sulfur, carbon and nitrogen compounds, consume a lot of water: to get one kWh of electricity, thermal power plants spend about 3 liters of water (atomic – even more: 6–8 liters). The waste water of the thermal power plants is polluted and has a high temperature, which causes not only chemical but also thermal pollution dangerous to flora and fauna.

Automobile transport

If we take into account that more than half of the Earth's population lives in cities, then it will become clear the crucial importance of vehicles for direct impact on people. Petroleum products, residues from wiped tires and brake pads, loose and dusty cargo, and chlorides used to spill roads in the winter, pollute roadside strips and water objects.

In car exhaust gases, carbohydrate oxide, nitrogen dioxide, lead, toxic carbohydrates (benzene, toluene, xylene, etc.) prevail. The interaction of hydrocarbons and oxides of nitrogen at high temperatures leads to the formation of ozone (O_3). If in the atmosphere of a layer at an altitude of 25 km high enough ozone, necessary to protect the organic life from hard ultraviolet radiation, the high content of ozone at the surface of the earth causes depression of vegetation, irritation of the respiratory tract and lung injury.

Pollution of the surface of land by transport and road emissions is accumulated gradually, depending on the amount of vehicles passing through the road, road, highway and is stored for a very long time even after the elimination of the roadway (the closure of roads, roads, highways or the complete elimination of roads and asphalt cover).

The overall noise level on our roads is higher than in the West. This is due to the fact that in the traffic flow too many trucks, the noise level of which is twice as high as that of cars. In the city, 60–80 % of the noise is generated by the movement of vehicles.

Among the branches of production, the largest sources of man-made hazards are metallurgy, chemical, pulp and paper, electronic industry, agriculture.

By the manifestation of appearance hazards are divided into:

– mechanical;

– energy;

– chemical.

Mechanical hazards create:

– all objects that have kinetic energy (falling, moving, rotating);

– sources of mechanical dangers that do not have kinetic energy (prickly, cutting, sharp objects, slippery places, etc.);

– noise, ultrasound, infrasound, vibration.

The energy hazards include: explosions, fires, ionizing radiation, electromagnetic fields, electric shock, and others.

Dangers associated with the use of combustible, flammable and explosive substances and materials are explosions and fires.

An explosion – is a process, almost instantaneous conversion of one kind of energy into another (other).

Explosions are: chemical, nuclear, electromagnetic and mechanical.

Chemical explosion – is an explosion, based on chemical transformations on atomic and molecular.

The detonation explosion is characterized by the phased transformation of the chemical energy of the explosive (or mixtures) into other types of energy: the energy of the pressure, the thermal and kinetic energy of the explosion products. This creates an air shock wave, which is a major contributor to the danger to humans and the environment.

A nuclear explosion – is an explosion in the allocation of internal energy in the disintegration of heavy uranium nuclei-235, 233, 238, plutonium-239, and others.

The thermonuclear explosion is based on the principle of the connection of light nuclei of the chemical elements of deuterium and tritium. Synthesis is carried out at high temperature (T_C > 100 million degrees Celsius).

The main types of hazards in nuclear and thermonuclear explosions are the damaging factors that lead to:

– mass deaths of people, animals and plants;

– destruction, flooding, fires;

– pollution of the environment with radioactive substances.

A mechanical explosion – is the process of transforming kinetic energy (or energy of pressure) into other types of energy.

Example of a mechanical explosion – is Chelyabinsk meteorite 02/15/2013. Elements of danger in such explosions are the victims of people, the death of animal and plant life in large areas.

Conflagration – is uncontrolled combustion of objects, residential buildings, forest and peat arrays and other material assets.

When combustion of many materials formed highly toxic substances, from which people die more often than from the fire. Earlier, during fires, mostly carbon monoxide was released. But in recent decades many materials of artificial origin are burning: polystyrene, polyurethane, vinyl, nylon, foam rubber. This leads to the release of hydrochloric, hydrochloric and formic acids, methanol, formaldehyde and other highly toxic substances.

The most explosive, and fire-hazardous air mixtures are formed when leakage of gaseous and liquefied hydrocarbon products of methane, propane, butane, ethylene, propylene, and the like.

Main hazards of conflagration:

– toxic action of combustion products (CO, CO_2, etc.);

– thermal effect, which leads to burns of varying degrees;

– smoke, lack of oxygen;

– destruction of material values.

Secondary hazards of dangerous conflagration:

– destruction of building structures, explosions;

– leakage of dangerous substances occurring as a result of a fire;

– panic.

Fire – is an extremely dangerous fire hazard. During a fire, the temperature of the flame can reach 1200–1400 °C and for people who are in the zone of fire, radiation flame can cause burns and pain.

The minimum distance from the flame in meters, in which a person may still be, is approximately equal to

$$h = 1{,}6\ H,$$

where H – is an average height of flame in meters.

For example, when a fire burns a wooden house with a height of 5 m to the roof of the roof, this distance will be 8 m.

The destruction of building structures is due to the loss of their bearing capacity under the influence of high temperatures and explosions. In this case, people can get significant mechanical injuries, fall under the rubble of sunken structures.

Explosions, leakage of hazardous substances may be caused by their heating during a fire, depressurization of tanks or pipelines with dangerous liquids and gases. Explosions increase the combustion area and may lead to the formation of new foci. People in the vicinity may be subject to an explosive wave, to be damaged by debris.

Panic is mainly caused by rapid changes in the mental state of a person, mostly depressive in the conditions of an extreme situation. Most people find themselves in difficult and extraordinary conditions for the first time and have no adequate mental health and sufficient training in this regard. When the action of the fire factors exceeds the limit of human psychophysiological capabilities, it can be subject to panic. In addition, a person loses prudence, its actions become uncontrollable and inadequate to the situation that arose. This phenomenon can lead to mass deaths of people.

Ionizing radiation. With the development of technical progress to natural added artificial ionization radiation. As a result of testing nuclear weapons and using the atom for “peaceful” purposes, the radiation background on Earth has increased significantly. In December 1955, the UN General Assembly established a Scientific Committee on the Effects of Atomic Radiation (NKADAR). The task of this committee is to study the levels of radiation, its effects on the environment and the danger to the population that is generated by any source of radiation: both natural and artificial. This was the beginning of scientific research in the field of protection of human from ionizing radiation. To this end, efforts were mainly aimed at the creation and improvement of nuclear weapons.

Artificial sources of ionizing radiation are created by: nuclear explosions, various kinds of nuclear facilities, uranium mines and concentrating factories, radioactive waste burials, equipment used in scientific and research work in the field of nuclear physics and energy, radionuclides used in appliances of household appliances, numerous control devices (metal defectoscopy, quality control of welded joints), in agriculture, geological exploration, in various areas of heavy (introscopy) and hara (sterilization of tools, consumables and food) in the industry, as well as in medicine (radiation therapy, X-ray machines), various building materials, light devices: hours, compasses, pointers, telephone discs (where phosphorus is used), color TVs, computers, super-high frequency generators, etc.

Chemical hazards includestrong poisonous substances (SPS), warlike poisonous substances, pesticides, their elements and dangerous parameters.

Strong poisonous substances (SPS) – are chemicals or compounds that directly or indirectly can cause death, acute or chronic illness or poisoning of humans, animals, plants and (or) harm the environment.

Hazardous chemicals (HC) in the human body can penetrate through the respiratory system, skin, mucous membranes, gastrointestinal tract. The degree of damage depends on their toxicity, selective action, duration, as well as their physical and chemical properties.

By nature of exposure to humans Hazardous Substances are divided into:

- ***commonly toxic*** – poison the whole organism (CO, mercury, lead, nitric acid, ftoretanol, dinitroortokrezol, etc.);
- ***irritating*** – affect the respiratory organs and mucous membranes (chlorine, ammonia, phosgene, acrylonitrile, nitrogen oxides, etc.);
- ***sensitizing*** – cause allergic reactions (varnishes, paints, formaldehyde, nitro compounds, etc.);

- ***carcinogenic*** – cause cancer diseases (chloride oxide, nickel, asbestos, etc.);
- ***mutagenic*** – causing a change in heredity (uranium, manganese, lead, dioxin, etc.);
- ***stuffy*** – cause spasm of the respiratory tract (chlorine, trichloric phosphorus, phosgene, acrylonitrile, nitrogen oxides, sulfur dioxide, hydrogen sulfide, etc.);
- ***metabolic*** – violate metabolism, central nervous system, parenchymatous organs; have properties of drugs, poisonous substances of skin-skin effect (methyl bromide, methyl chloride, dimethyl sulfate, ethylene oxide, etc.).

By selective action EHC can be divided into:

- ***cardiac*** – cardiotoxic action: medicines, plant poisons, barium salts, potassium, cobalt, cadmium, etc.;
- ***liver*** – chlorinated hydrocarbons, aldehydes, phenols, poisonous mushrooms;
- ***renal*** – compounds of heavy metals, ethylene glycols, oxalic acid;
- ***nervous*** – violations of mental activity (carbon monoxide, alcoholic beverages, narcotic drugs, hypnotics, etc.);
- ***blood*** – derivatives of aniline, aniline, nitrites;
- ***pulmonary*** – nitrogen oxides, ozone, phosgene.

For the duration of exposure hazardous chemicals(EHC) can be divided into three groups:

- ***fatal***, leading or can lead to death (in 5 % of cases) – the validity period up to 10 days;
- ***temporary***, leading to nausea, vomiting, swelling of the lungs, chest pain – from 2 to 5 days;
- ***short-term*** – the duration of several hours, lead to irritation in the nose, oral cavity, headache, breathlessness, general weakness, decrease in temperature.

The most common in the structure of the national economy are ammonia (NH_3), chlorine ($C1_2$), phosgene ($COCl_2$), carbon monoxide (CO), sulfur dioxide (SO_2), pesticides, chladones (freons), and others.

The striking factor of chemical dangers is their toxic effects on the human body.

To characterize the toxicity, the following indicators are introduced:

Limit concentration (LC) – is the concentration of chemically dangerous substances in the air (g / m^3), in which the first signs of damage appear. Workability is not lost.

Toxoid (T) – takes into account the time factor when toxic.

The tolerance limit is the minimum concentration of chemicals that a person can withstand without a permanent defeat (g / m^3).

Impressive Concentration (IC) – is the concentration of poisonous substances that affects individual organs.

Deadly concentration (DC) – is a concentration of poisonous substances, which leads to a fatal outcome.

1.3.4. Social and socio-political dangers

Emergency situation of a social nature – a situation on a certain territory, formed as a result of a dangerous social phenomenon, which led or may lead to human sacrifices, damage to people's health or the environment, significant material damage

The dangers that lead to these ES are characterized by a very wide range of factors, among which one can distinguish:

- conflicts as socio-political origins and other (economic, organizational, etc.);
- extreme situations of criminogenic character;
- dependencies – tobacco smoking, alcoholism, drug addiction, gambling, internet addiction, etc.;
- social diseases and epidemics – influenza, hepatitis, tuberculosis, AIDS and others;
- dangers caused by the rapid rate of urbanization, which leads to an increase in the level of crime, air pollution, water, noise, vibration, electromagnetic pollution and other hazards.

The conflict – is a collision of opposing interests, views, sharp controversy, complications, struggle between the conflicting parties of different levels and the composition of the participants.

In order to choose the appropriate method of influence and management of the conflict, it is expedient to conduct a classification depending on the main features: the method of solution; spheres of manifestation; direction of influence; the degree of expressiveness; number of participants; disturbed needs (Table 1.2).

Table 1.2. Classification of conflicts

Sign of classification	***Types of conflicts***
Way of solving	Violent – non-violent
Sphere of manifestation	Political – social – economic – organizational
Direction of influence	Vertical – horizontal
The degree of expressiveness	Open – hidden
Number of participants	Intrapersonal – interpersonal – intergroup
Needs	Cognitive – conflicts of interests

The way to resolve conflicts involves their division into antagonistic (violent) conflicts and compromise (non-violent). **Violent(antagonistic)** conflicts represent ways of resolving contradictions by destroying the structures of all parties-conflicts or the refusal of all parties, except one, to participate in the conflict. This side is winning. **Non-violent (compromise)** conflicts allow for a number of options for solving them through mutual change in the objectives of the parties to the conflict, terms and conditions of interaction.

Spheres of manifestation of conflicts are extremely diverse: politics, economics, social relations, views and beliefs of people. Allocate political, social, economic, organizational conflicts. **Political conflicts –** collision with the division of powers, forms of struggle for power. **Social conflict** is a contradiction in the system of relations of people (groups), characterized by the growth of opposite interests, trends of social communities and individuals. Variety of social conflicts are considered conflicts in **family, labour or**

social-labour, that is, in the field of labour. This is a large group of conflicts that recently arise in our country very often in the form of strikes, pickets, speeches by large groups of workers. **Economic conflicts** represent a wide range of conflicts, which are based on contradictions between the economic interests of individuals and groups. It is a struggle for certain resources, privileges, spheres of economic influence, distribution of property, etc. These types of conflicts are distributed at different levels of management. **Organizational conflicts** are the result of hierarchical relations, the regulation of the person's activities, the application of distributive relations in the organization: the use of job descriptions, the functional attachment of rights and duties of the employee; the introduction of formal management structures; the availability of provisions for payment and assessment of labour, employee bonuses.

By influence direction there are vertical and horizontal conflicts. One of their main characteristic is the division of dimension of power, situated in opponents at the beginning of conflicting interactions. ***In vertical conflicts*** the dimension of power reduces vertically from top to bottom, this defines different starting conditions for the conflict participants: boss – subordinate, higher institution – enterprise, founder – small business. ***At horizontal conflicts*** an interaction of equivalent by dimension of existing power or hierarchic level of subject occurs: managers of the same level, specialists – between themselves, providers – consumers.

Degree of expression of conflicting oppositions assumes the allotment by the form of manifestation of hidden and open conflicts. The last are characterized by clearly expressed opponents clash: quarrels, discussions, impacts. An interaction is controlled by norms of certain situation and status of conflicting members. ***In case of hidden conflict*** external aggressive actions between conflicting sides are absent, but oblique influence are used. This happens providing that one of conflict interaction members is afraid of another, he hasn't got enough power and strength for an open struggle.

The number of participants conflict interaction devides them into intrapersonal, interpersonal, intergroup. ***Intrapersonal conflicts*** are clashes inside personalities equal in strength, but opposing motives, needs and interests. The peculiarity of this type of conflict is the choice between desire and opportunity, between the need to comply and the necessary rules. To choose the right solution in the case of intrapersonal conflict, a person can spend a lot of time and effort, and therefore, emotional tension is rapidly increasing, stress may occur, and before the decision can be made, the person's behaviour can become uncontrollable. An intrapersonal conflict can also arise as a result of the fact that the production requirements don't coincide with the personal needs or values of the employee. The complexity of solving intrapersonal conflicts is that sometimes there is a collision of the three components necessary to achieve the goal: the desire ("want"), the ability ("I can"), the need ("necessary").

Intergroup conflicts are those between different groups, units that interfere with the interests of people united during the conflict in a united cohesive community. It should be noted that this cohesion can disappear immediately after the end of the conflict, but at the time of advocating common interests, the unity of the group can be quite significant.

Interpersonal conflicts are the clash of individuals with the group, among themselves, the struggle for the interests of each of the parties. This is one of the most widespread types of conflict.

Depending on the needs expressed, there are cognitive conflicts and conflicts of interest. ***Cognitive conflict*** is a conflict of views, points of view, knowledge. In such a conflict, the purpose of each subject is to convince an opponent, to prove the correctness of his point of view, his position. ***Conflicts of interest*** can be represented as a counterbalance to the conflict cognitive, which means confrontation, based on the collision of the interests of various opponents (groups, individuals, organizations). Due to the fact that the distribution of conflicts by species seems rather conditional, there is no clear distinction between different types, and in practice there are such conflicts: organizational vertical interpersonal; horizontal open intergroup, etc.

The conflict implies awareness of the contradiction and subjective reaction to it. If a conflict arises in a society, then it is a social conflict. Any social conflict, gaining on a large scale, objectively becomes socio-political.

The most characteristic social and political dangers include conflicts at the inter-ethnic and interstate levels, spiritual oppression, political terrorism, ideological, inter-party, inter-confessional and armed conflicts, and wars. Another factor that causes tensions in relations between countries and nations is militarism, that is, policies for the pursuit of arms, the preparation and resolution of aggressive wars.

Security in the political sphere aims to protect the vital political interests of society (individuals, social strata, the community as a whole) from internal and external threats.

External threats:

- nomination of territorial claims;
- interference in internal affairs;
- use of resource and technological dependence for political pressure;
- loss of traditional markets, imperfection of economic ties;
- damage from sanctions of international organizations, other countries;
- the reorientation of society into a nation's worth for others;
- strengthening of uncontrolled migration processes, etc.

Internal threats:

- activation of separatist (desire to separate) movements in some regions;
- reduction of the combat capability of a military organization;
- inter confessional and interethnic conflicts;
- falling production, the destruction of industry;
- growth of "shadow" economy, illegal export of capital abroad, raw materials;
- a drop in the standard of living of the population;
- crisis of payments, etc.

Terrorism

Terror has become a component of modern life, has become global.

Terrorism is a form of political extremism, the use or threat of the most brutal methods of violence, including the physical destruction of people and intimidation to achieve certain goals.

The most widespread terrorist acts are:

- attacks on state or industrial objects;
- capture of state institutions or embassies;
- capture airplanes or other vehicles;
- abduction or violent acts against the victim;
- political assassinations;
- explosions and massacres designed for intimidation;
- distribution of infectious diseases.

1.4. Risk as a criterion and object of security

1.4.1. Risk as a quantitative assessment of a hazard

Risk is a quantitative assessment of the probability of a dangerous event with certain undesirable consequences.

A comprehensive risk assessment is the risk (R), which is defined as the product of the frequency of danger to the detriment that it causes

$$R = p \cdot E.$$

Risk assessment is the process of determining the likelihood of accidents or emergencies and their corresponding losses.

The probability of a risk is the frequency of manifestation of any danger.

The probability of risk (p) is defined as the ratio of the number of hazards that manifests itself with the negative consequences (n) to their possible number (N) for a specific period of time

$$p = \frac{n}{N}.$$

There is no zero risk (absolute security). There is such a thing asneglected risk is a risk that is so low that it is within the tolerances of the deviations of the natural (background) level ($R \leq 10^{-7}$).

Acceptable risk is a level of risk that society can accept (allow), taking into account technical and economic and social opportunities at this stage of its development($10^{-7} < R \leq 10^{-4}$).

Extremely permissible risk is the maximum risk that should not be exceeded, despite the expected (social, techno-economic) result ($10^{-4} < R \leq 10^{-2}$).

Excessive risk is characterized by an extremely high level, which in the vast majority of cases leads to negative consequences ($R > 10^{-2}$).

Integral risk is the total risk for the population, social, man-made and natural objects from all possible negative events of natural and man-made origin.

Risk analysis is the systematic use of available information for identifying hazards and risk identification, comparing it with acceptable risk, justifying rational protection measures.

The objects of risk, sources and effects depending on the type of risk are given in Table 1.3.

Table 1.3. Types of risks and their characteristics

Type of risk	**Object of risk**	**Source of risk**	**Consequences**
Individual	Pearson	Pearson's living conditions	Disease, injury, disability, death
Technical	Technical systems and objects	Technical imperfection, violation of rules of operation of technical systems and objects	Accident, explosion, catastrophe, fire, destruction
Ecological	Ecological systems	Anthropogenic interference in the natural environment, man-made emergencies	Anthropogenic environmental disasters, natural disasters
Social	Social groups	Emergency situation, lower quality of life	Group injuries, illness, death of people, increase in deaths
Economical	Material resources	Increased risk of production or of the environment	Increased security costs, damage from insecurity

Classification of risks:

- ***subjective*** – the risk, the consequences of which can not be objectively estimated;
- ***dynamic*** – the risk, the probability and consequences of which vary depending on the situation, for example, the risk of an economic crisis;
- ***potential territorial*** – implementation rate risk damaging factors technogenic accidents in a particular area;
- ***technical*** – the risk of the failure of technical devices with the consequences of a certain level for a certain period of operation of the PNO;
- ***acceptable*** – risk level is acceptable and reasonable based on socio-economic considerations;
- ***environment*** – the risk probability of environmental disaster, disasters, abuse further existence and proper functioning of ecological systems and facilities as a result of natural disasters or human intervention in the environment;
- ***static*** – the risk is practically unchanged over time, such as the risk of fire;
- ***objective*** – risk with precisely measurable consequences;
- ***financial*** – the risk, direct consequences of which are money losses;
- ***non-financial*** – the risk with non-monetary losses, such as loss of health, disability, life;
- ***fundamental*** – unsystematic not diversified, the risk of pervasive consequences;
- ***private*** – systematic, diversified, risk with local consequences;
- ***net*** – a risk, the consequences of which can be only damage or maintaining the current position.

Methods of risk assessment

Engineering method

Based on statistics, the incidence of PSD calculation, probabilistic safety assessment, building tree hazard, special computer programs.

Expert method

Is to use the findings of experts and specialists also can be attributed to subjective methods for determining the level of security.

Statistical

Based on the analysis of fluctuations of the studied parameters for a certain period of time. It is assumed that a test pattern changes apply to future values. For long periods of time, this tends to be fair, but for short-term evaluation of the extrapolation of former patterns makes significant mistakes. Therefore, simple extrapolation of strategic laws doesn't allow realistically to assess risk.

Model

Based on the construction of models preconditions events in the system with the influence of harmful factors at the individual, social, professional groups, etc. Based on constructing a model of the impact of hazards on an individual.

Normative

There are very convenient in practice. Its positive feature is the ease of calculations. The system of standards can be considered as one of the options of the rating method with the difference that the scale of assessment is pre-formed and consists of a minimum of values of the ranking.

Normative method of estimation allows to determine the degree of risk with the maximum accuracy: comparison with the norm occurs on the scale "low risk", "normal risk", "high risk". But this method doesn't allow for taking into account all the nuances of a particular situation.

Sociological

Based on a system of methodological, methodical, organizational and technical measures linked sole purpose: to obtain reliable data on the phenomenon or process being studied for their subsequent use to reduce the danger to human life.

Analogue

Based on the use and comparison of hazards and risk factors that occurred in similar circumstances and situations.

1.4.2. Individual and group risk

Individual risk is the probability of hitting the individual over time as a result of influence of factors of danger in the implementation of adverse events based random probability of its presence in the affected area.

Individual risk R_i characterizes the realization of the danger of a certain type for a particular person, as well as the distribution of risk in time and space

$$R_i = L\frac{P}{f},$$

where P – the number of victims (dead) per unit time t from a certain risk factor f;

L – the number of people who are prone to the appropriate risk factor per unit time t.

In determining the individual risk, it is necessary to take into account the proportion of time spent in the "risk zone" and the permanent residence of the person (Table 1.4.).

Table 1.4. Sources and factors of individual risks

Source of individual risk	**The most common risk factor for death**
internal environment of the human body	hereditary genetic, psychosomatic diseases, aging
victimization	a set of personal qualities of man as the victim of potential dangers
habits	smoking, drinking alcohol, drugs, irrational nutrition
social ecology	low-grade air, water, food; viral infections, trauma, domestic fires
professional activities	dangerous and harmful production factors
transport	accidents and catastrophes of vehicles, their collision with a person
unprofessional activities	hazards caused by amateur sports, tourism and other hobbies
social environment	armed conflict, crime, suicide, murder
environment	earthquake, natural disasters

Individual risk is divided into categories: household; professional; voluntary, forced. Individual risk can be voluntary, if it is due to human activity on a voluntary basis, and forced if a person is at risk in a part of society (for example, living in environmentally unfriendly regions, near sources of high danger).

A comparison of the individual risks of deaths in the United States and Ukraine is presented in Table 1.5.

Individual risk doesn't allow us to judge the scale of the disaster, so the concept of group (social) risk is introduced.

Table 1.5. Comparison of individual risks of deaths in the United States and Ukraine

Country	**Factors of Risks**					
	Transport	**Poisoning**	**Drowning**	**Fire**	**Electricity**	**All the factors**
USA	$3{,}2 \times 10^{-4}$	2×10^{-5}	3×10^{-5}	4×10^{-5}	6×10^{-6}	6×10^{-4}
Ukraine	$1{,}6 \times 10^{-4}$	31×10^{-5}	9×10^{-5}	3×10^{-5}	20×10^{-6}	$15{,}6 \times 10^{-4}$

Group or social risk is the relationship between the frequency of events (accidents, catastrophes, natural disasters) and the number of people affected, characterizes the magnitude and severity of the negative consequences of emergencies, as well as various phenomena and transformations that reduce the quality of life of people.

Social risk, in contrast to the individual, characterizes the scale of catastrophic hazards.

Perception of the risk of human dangers subjectively. Every day in a production dies from 40 to 50 people, and in general in the country from various dangers lose more than 1,000 lives. But these data are less impressive than the death of 5–10 people in one accident or some kind of conflict. The most common social risk factors depending on the source are given in Table 1.5.

It is believed that ***if the state does not take any measures to reduce the level of risk that can be observed, then this risk is socially feasible.*** The criterion of admissibility may be allocations allocated for health and safety of people (labour protection, emergency and rescue service, etc.).

If the population of the country increases and the allocations for the specified purposes also increase in proportion to the population, then the risk of death of people in this country is considered socially permissible.

The assessment of group, or social risk, can be, for example, by the dynamics of mortality, calculated on 1000 persons of the corresponding group.

1.4.3. The concept of acceptable risk

The modern world has rejected the concept of absolute security. To date, the concept of ***accepted (admissible) risk*** has been developed and applied, the essence of which is the desire to provide such a degree of security that is perceived by society at this time.

Acceptable risk combines technical, economic, social and political aspects and represents a certain compromise between the level of security and the opportunities to achieve it.

Table 1.6. Sources and factors of social risk

Source of social risk	The most common factors of social risk
Urbanization of environmentallyfragile areas	Settlement of people in zones of possible flooding, landslides, landscapes, volcano eruptions, increased seismicity of the region
Industrial technologies and high-risk objects	Accidents at NPPs, TPPs, chemical combines; transport accidents; technogenic pollution of the environment
Social and military conflicts	Fighting action; the use of weapons of mass destruction
Epidemics, pandemics	The spread of infections
Reduced quality of life	Hunger, poverty; poor living conditions; insufficient and poor quality food; deterioration of health services

We must bear in mind that economic opportunities for improving the safety of technical systems are not unlimited. Spending money on improving safety, can cause damage to the social sector, for example, reduce the cost of healthcare, culture and so on., Increasing social and economic risks. With increasing costs technical risk is reduced, but social growth. The total risk is at least some correlation between investment in technical and social sphere.

These circumstances must be considered when choosing a risk that society is forced to accept.

Figure 1.6 shows a graph illustrating a simplified example of determining acceptable risk. From this graph, it is evident that with increasing costs of technical systems security in the conditions of limited funds, technical risk decreases, but socio-economic increases as the amount of funds coming to this sphere decreases. Spending excessive funds to increase the safety of technical systems under the specified conditions can cause damage to the social sphere, for example, worsen medical care, reduce assistance for the elderly, children, the disabled, etc.

As shown in Fig. 1.5, there is an optimal amount of funds that should be invested in the technical security system and which provides the minimum value of the individual risk factor. The area shown on the chart as a "zone of acceptable risk" is optimal to ensure minimum risk. The risk to human activity increases to the left and to the right of this site. On the left, the high coefficient of individual risk is due to the imperfection of the technical system, and to the right – due to the low level of socioeconomic security.

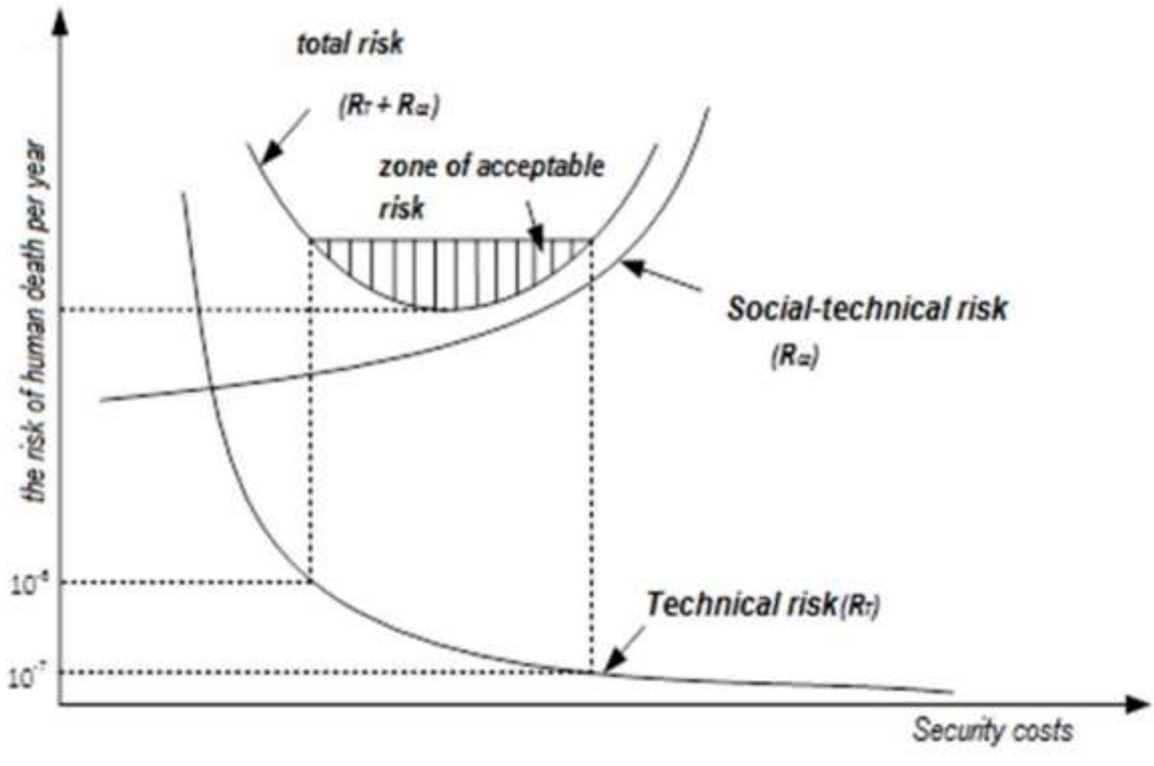


Fig. 1.5. Determination of acceptable risk

Full security can not be guaranteed to anyone, regardless of lifestyle. When the risk is lower than 10–6 per year, the public does not express an excessive concern, and therefore rarely take special measures to reduce the risk. The individual risk of death is 10–8 per year rather small.

It is believed that modern technical systems of high energy power should have the influence of dangerous factors on a person at the level of 10–6 – 10–8 per year and less with all types of influence on the system (failure of technology, errors of the performer, spontaneous phenomena). Such is a concept of acceptable risk. Some experts criticize it, seeing in it an inhumane approach to the problem. In fact, acceptable risks are 2–3 orders of magnitude more severe than actual ones. Consequently, the introduction of acceptable risks is an action aimed at protecting a person.

1.4.4. Levels of risk

In order to determine the severity of the risk, there are different criteria.

The categories of seriousness of hazards establish the quantitative significance of the relative seriousness of the probable consequences of hazardous conditions.

The use of the danger category is very useful in determining the relative importance of using preventive measures to ensure the safety of life when used for certain conditions or system damage (Table 1.7).

Table 1.7. The types and categories of seriousness of dangers

Type	Category	Description of accident
Catastrophic	IV	Death or destruction of the system
Critical	III	Serious injury, persistent disease, significant damage to the system
Marginal	II	Minor injury, short-term illness, damage to the system
Insignificant	I	Less important than category III injuries, diseases, damage to the system

The levels of probability of danger are a qualitative reflection of the relative probability of an unwanted event occurring as a result of an unsolved or uncontrolled danger.

Based on the higher likelihood of the danger of any system, we can draw a conclusion on the specific types of human activity.

Levels of probability of danger are presented in Table 1.8.

Table 1.8. Levels of probability of danger

Type	**Level**	**Description of consequences**
Frequently	A	It is highly probable that the event will take place
Probable	B	It can happen several times in a life cycle
Possible	C	Sometimes it can happen for a life cycle
Rare	D	Unlikely but possible event throughout the life cycle
Virtually incredible	E	It is unlikely that we can assume that such a danger will never happen

Using the methods of determining the severity and probability of danger at the same time, it is possible to determine, to study the dangers, to attribute them to a certain class and to solve them.

By setting up an alphanumeric risk assessment system for each category of severity and each level of probability, you can deeper classify and evaluate the risk of the degree of acceptability. The use of such a matrix facilitates risk assessment (Table 1.9).

Table 1.9. Classification and assessment of risk according to the degree of admissibility

Frequency with which an event occurs	**Danger category**			
	IV Catastrophic	III Critical	II Boundary	I Negligible
(A) Often	4A	3A	2A	1A
(B) Probably	4B	3B	2B	1B
(C) Maybe	4C	3C	2C	1C
(D) Rarely	4D	3D	2D	1D
(E) It is practically impossible	4E	3E	2E	1E

Table 1.9 continuation

Hazard risk index	
Risk Classification	Risk Criteria
4A, 4B, 4C, 3A, 3B, 2A	Invalid (excessive)
4D, 3C, 3D, 2B, 2C	Undesirable (maximum permissible)
4E, 3E, 2D, 2E, 1A, 1B	Acceptable with validation (acceptable)
1C, 1D, 1E	Acceptable without validation (neglected)

1.4.5. Management of the identified risk

The main issue of the theory and practice of safety of life is the issue of raising the level of safety.

Risk management is an early detection of risk-related hazards and the introduction of effective risk mitigation measures through targeted change in negative factors, taking into account the effectiveness of the measures taken (Figure 1.6).

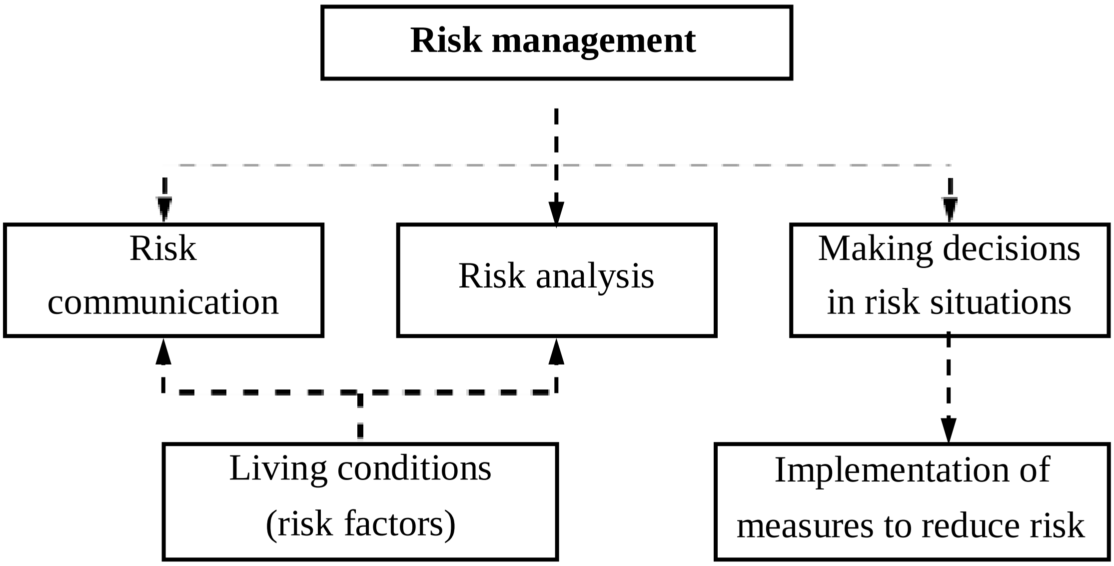


Fig. 1.6. Risk management

In order to give preference to concrete measures and means or a certain complex of them, compare costs of these measures and means and the level of harm reduction that is expected as a result of their introduction.

Such an approach to reducing the risk of danger is to manage the identified risk.

The concept of risk management

The concept of risk management of man-made and natural emergencies, adopted by the Cabinet of Ministers of Ukraine Order No. 37-r of January 22, 2014, states that when determining the levels of acceptable risks, the significance of risks used in economically developed countries is applied, namely:

- the minimum risk is less or equal to 1 · 10–8;
- the maximum permissible risk – which is equal to 1 · 10–5;
- the risk, the value of which is lower than or equal to the minimum, is considered absolutely acceptable, and the risk, the value of which is more than the maximum permissible, is considered totally unacceptable.

If the identified danger cannot be completely eliminated, it is necessary to reduce the probability of risk to an acceptable level by choosing the appropriate solution. It is possible to achieve this goal, as a rule, in any system or situation in several ways. Such paths, for example, are:

- complete or partial refusal of works, operations and systems that are of high degree of danger;
- improvement of technical systems and objects;
- improvement and introduction of new technologies;
- use of new materials and substances;
- development and use of special means of protection;
- organizational and managerial measures, including: monitoring security, training people on security issues, promoting safe work and behaviour.

The significance of the maximum permissible risk set by the Concept of risk management for emergencies of anthropogenic and natural nature, less than the risk of mortality in life and the risk of death in production in our country, therefore, in order to implement this Concept, a plan of measures for 2015–2020 has been developed. This plan provides for:

- analysis of existing regulatory and legal acts in the field of technogenic and natural safety and elaboration of proposals to amend them taking into account the provisions of the Concept;
- development and adoption of national standards in the field of risk management that meet international standards in this area;

- development of the provision on the organization of risk management;
- development of sectoral normative documents on the application of risk-oriented approaches in the conduct of activities on safety issues in the field of production;
- development of methodology for risk assessment and risk maps for certain types of emergencies;
- development of recommendations on the application of risk assessment methods, standards and programs;
- definition of acceptable levels of risk, high, medium and low risk ranges in the manufacturing sectors and their reduction algorithms to the levels used in economically developed countries;
- analysis of the state of technogenic and natural safety in Ukraine and on the basis of its results of regionalization of territories taking into account the presence of potentially dangerous objects and dangerous geological, hydrogeological and meteorological phenomena and processes, as well as risks associated with such phenomena and processes;
- development of a complex of economic mechanisms of state regulation in the field of risk management, including those that will include the introduction of a system of compulsory insurance against risks.

The concept of risk management can be effectively applied to any sphere of activity, industry, enterprises, organizations.

1.5. Ensuring safety of life

1.5.1. General model of safety of life at work and at home

Provision of BC is the creation of such conditions of a person's rights (social group, society), when the risk of manifestation of any danger does not exceed the corresponding established level.

Ensuring security in all cases of ***manifestation of danger*** should be subject to well-ordered laws, which form the methodological basis of the BCC model. Its essence lies in the clarification of the tasks given in Fig. 1.7.

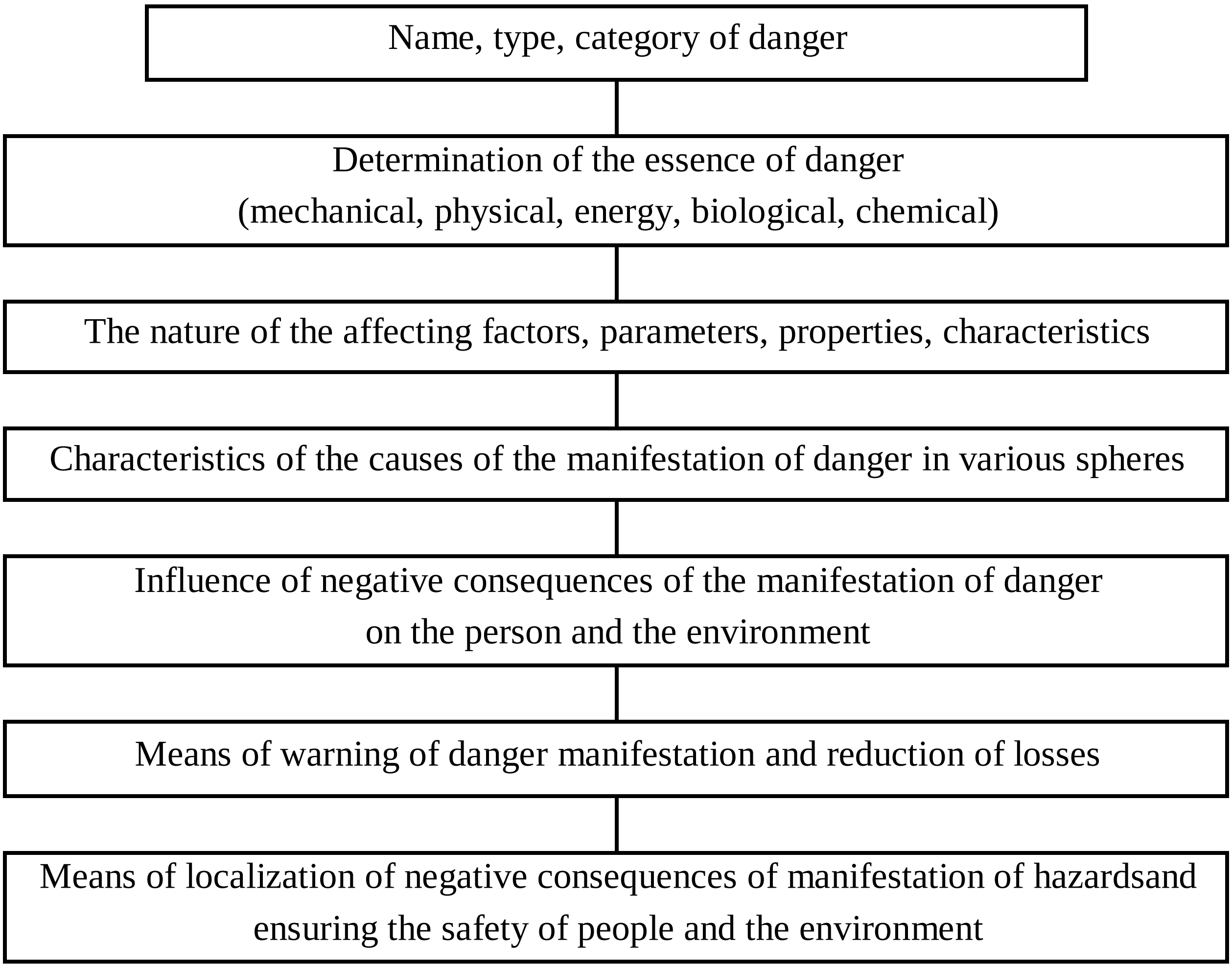


Fig. 1.7. Challenges for BC

Barriers to ***prevention and protection*** are important in ensuring human security – these are measures and means aimed at protecting the human's system of human life from external and internal dangers.

Conditional barriers can be divided into three major categories:

- physiological barriers of the human body;
- natural barriers to the protection of the biosphere;
- artificial barriers to the protection of the environment and human dignity.

Physiological barriers of the human body

It is known that a person is a complicated self-regulating system that, depending on the situation, can flexibly use its capabilities to achieve the goal, while avoiding the dangers. It manages all functions of the nervous system of the body, which has a lower and higher form of nervous activity.

The lower form of nervous activity regulates the internal state of the body at the level of reflexes. Their forms are programmed genetically and transmitted inherited. The higher form of nervous activity provides the expedient behaviour of the organism in connection with changes in the environment. Adaptive reactions carried out by the highest form of nervous activity are the consequences of individual learning.

A person's life takes place in the workplace where it is implementing its labour activity, or in the everyday sphere where people live or spend their non-working hours.

The following tasks are assigned to the subsystem of BC production:

- achievement of accident-free;
- prevention of occupational diseases;
- prevention of injuries;
- provision of health and working capacity of workers;
- increase of labour efficiency due to its safety;
- prevention of pollution of the environment.

Actual work safety is due to two generalized factors:

- resultant industrial hazard;
- the resultant protection of a person from this danger.

Under ***protection*** is understood the ability of a person not only to withstand industrial hazards, but also to not provoke his activities to manifest these dangers. Detailed assessment and safe working conditions are discussed in Section 2.

Subsystem of maintenance of BC in the home solves the following tasks:

- to prevent the occurrence of pollution of the environment by living in domestic, industrial and other wastes;
- to prevent injuries of people in everyday life;
- to control the quality of goods, products and beverages consumed by the population;
- to work on ensuring the safety of people in the places of cultural events;
- to create comfortable and safe conditions in residential houses and places of rest;

- to ensure the safety of people's movement by any type of transport;
- to create conditions for the uninterrupted operation of emergency services (112 – emergency services, 101 – fire protection, 102 – police, 103 – emergency medical aid, 104 – emergency gas service);
- to conduct preventive and explanatory work among the population in order to prevent accidents, etc.

To ensure the fulfillment of these tasks, appropriate **means and measures** are used.

Means **–** a device, an instrument for carrying out any activity.

The event **–** a method, an action used in the performance of any work or the realization of any activity.

Means and measures are closely interconnected and implemented one by one.

There are a lot of means and measures of safety in the production and domestic spheres. They, as principles and methods, are the logical stages of security. Their choice depends on the specific conditions of activity and everyday life, the level of safety, stability and other criteria. Due to the large number of tools and measures for today, there is no clear classification of these basic concepts. However, existing protective structures (e.g., civil defense, occupational safety, etc.) have real personal protective equipment (PPE) and collective defense (HR), which in turn are subdivided into subgroups depending on the nature of the danger, the design, the purpose, etc.

1.5.2. Main directions of life safety

If it is known what threats the person threatens, one can develop the ***main directions of safety of life.***

1. Ensuring natural safety

Ensuring natural safety requires:

- to develop environmental laws and to strictly monitor their implementation;
- constantly monitor the natural hazards;
- to conduct environmental land-use and mineral products;
- it is enough to finance activities aimed at protecting the natural environment;

- to take preventive measures in a timely manner to prevent the emergence and development of epidemics, epizootics, epiphytotism;
- to prevent industrial and other emissions from the reservoirs and the atmosphere without the use of treatment facilities;
- use mineral fertilizers and pesticides in a timely and appropriate quantity;
- to preserve greenery from unreasonable felling and to make new green plantations (including forest protection strips).

2. Provision of technological safety

Providing of technological safety is possible if:

- a set of measures (legal, socio-economic, political, organizational, technical, sanitary and hygienic) is being prepared and implemented, aimed at carrying out an assessment of the levels of risk, an early response to the threat of an emergency;
- the monitoring of the possible course of events is conducted in order to prevent their emergence in an emergency or mitigate its possible consequences;
- the identification and registration of high-risk objects is constantly maintained;
- declarations of safety of potentially dangerous objects are prepared (see Appendix 1);
- controlled materials, substances used in the production and domestic environment and can be dangerous for people's life and health;
- the conditions of the technological process and the rules of operation, especially in dealing with dangerous substances and materials, are strictly fulfilled;
- the use of permanently withdrawn imperfect and insufficiently reliable home appliances and appliances, vehicles, and other;
- the technical condition of buildings, buildings, structures, roads, vehicles, etc. is constantly checked;
- monitoring of safety of medical products, equipment and means of inspection;
- safety and compliance with food and beverage standards are checked.

3. Ensuring socio-political security

Ensuring socio-political security implies:

– availability of the relevant legislative and legal framework for human security;

– settlement of armed conflicts through peace talks;

– an international struggle against any manifestations of terrorism and extremism;

– compulsory liability for criminal acts;

– prevention of social dangers in society;

– adequate financing of protective social programs;

– Economic and political stability in the state.

Further, let’s take a closer look at the most relevant and widespread threats to this area that people can face in the modern world.

Influence of modern information technologies on human and society safety

The dangers of modern information technologies include cyber-security (information and psychological impact on a person in order to change his behaviuor, the use of personal data, information warfare, viral attacks at all levels of society) and computer dependence.

Modern information technology has long ceased to be an attribute of only the scientific and technical sphere. They became an integral part of the everyday culture of society. But on the contrary, there are disadvantages and dangers of such an era. Yes, social networks are the easiest way to find information about a person using photos, posts that people place on their page and it may be dangerous to them. If before the intelligence services collected information about people, wasting time and strength, now it has become much easier because the person himself tells everything about himself. But not everyone does it, there are people who deliberately do not use social networks or use it exclusively as a way of communication (chat, audio, video communication).

Also, some online games may be dangerous, especially for teenagers, which is very much said and written.

But the most dangerous is an information warfare, when information is not specifically given. Purposeful informational and psychological impact on a person with a view to changing his behaviour is known from ancient times. We, unwittingly, witnessed such a war and our own experience, realized the value of information, how easily it is possible to disinform people who listen to radio, watch television, read newspapers.

Through the information war, many people quarreled, hated each other and began to insult each other, but the worst thing is that everyone thinks that it is OH! is right in this situation. Such an opinion leads to chaos and impossibility of order. The only way to not get lost in this chaos is to get information from several sources (even foreign ones, if there is such an opportunity) and to analyse the reading, maybe something is a fabrication of journalists in order to make a sensation, and perhaps indeed, the news is true.

Information security characterizes the state of security in the information sphere of interests of the individual, society and the state. Therefore, ensuring information security is no less important than ensuring fire safety, ensuring road safety. In order to combat this kind of crime in Ukraine, a cyber police – a state organization for fighting cybercrime – appeared in Ukraine.

The task of the cyber police:

- “household” online fraud;
- more serious viral attacks in banking and payment spheres;
- the fight against illegal and prohibited content;
- the field of cyber security and the appropriate interaction with the police in criminal proceedings of general criminal nature.

The increase in the number of personal computer users, including those who joined the Internet, the spread of various computer programs – all this has led to a new problem – computer dependence: the psycho-physiological and socio-psychological impact of new information technologies on the personality of man and his health.

In 1996, in the American Classification of Mental Disorders (DSM), a new section – “cybernetic disorders” – appeared, and some experts began to talk about Internet addiction syndrome. In general, if earlier the problem “computer-man” was considered mainly within engineering psychology, now it is studied by specialists from general, medical, social, age and pedagogical psychology, etc.

In particular, this problem was one of the central among those debated at the VII European Congress on Psychology (2001). In modern psychological science there are several areas of research on the problem of “man-computer”: the psychology of virtual reality, psychology of communication on the Internet, psychological peculiarities of computer perception, psychological peculiarities of different categories of programmers, psychological impact of computer games and other activities on Computer.

One of the most urgent aspects of the problem is the interconnection of computer programs (especially gaming) with the level of aggressiveness and aggressive behaviour of computer users. This problem is due to the fact that some computer programs contain a hidden or obviously aggressive plot. The results of empirical studies indicate that in many subjects who played virtual waves, there was an increase in physiological excitation and aggressiveness of thoughts.

In the conditions of the prevalence and availability of computers and the Internet, there was a sharp jump in the number of people with uncontrolled attraction to them. From 5 to 14 % of people using the Internet suffer from computer dependence. Often, these are teens and young people.

An important feature of the dependent behaviour of young people is the possibility of an easy transition from one destructive habit to another, that is, the desire to get out of reality by artificially changing its mental state by taking some substances or permanently fixing attention to certain activities in order to develop and maintain intense emotions.

In the structure of computer dependence, there are 5 types: obsessive surfing (trip online, search information from databases and search sites); passion for online stock trading; virtual dating without the desire to translate them into reality; cyber sex (capture porn sites); computer games.

Psychological symptoms of computer dependence:

- a good state of health for the computer unlike the previous state or even euphoria;

- impossibility to stop, an increase in the amount of time spent on a computer;
- disrespect for parents and friends;
- a feeling of emptiness, depression, irritability during the period of reduction or discontinuation of the use of the Internet;
- providing false information to employers or family members about their activities;
- a problem with work or study, the use of the Internet as a way to escape from problems or relieve heavy emotions (feelings of helplessness, fury, anxiety, depression).

Physical Symptoms of Computer Dependence:

- carpal tunnel syndrome (tunnel defeat of the nerve trunks of the hand associated with prolonged muscular tension);
- dryness in the eyes;
- headache type of migraine;
- back pain;
- irregular nutrition;
- disregard for personal hygiene;
- sleep disturbance, change in sleep mode.

Formation of computer dependency takes place in three stages:

The first is the stage of the risk of developing a computer dependence. The main characteristics are an increase in the time spent to achieve the goal and work on the computer, a loss of a sense of time, the reception of emotional satisfaction by the computer, the consumption of more money for computer activities, the first signs of social maladaptation.

The second stage of *the formed computer dependence*. The main features are emotional and volitional disturbances and psychological dependence. There is an increase in computer tolerance, obsessive thoughts about it and fantasy. There is a deactualization of the main problems – sleep, rest, eating, personal hygiene. Violated modes “sleep-vigil” and “rest-load”, while working on a computer – not only daytime, but also night. The activities of the computer are carried out at the expense of learning, work, social and personal relationships. On the one hand, Internet dependent fully oriented in computer technology, on the other hand – there is a peculiar form of infantilism, almost complete helplessness in the world of social norms and relationships.

The third stage of total computer dependence. There are signs of both mental and physical dependence. There are unsuccessful attempts to control the work of the computer. In the structure of the syndrome, the actualization of the compulsive traction is dominated by aggressiveness, anger, psycho-motor disturbance, depressive phenomena, scattered attention, involuntary "typing movements" of the fingers. Probably a demonstration-blackmail suicidal behaviour when trying to prevent others from interfering with computer activities. At this stage, there are physical symptoms. There is a social and family disadaptation.

Personal Cybersecurity Compliance Rules:

- Tell your close ones where you are and when you are at home so that they can't cheat the scammers;
- Do not tell anyone your personal data;
- Learn languages in order to be able to receive information from various sources about the news you are interested in;
- Learn to analyse what you saw and hear; the best simulator is reading books;
- Do not post all information about yourself on social networks, it shows that you do not have a live communication and need it; such a person is the best sacrifice for criminals;
- Do not succumb to emotions when you hear some news, emotions prevent you from clearly seeing and evaluating the situation.

Harmful habits, social diseases and their prevention

Harmful habits are a number harmful to the human body habits. They cause a person's dependence on one or another substance that it uses and prevents a person from developing both mentally and physically. Among these habits are some of the most harmful – it's alcoholism, tobacco smoking, drug addiction and substance abuse.

Alcoholism is a social disaster and a terrible disease, which, in distribution among the population, ranks third, second only to cardiovascular and cancer.

Stages of development of alcoholism have a certain regularity. The first method causes a protective reaction – because the body has taken poison. This may be nausea, vomiting, headache, dizziness, and so on. There are no pleasant feelings in this case. However, when repeated drinking of alcohol comes the euphoria, and the protective reaction gradually weakens. Over time, the state of euphoria becomes a human need, and it can no longer dispense with alcoholic beverages.

Due to the repeated use of alcohol, the dependence on it is constantly increasing, in the absence of alcohol, a person begins to experience a painful condition that is very difficult to tolerate. Sharply reduced efficiency, headache, trembling limbs, frostbite, are characteristic symptoms of abstinent syndrome (alcohol hangover). In this state, it is best to relieve the headache of repeated drinking, which only affects the dependence of a person from him. Gradually, this addiction turns into an irresistible train immediately, as soon as possible find and take alcohol.

Like nicotine, alcohol is a drug that is quickly becoming accustomed to and not content with small doses.

In our body there is no body in which alcohol does not act negatively. Alcohol consumed in the oral cavity, further – in the digestive system: in the stomach – about 20 %, in the intestine – about 80 %. Already after 5 minutes after drinking alcohol is detected in the blood, and after 2 hours it is completely absorbed into the bloodstream.

If the concentration of alcohol in the blood take 100 %, then in the liver its concentration is 148 %, in the cerebrospinal fluid – 150 %, in the brain – 175 %.

About 10 % of drinking alcohol is excreted from the body with exhaled air and urine. The bulk of alcohol is neutralized in the liver, but it is released from the body very slowly for up to 2–3 weeks. Taking part in the disinfection of alcohol, the liver itself experiences its harmful effects. Alcohol causes inflammatory reaction in liver cells, there is a partial replacement of dense connective tissue scars. In the brain, alcohol is stored for up to 90 days. Alcohol has a very negative effect on the central nervous system of a person, even in moderate doses, reducing the efficiency by 16–17 %.

People who abuse alcohol are more likely to suffer, tolerate shortages of work, are more likely to be exposed to various dangers: alcohol abuse is the cause of 20 % of household and 456 % of street injuries, because of the fault of drunken drivers there are 72.5 % of accidents, 96 % of offenses committed in the state of alcohol intoxication.

Tobacco smoking. The danger of smoking has both purely medical and socio-economic aspects. To grow tobacco, the best land in the most favorable climatic conditions is used. All of them could be used to grow crops that are useful to humans. It is estimated that to dry a tobacco leaf, sufficient for the manufacture of 300 cigarettes, it is necessary to cut down one large tree.

To remove odors from tobacco, the tobacco industry uses expensive and scarce substances and foods: geranium oil, nutmeg infusion, Peruvian balm, aniseed oil, nutmeg butter, repermint oil, lemon essence, bergamot oil, natural honey, vanillin, arovaniline, roman essence, and so on.

Tobacco business invests significant resources in advertising its products, only cash costs are estimated at hundreds of billions of dollars.

Tobacco smoking is one of the main causes of premature death that can be prevented. Tobacco is a risk factor for more than 25 diseases. Tobacco smoke (depending on quality, grade and content of tobacco additives) contains up to 4200 different components. Harmful substances that are part of tobacco smoke, it is expedient to divide into 3 groups:

- poisonous action – nicotine, hydrocyanic acid, carbon monoxide, ammonia;
- carcinogenic action – benzopyrene, polonium-210, lead-210, bismuth-210;
- defeat of the pulmonary surface – tobacco tar (a mixture of vegetable *resins).*

A lethal for an adult is a dose of one-time use of nicotine in the amount of 50–60 grams.

After smoking even one cigarette, the following violations of the psycho-physiological functions of the smoker are observed:

- narrowing the field of vision;
- disturbing perception of colors, especially – red and green;
- falls to 20 % of the perception of visual information;
- decreases by 25 % speed of motor reactions;
- the severity of hearing in the range of spoken language is reduced.

Physical and psychological dependence on nicotine develops much faster than alcohol. Unlike alcoholism and drug addiction, tobacco addiction does not lead to personality degradation. But smoking is a dangerous disease that destroys human health and reduces its life. According to WHO, the risk of premature death due to illnesses caused by smoking in the structure of lethal domestic risks ranks first.

Numbers and facts about smoking:

- WHO estimates that about a third of the world's adult population (including 200 million women) smoke;
- every year in the world of tobacco causes 3.5 million deaths, or 1000 – every day;
- according to forecasts, global tobacco "epidemic" will take away the life of 250 million modern children and adolescents.

Characteristically, there are two trends: a decrease in smoking in developed countries and an increase in the backward. So, in the USA over the last years more than 30 million people have been quit smoking. Currently, the United States smokes only a quarter of the adult population. At the same time, in the lagging countries over the past 25 years, the number of smokers is increasing, which experts estimate will lead to the death of more than 7 million people in the next 20–30 years annually from illnesses associated with smoking.

In Ukraine, about 40 % of the working-age population is smoked – this is one of the highest rates in Europe. An adult smoker in Ukraine smokes an average of 1,650 cigarettes for 1 year.

Recently, the international community, protecting non-smokers, is taking energetic measures: it is forbidden to smoke in public places (in restaurants, cafes, bars, cinemas), in transport (on airplanes, railway cars), at work.

The fight against smoking is based on three basic principles:

- to produce in people, especially adolescents and young people, a firm belief that smoking is harmful, it causes irreparable damage to health and does not need to start smoking;
- administrative measures to restrict and ban smoking in public places;
- reduction of the number of smokers due to awareness of their harmful effects.

Drug (from the Greek τοναρκωτικό – stunning) is a substance of plant (opium, cocaine, morphine) or synthetic origin, which, when it enters the body, excite or suppresses the central nervous system, and as a result of multiple use leads to mental or physical dependence.

The beneficial effect of narcotic substances is their analgesic effect: in the absence of such substances it would be impossible to perform complex surgical operations.

Drug addiction is an irresistible painful attraction to the use of drugs for the purpose of excitation, intoxication; severe illness, which leads to disruption of life, deep nervous-psychiatric disorders, personality degradation, disability and death.

Today, drug addiction is a global problem, it is present on all continents and shows a tendency towards unshakable growth. The WHO team of experts identified drug addiction as "the state of episodic or chronic poisoning caused by multiple drug injections". The WHO Expert Committee distinguishes between drug addiction as a condition of two states – dependence and addiction.

From the psychopharmacological point of view, drugs can be divided into three large groups:

– drugs that suppress the activity of the central nervous system (opiates, barbiturates);

– drugs that stimulate the activities of the central nervous system (amphetamines, cocaine, hashish);

– drugs that cause hallucinations (marijuana, nutmeg, LSD, mescaline, psilocybin).

In most drug addicts, personality changes are quickly detected: more than half of them experience memory impairment and decreased intelligence, and 71 % noticeable loss of moral and ethical qualities, degradation.

In purely psychological terms, the main cause of human passion for narcotic substances is the desire to relieve stress and anxiety, to escape from the problems that surround a person in everyday life. The drug trafficking is quickly becoming a habit for people of weak will, people who are mentally unbalanced, prone to artificially lifting their spirits and working capacity. In Ukraine there are about 450 thousand drug addicts, of which two thirds are HIV-infected.

There are three main clinical manifestations associated with drug use:

- mental dependence when a person needs drugs to maintain his lifestyle;
- physical dependence, when the drug becomes part of the metabolism and the body can not do without it physically: stopping the use of the drug at this stage of addiction, the drug addict suffers physical suffering (this condition is called a withdrawal syndrome in medicine, and in life – a “break”);
- increased drug tolerance (tolerance) when it grows ever more and more, requiring new and new means to purchase it.

With the constant use of drugs, there is a chronic narcotic poisoning, which causes disorder of many systems of the body, first of all – the central nervous system.

The diagnosis of “addiction” is posed when the disease is a consequence of the use of substances included in the official list of narcotic drugs. Otherwise, they are diagnosed with “substance abuse”. These two illnesses are equally dangerous.

Drug addicts are the most dangerous risk group for AIDS (among AIDS patients, 70 % are drug addicts). This is due both to the injection of drugs and to the risk of mentally inadequate behaviour in various life situations, including sexual ones.

In Ukraine there is a criminal responsibility for the use, production, storage and sale of narcotic substances, as well as involvement in their use.

Social diseases – a human disease, the emergence and distribution of which is mainly associated with unfavorable socio-economic conditions (sexually transmitted diseases, AIDS, tuberculosis, hepatitis, etc.).

In recent years, the situation with regard to the incidence of sexually transmitted diseases has deteriorated sharply in Ukraine. According to the international classification of WHO, today there are about 30 sexually transmitted diseases. This category includes several groups:

- bacterial – syphilis, gonorrhea, as well as various urethritis, bacterial vaginosis;
- viral – genital herpes, AIDS, viral genital warts, etc.;
- parasitic – scabies, etc. optimal conditions for transmission are created by sexual contacts;
- fungal – genital warts, etc. can occur without infection, but as a consequence of antibiotic therapy, but transmitted and sexually transmitted.

Taking into account the difficult situation in Ukraine with regard to the spread of these diseases, it should be noted that prevention is important, in particular: accidental connections, condoms, and hygiene rules should be avoided.

Corruption and criminalization of society

Corruption is a complex social phenomenon that negatively affects all aspects of the political and socio-economic development of society and the state.

The Law of Ukraine "On Preventionof Corruption" [2] provides the following wording: *"... Corruption refers to the activities of persons authorized to perform state functions aimed at the illegal use of material goods, services, benefits or other benefits".*

Corruption in Ukraine has become one of the threats to national security. In essence, in a society there are two subsystems – official and informal, practically equal in their influence. Society and the state as a whole are affected by negative corruption, it undermines the economic foundations of the state, blocks the arrival of foreign investment, provokes distrust of the population to the authorities. Corruption negatively affects the international image of Ukraine, leads to “shadowing” of the economy, promotes the growth of the influence of organized criminal groups.

Crime as a Danger

Crime – a relatively massive, historically changing, social and criminal phenomenon, which represents a coherent set of all crimes committed in a certain territory for the appropriate period of time. This is another acute social problem of our time. The number of crimes recorded in the world on average increases by 5 % every year. But in recent years, the proportion of those belonging to the category of serious (murder, violence, etc.) has increased especially rapidly. The most severe penalties provided for in the Criminal Code of Ukraine are set for murder and rape [3].

In the conditions of the crime situation in our country, the issue of personal security concerns every citizen, because everyone can become a victim of a crime. An effective remedy against encroachments on personality is self-defense. Taking into account the complex criminal situation in Ukraine, every one of her people should be able to protect themselves in situations involving violence.

The following technical means are allowed for self-defense in Ukraine:

Noise gun. Action: A copy of the military weapon acts psychologically, creating the effect of a shot. Anyone can be at the age of 18 (to have a passport with you). Price: from 1 600 UAH.

Gas cartridges (Teren-1, Teren-4, Chance-1). Action: affects the mucous membrane, respiratory tract, causes coughing, heartburn in the nasopharynx, discharge from the nose, nausea, tearing. Treatment is not needed, the listed manifestations pass independently in 10–15 minutes. Anyone can be at the age of 18 (to have a passport with you). Price: within 50–160 UAH.

Gas gun. Action: Effect, like from a gas cartridge, but more powerful. Can be purchased by anyone in the possession of a permit issued by the law enforcement agencies to persons under the age of eighteen and meet the relevant requirements (according to the certificate) regarding the health status. Price: within the limits of 230–2 000 UAH.

Pistol with rubber bullets. Action: traumatic action (there are hematomas), it is not recommended to shoot in a person from a distance closer than 4 meters. It is possible to buy journalists, employees of the Ministry of Internal Affairs, military, lawyers, judges, lawyers in the presence of permits. Price : from 8 000 to 36 000 UAH.

Pneumatic gun. Action: Causes severe pain when it reaches the open areas of the body. Anyone can be at the age of 18 (to have a passport with you). Price: from 1 500 to 4 000 UAH.

An extremely effective means of self-defense is the autonomous signaling devices, their application is very simple: pull the dart – key chain, bag or diplomat begin to produce such loud and dazzling sounds that any attacker will be afraid to deal with you further without attracting general attention. Such a signal device is designed for 1 or 2 hours of continuous crying, and shutting it off without knowing the secret is practically impossible. The tool is considered to be quite safe. The only caveat – the power of the sound pressure should not exceed 80 decibels.

By resorting to any form of self-defense, one must always be aimed at victory, act confidently and resolutely. Often the help comes with the ability to own a mental state, the ability to direct the mental pressure on the offender, suppressing his will. Defendant protection tactics do not have ready-made stamps and recipes: they must be produced each time individually, depending on the situation.

If a person is unable to purchase or can't afford to use self-defense weapons, you can use simple personal safety tips every day:

– do not open the door to an unfamiliar person (or hold the door on a chain); remember that robbers may come under the guise of plumbers, gas service employees, power grids and even police officers; officials are obliged to present a certificate themselves;

– keep money and valuables with you; handbags, handbags do not leave without care; In a cafe or bar, before hanging a coat on a hanger or a back of a chair, take away money and documents from it;

– if you have pocket money at your disposal, then, if possible, take them as much as you think to spend; do not show openly that you have a lot of money with you;

– a purse with money should never be put into the outer pocket of a coat, jacket or bags, especially in a bag filled with food;

– attacking on women, criminals often try to snatch a handbag from their hands, so it's safer to carry the bag on the strap over your shoulder, pressing it to yourself;

– never carry money and documents together;

– when returning home late at night, try to walk on a lighted and lively street, avoiding dark alleys and parks, although it will take longer; in the evening it is necessary to be ready on the street, in the transport, in the entrance of the house, in the elevator;

– avoid returning home at night alone; never get into the car for strangers;

– do not go down the streets with headphones: you can not hear the offender who is falling from behind or someone else's warning;

– avoid situations that threaten violence (a dispute with drunken, aggressive), it is better to look like a coward in the eyes of thieves, than to be beaten to death;

– if you are attacked, try to talk to the attacker and look at his feelings, if it does not, shout as loudly as possible or break the glass of the nearest house or store.

Concept and types of crowds

The crowd is a special community of people, whose behaviour almost does not depend on the educational level, nor on the cultural level of the people forming the crowd. Mutual influence of people in the crowd promotes the creation of a single mood ("collective, soul", according to G. Lebon).

Feeling their unity and power of the crowd can quickly radykalizuvatysya changing the nature and direction of their actions. The peculiarity of the crowd is that it is devoid of a hierarchical division – all people in the middle of a large group of people are equal, the differences between them are eliminated.

There are 4 types of crowd:

– accidental – a group of people whose attention has attracted a certain event, for example, an accident;

– expressive – a group of people, united by the desire to jointly express their feelings: joy at the wedding, sorrow at the funeral, solidarity at a rally or demonstration;

– conventional – a group of people who are participants in mass entertainment (viewers, fans): they are united by the interest in the action, which they react according to traditional rituals and norms (hence the name is conventional, that is, the one envisaging an agreement);

– active, including aggressive (for example, self-guilty of a crowd over a criminal caught on a "hot"), panic (massive flight of people from danger), ***selfish*** (robbery of stores, financial institutions, etc. during natural disasters, looting), rebel (when people spontaneously unite against oppression, arbitrariness of the authorities, etc.).

In the crowd, people are so tight that it allows them to maintain visual and auditory contact between themselves, while experiencing the reactions of each other to external stimuli (for example, to the speaker's words during the rally).

The human psyche undergoes great changes in the crowd: the human person is noticeably leveled, and the special and unique that is in each of us, goes back to the background. Losing individuality, people in the crowd begin to think and feel equally, show a tendency to the same solutions and influences – they are supposedly becoming one being with subindividual mental traits and properties. But inferring to individuality, a person in the crowd feels security from the outside world, which she may have lacked in her usual life. The sense of complete security obtained in the crowd often leads to irresponsible behaviour of a person who perceives received protection as a permission for impunity and permissiveness.

The crowd needs holistic images and statements that are "perceived" without need of argument. People who are united in the crowd often find the ability to sacrifice themselves and heroism, which they alone never reveal. A person who finds himself in the crowd, as a rule, can not resist him (neither physically nor mentally). In this case, the crowd is a great danger to human health (both physical and mental).

The risk of physical damage arises at a high density of the crowd, especially when it starts to move (panic escape). When a person falls in a dense moving crowd, the probability of being trampled is sharply increasing, since it is almost impossible to stand on his feet alone.

The risk of deforming mental health increases with insufficient self-confidence and a low level of self-awareness when a person systematically "dissolves" in the crowd.

Panic is the extreme manifestation of the spontaneous, impulsive behaviour of people in the absence of their social organization, the state of mass emotion that occurs in response to shocking circumstances.

The crisis situation creates the need for immediate action, and their conscious organization is impossible due to information-oriented insufficiency.

In the room (at a concert or in another mass event) when there is a danger everyone begins to seek salvation at the same time, in most cases it happens chaotically. Particularly active are people who are far from exits. They start struggling hard on those who are ahead, and as a result, most people are pushed to the walls ahead. There is an exertion, as a result of which many people may be crushed between the wall of the room and human bodies.

If you have to deal with the confluence of passes in the place of a mass sight, violation of the rules of fire safety or public order, the correct action at this will leave this event.

It is more likely to be saved from those who know where the next exit is. Especially important to rush him before the crowds come in motion.

However, when the crowd gained full strength, an attempt to move through its stratum may have the most negative consequences. It is wise to wait until the main stream is going to shake.

To direct the movement in narrow passages, when the crowd has already come into force, it is permissible only in the case of a rapidly expanding fire or smoke as a result of combustion of plastic materials and coatings.

The rules of conduct in the crowd are a set of measures that help maintain security in places of high concentration of people.

To avoid troubles and accidents in the crowd:

– try to avoid large crowds of people;

– do not join the crowd, whatever the interest in what is happening;

– during the riots, try to get around the crowd;

– if you get into the crowd, let him carry you from the center to the edge of the crowd, trying to get out of it gradually;

– do not hold your hands in your pockets, breathe deeply, and spread the arms bent in the elbows to the sides, fist upwards so that the chest is protected from compression;

– try to stay away from stupefying people, or those who have cumbersome items or large bags;

– being in a moving crowd it is necessary to stay away from any walls and protrusions, especially in these cases, all kinds of metal lattices are dangerous;

– try to keep balance, not to fall;

– moving, place your foot on a full stop, do not take short steps, do not climb upright;

– if the embargo has taken a threatening nature, immediately, without thinking, free yourself from any load, first of all from the bag on a long strap; remove long, very free clothes fitted with metal details, as well as everything that you can put your neck, that is, a scarf, a tie, a lanyard medallion, a chain, any jewelry and jewelry;

– if you have something dropped out, do not lean in any way to lift it.

– in the event of a fall, try to get up on your feet as soon as possible, but do not rest on your hands (they will be repulsed or broken); try to stand on the soles or socks at least for a moment; finding resistance, “grow up”, sharply pushing off the ground with his feet; If you can not get up, bend your head with a ball (protect your head with your forearms, cover your neck with your palms, and your abdomen – bent and tucked up to the body with your legs).

Once in the crowded room, pre-determine which place when a dangerous extreme situation (the passages between the sectors of the stadium, glass doors and partitions in concert halls, etc.), pay attention to spare and emergency exits, plan your way to them.

One must beware of the walls and narrow doors. To do this, try:

– to get into the “mainstream”, avoiding exhaustion;

– direct the movement to the side where it can be more free;

– it is better to put the child on the shoulders and move forward further or two adults can turn face to face, to create from their bodies and hands the similar protective capsule for the child.

In case of panic, try to stay calm and ability to soberly assess the situation.

1.6. Provision of the first incidental medical service

1.6.1. The importance of providing first-aid care to save the health and life of the victim

A number of factors in the environment can have a negative impact on human health and life. Accidents occur at home, at work, on roads, in places of rest – in places that is far from medical institutions. They always happen unexpectedly and require emergency care within the first 4–5 minutes after an accident, when irreversible changes in the cells of the body have not yet occurred.

The first incidental medical service is a complex of simple urgent actions aimed at preserving the victim’s health and life.

However, in the first minutes, there are not always medical personnel next to the victim. Therefore, pre-nursing care can and should be provided by bystanders of the incident. This requires special knowledges and skills. Everyone needs to know the methods of primary reanimation, eg. a set of measures to provide assistance at the place of incident, prevent the death and revitalize a person.

Inaction during time of waiting medical workers, should be regarded as a failure to comply with moral and civic duty in relation to the person who dies, no matter how it is motivated: confusion, fear or inability.

According to WHO (worldwide health organization), about 30 % of people who died as a result of accidents or extremal situation could have been rescued if there had been provided timely and correct first-aid treatment, revived measures, or delivery to a hospital.

The victim also has a strong need of moral and psychological support from surrounding persons. Attention, sincerity and caring are factors that, after conducting the first preventive measures, will help to wait for the aid. The correct psychological impact and positive behaviour of those who surround the victim and provides with support is an important part of pre-nursing care.

The timely provision and proper first-aid treatment not only saves the life of the victim, but also ensures further successful treatment, prevents the development of severe complications, and after the treatment reduces the loss of performance efficiency or degree of injury.

1.6.2. Medico-biological and social health problems

The study of various aspects of health as a qualitative value of human and society, the study of complex interconnections between the factors of the environment and people's health is an important task of the discipline "health and safety".

"Health not only the absence of illness and physical disabilities? But also a state of complete physical, spiritual and social well-being" – the words written in the statute preamble of the World Health Organization (WHO). In the "human-health-environment" system there are three interrelated levels of health-social, group, and individual.

The first is social level – characterizes the health of the population as a whole and reveals a holistic system of material and spiritual relations that exist in society. The second is the group health, which is conditioned by the peoples life specifics of the given personnel or family and the environment in which take part its members. The third is the individual level of health, which is formed in the conditions of the whole society and group, and on the basis of the individual's physiological and psychological characteristics, the unique way of life.

There are three levels that describes the value of "health":

- biological – initial health involves the perfection of self-regulation in the body, harmony of physiological processes as a result of maximum adaptation;

- social – health is a measure of social activity, the activity of the human’s attitude to the world;
- special psychological – health is the absence of the disease, but rather the negation of it, in the sense of overcoming (health not only the state of the organism, but also the strategy of human life).

Human health can not be considered as something independent, autonomous. It is the result of the impact of natural, human and social factors. The gigantic tempo of industrialization and urbanization under certain social conditions can lead to a disturbance of the ecological balance and cause degradation not only of the environment, but also of people's health.

What can serve as indicators of public health? According to scientists, it is quite acceptable to use demographic indicators such as mortality, infant mortality and average life expectancy to assess the health of the population.

Human health depends on many factors: climatic conditions, the state of the environment, food supply and it’s quality, socio-economic conditions, and the state of medicine.

It is proved that the way of life determines about 50 % of human health. Negative factors include harmful habits, unbalanced, malnutrition, unfavorable working conditions, moral and psychological stress, sedentary lifestyle, poor physical conditions, lack of harmony in the family, loneliness, low educational and cultural level, etc.

Unfavorable environmental conditions, such as air pollution, water, soil, as well as complex natural climatic conditions have also a negative impact on the formation of health (the share of these factors is up to 20 %).

Significant importance is the state of the genetic fund of the population, the aptitude to hereditable diseases. It is about 20 %, which determine the current level of population’s health.

Health care with its poor quality of medical services accounts only 10 % of the “contribution” to the level of health of the population that we have today.

The causes of the normal life violation and the emergence of pathological process can be abiotic (properties of inanimate nature) environmental factors.

That’s why we can see the obvious connection of the geographical distribution of diseases quantity with climate and geographic zones, altitude, radiation intensity, air displacement, atmospheric pressure, humidity, etc.

Human health is affected by the biotic (properties of living nature) component of the environment in the form of plants metabolism products and microorganisms, pathogenic microorganisms (viruses, bacteria, fungi, etc.), poisonous substances, insects and animals dangerous to humans.

The factors of the social environment affect the health of population: demographic and medical situation, spiritual and cultural level, material condition, social relations, mass media, urbanization, conflicts and the like.

1.6.3. General principles of first premedical services

Premedical care means urgent actions and organizational measures aimed at saving and preserving a person's life in an emergency and minimizing the consequences of such a condition on health, carried out on the scene by persons who do not have medical education, but in their official duties, “connections must have basic skills in saving and preserving the life of a person who is in an urgent situation and are required by law to carry out such actions and activities”.

To avoid misunderstanding, we note that in our course the term “First aid” is used, since this term is more historically applicable and understandable. But at the same time it must be understood that this is the first aid center.

Every year, tens of thousands people in Ukraine die from accidents. A significant part of these people could be saved if there was someone nearby who had knowledges about the basics of first aid.

First aid is a complex of urgent measures carried out by a person who suddenly fell ill or suffered from external factors in his transfer, if necessary, to the care of qualified medical personnel.

Despite the fact that all people are aware of potential dangers and all sorts of trying to avoid them – accidents still happen. The reason may be own inattention, fatigue, overestimation of one's own strength, insufficient preparation. Also, incidents can occur due to factors beyond the control of the victim – as the actions of second persons or natural disasters or man-made accidents.

When an accident occurs, time is not on your side. The victim needs to provide effective assistance as soon as possible, on which often depends not only the duration and severity of the process of restoring his health, and perhaps even the life. Therefore, in order to act effectively in such situations, it is necessary to understand the basic principles of the FA.

The main principles of First Aid

1. Do not panic. Regardless of the person's heart stopped, just the blood runs from the deeply cut finger, people who witnessed such cases can succumb to panic and act inadequately. Always keep calm and common sense, do not give in to the panic of others and do not create yourself. In order not to succumb to panic, you need to know what and how to do. Knowledge, skills and readiness to act are the main prerequisites so as not to succumb to panic and succeed!

2. "Take care of safety!" Salvation of the victim should not endanger you, other rescuers, the victim himself or any of the others. When approaching the victim, assess the danger from the environment (the proximity of electrical networks, open fire, the presence of life-threatening substances, the victim's stay in a dangerous place: near water, ice, on the highway, potentially dangerous to be in a confined space, etc.). If the victim can be transferred / moved to a safer place, do it first. The second possible danger is from the victim himself (he can be aggressive considering the effects of alcohol or drugs). A typical threat is contact with body fluids: blood, vomiting, saliva, urine, feces). Therefore, whenever possible, use medical gloves to provide FA.

3. "Stop the damaging factor". If you have witnessed an accident, the first thing to do is to stop the effect of the damaging factor – extract it from the water, pull it away from the electric current, extinguish the clothing, stop the gases, high temperature, cold and so on.

4. "Determine who is in charge here". If you are not a doctor, find out if they are around you. If you are the most qualified – take the situation under your control. If the victim in consciousness tells him who you are, quickly find out with him all the circumstances of the incident and tell him what you intend to do. At the victim in consciousness you should receive the consent to any actions concerning it. If the victim's consciousness is not available, or her degree does not allow him to make adequate decisions, and also in the case of assistance to a minor child, you have the right to act trying to obtain consent, in the absence of a number of their relatives or guardians.

Your actions should be confident, resolute, orders or requests clear and understandable. Your confidence will reassure the victim, pass on to the rest and protect you from a heap of meaningless and unnecessary advice from others.

5. "What happened?" Ask the witnesses, if possible the victim himself, to inspect the place where the accident occurred in order to understand as much as possible what happened and to determine the causes and mechanisms of damage. It is from this often depends the success of the first medical aid, as well as the further treatment of the victim.

6. "Assess the condition of the victim and act!" At this stage, you need to find out whether the injuries received threaten the life or loss of human health and, accordingly, begin rescue operations.

The greatest threat to human life at the stage of pre-medical care is a violation of breathing and blood circulation (blood circulation), massive blood loss. Therefore, always start helping to eliminate these very threats.

If the victim is unconscious, two questions need to be resolved:

1. Does the person have signs of consciousness?

2. If there are no signs of consciousness, find out if the person is still alive?

Signs of consciousness in the victim show a reaction to the Voice and pain.

The level of consciousness is determined using the AVPU scale

Changes in the assessment of the consciousness of a wounded person on the AVPU scale may indicate changes in the state of his health (Fig. 1.8), especially if the injured person is injured in the head.

Check further the level of consciousness of the wounded about every 15 minutes, marking it with the corresponding letter, where:

A (alert = consciousness) – is injured by the Diabetes, is in a clear consciousness (may be confused or disoriented), knows who he is, the date where he is, what happened.

V (verbal, voice = voice) – the wounded does not realize what is happening, but still responds to verbal (voice) commands.

P (pain = pain) – wounded reacts to pain, but not verbal orders.

U (unresponsive = consciousness) – is wounded consciousness, does not respond to orders and pain.

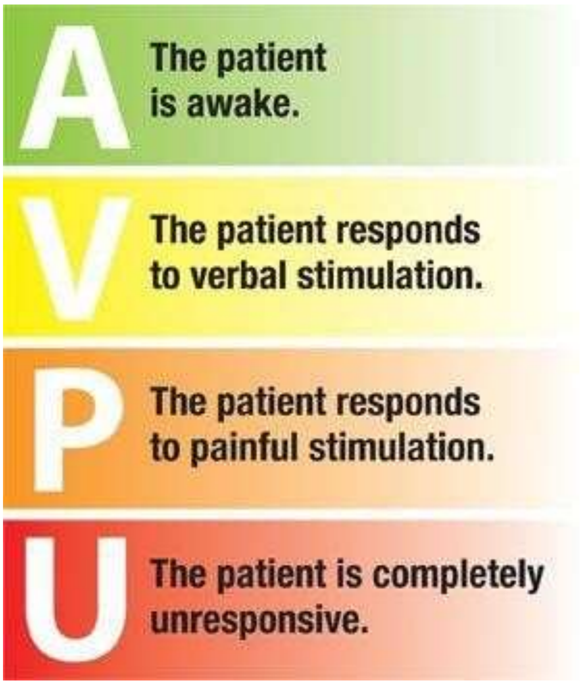


Fig. 1.8. The scale of the level of consciousness

NOTE: The injured person who screams at you, tells you about what happened or performs such actions, is in his right mind.

NOTE: If the injured person is in his right mind or responds to voice commands, do not test him with a reaction to pain.

Painful irritations (vigorous friction of the sternum of the injured by the bones of your fingers, or a strong contraction of the muscle in the fold between the thumb and forefinger of the wounded, pressing with a fingernail, pencil, match on the nail bed of fingers) apply when suspected of injuring the spine of the injured person. If there is no suspicion of spinal injury, pain stimuli for checking consciousness can be replaced by shaking on the shoulders of an adult or child, or by mild irritation (tapping, tingling, tickling) of the feet, chest and shoulders in newborns. If you suspect a damage to the spine of the injured person, do not shake it!

Signs of life is the presence of breathing and pulse, as well as the reaction of pupils to light (Extended pupils of a living person narrow with the direction of light on them). If the victim is unconscious of these signs is available, he is in the state of clinical death and this is a signal for the immediate initiation of resuscitation.

To assess the situation Use the ABCDE mnemonic rule:

A: Airway – airways (whether free airways?).

B: Breathing – breathing (Or is there a breath?).

C: Circulation – blood circulation: pulse / bleeding (whether the pulse and external bleeding? If there is a large arterial bleeding – quickly stop it in the first place).

D: Disability – incapacity (Is there physical or mental disability?).

E: Expose – conduct further analysis and assistance.

If the unconscious person does not show visible signs of breathing and can not find the pulse, he must be turned gently to the back to release airways, check breathing and pulse, and, if necessary, carry out resuscitation.

In the absence of the consciousness of the injured person and in the presence of breathing, it is necessary to provide him with a stable position on his side in order to prevent the tongue lagging and asphyxia with vomit (if there is no suspected spinal injury and fractures of the limbs). If you suspect a spinal injury and if you have independent breathing, the victim should be left until the arrival of professional assistance in the situation in which he is.

Signs of biological death are the opacity and drying of the cornea of the eye; presence of the symptom "cat's eye" – when the eye is compressed, the pupil deforms and resembles a cat's eye; cooling of the body and the appearance of cadaveric stains. At biological death reanimation measures are not carried out.

So, to examine and provide assistance to the victim it is necessary in such a sequence (using AVPU and ABCDE rules):

- checking for signs of consciousness (voice, pain-AVPU);

- detection of respiration (AB);
- detection of pulse (C);
- examination of the head, neck, chest, abdomen, limbs for bleeding, fractures and other injuries (CD);
- identification of other conditions (primarily signs of shock) (E).

7. "Call 1-0-3". If the condition of the victim requiring emergency care call 103, if none of the others have done so. Only in the case of resuscitation of children and infants, when you can not lose a second, a quick one should be called in 1–2 minutes after the start of resuscitation (if the rescuer is one).

Calling an ambulance, clearly tell what exactly happened, what damage was found, especially life-threatening, the number and condition of the injured, whether there are among them children, elderly people, the scene (street, house number, characteristic points on the ground) that was provided help. Enter your name, phone. Make sure that the dispatcher has accepted the information provided and is ready to send an ambulance. Find out an approximate time when to expect help arriving. Only hang up after the dispatcher.

After calling the ambulance (and, if necessary, other services) continue to provide first aid until it arrives, the affected limbs are frozen, warm and soothe the victim.

8. "Do no harm!" When starting to provide the First Medical Assistance itself, always keep in mind this ancient medical commandment. If you are not sure that you will not cause harm by some kind of interference, it's best not to do it.

9. "Act quickly – time is not on your side!" When an accident occurs, time is not on your side. The victim needs to provide effective assistance as soon as possible, on which often depends not only the duration and severity of the process of restoring his health, and perhaps even the life of a person. Therefore, when submitting a FA, adherence to the principles presented here should not slow the beginning of the assistance process itself, which you should start almost simultaneously with clarifying all other circumstances.

10. "Transfer the victim to the care of qualified medical personnel". Passing the victim to professional medics is in fact your main and only task, while doing everything you can to ensure that the process of further assistance is most effective. After rendering the FA, the victim should prepare it, if necessary, for transportation to a specialized medical institution. Continue guardianship and assistance while waiting for transportation and during transportation itself.

The sequence of actions in the event of an accident is the elements of the rescue chain.

Assistance to the victims is divided into two stages:

Stage 1. The first medical (home help) assistance is at the scene provided by the witnesses of the incident.

Stage 2. Medical qualified care.

The first stage (FA) includes three links of the rescue chain:

1) priority actions – that is, assessing the situation, fencing the scene, interviewing, checking vital functions, assessing the state of the victim, implementing activities directly aimed at supporting the life of the victim;

2) call an ambulance;

3) the further actions are directed on rendering of the first medical aid to victims before arrival of the qualified help (thermal insulation, psychological support, preparation for transportation).

SELF-CONTROL QUESTIONS TO SECTION 1. SAFETY OF LIFE – SUSPENSION OF SUSTAINABLE DEVELOPMENT

1. Describe the urgency of life safety problems.

2. Analyse the structural relationship of life safety with basic and applied sciences.

3. Identify and describe the purpose, objectives, object and subject of life safety.

4. Define the concepts of human security, society, national security and describe the principles of national security.

5. Describe the impact of security culture on the protective function of mankind.

6. To determine the methodological bases of life safety.

7. Define and characterize the concepts of taxonomy, identification and quantification of hazards.

8. Describe the types of hazards and their signs.

9. Give and describe the classification of hazards and the principles of their identification.

10. Define and describe the basic concepts of security in the system “man-machine-environment”.

11. Define and describe the concept of “human factor” and the directions of manifestations of dangers that arise as a result.

12. Analyse the types of natural hazards.

13. Identify and characterize natural disasters.

14. Identify and characterize natural radiation and ways to protect against them.

15. Define and describe the concept of atmospheric electricity.

16. Identify and characterize biological hazards and methods of protection against their negative effects.

17. Define and describe the concepts: man-made hazards, striking, harmful, dangerous factors.

18. Identify and characterize a fire as an energy hazard, its impact.

19. Give and analyse the characteristics of ionizing radiation.

20. Identify chemical hazards and characterize them by the nature of the impact on humans, the selectivity of action, the duration of action.

21. Give the main types and characteristics of modern socio-political dangers.

22. Describe the impact of modern information technology on human health and public safety. Give and analyse the rules of personal cybersecurity.

23. Identify and characterize bad habits. Their prevention.

24. Identify and characterize social diseases. Their prevention.

25. To characterize crime as a factor of danger, its types.

26. Provide concepts and varieties of the crowd. Human behaviour in the crowd.

27. Analyse risk as a quantitative assessment of hazards.

28. Provide and describe the types of risks.

29. Provide definitions and explain the sources and factors of individual risk.

30. Provide definitions and explain the sources and factors of group risk.

31. Explain the essence of the concept of acceptable risk.

32. Describe the levels of risk according to the degree of acceptability.

33. Describe the concept of risk management.

34. Describe the general model of life safety.

35. Identify and describe the main areas of natural security.

36. Identify and describe the main areas of man-made safety.

37. Identify and describe the main areas of socio-political security.

38. Define the general principles of certification and creation of a national register of potentially dangerous objects.

39. Prove the importance of first aid for the health and life of the victim.

40. Describe the organization of first aid in the enterprise.

Section II. LABOUR PROTECTION

2.1. Place and Importance of Labour Protection in the System of Ensuring Life Safety. Object and Scheme of Labour Protection

Labour is a purposeful activity of a person, who uses his/her physical and mental abilities in order to obtain certain material or spiritual goods. Labour is the life-sustaining activity of people. The labour process takes place in the industrial environment (enterprises, institutions, organizations, educational institutions, etc.), which is one of the components of an artificial environment in the general system of vital activity (see Fig. 1.1), where a person performs his/her labour activity. The labour protection deals with the issues of ensuring the safety of human life during the labour process in the industrial environment, if it is carried out under the labour legislation.

The physiological aspect of labour is manifested in the fact that, being a social phenomenon it has a natural precondition – the use of physiological functions of the worker to create certain social values. During the labour process all organs and systems of the human body – the brain, muscles, blood vessels, heart, lungs, etc. – are mobilized, physiological functions are mobilized too, while the nervous and muscular energy is consumed. To provide functioning of the organs and to exert energy, muscle groups are used, the reduction of which is regulated by the process of excitation coming from the nerve centers. These muscles are controlled with the help of an increased flow of blood that brings nutrients and oxygen, using the products of decay of substances that serve as a source of energy. In order to provide enhanced blood circulation and metabolism and energy, the work of the heart and the respiratory organs is increased accordingly. But if the labour process occurs with excessive strain of the forces of the human body or in unfavorable harmful conditions, the negative consequences of labour may be manifested in the life-affirmation of the body of the worker and in the state of his/her health, while the optimal conditions may, on the contrary, be the factor of improving the labour efficiency of a person.

The influence on a state of health and the labour efficiency of the worker is determined by the characteristics of the labour process and the environment in which it is carried out. From this perspective, the immediate labour process is characterized by such parameters as *the severity* and *intensity of labour*.

The severity of labour is a characteristic property of the labour process, which reflects the load on the musculoskeletal system and functional systems of the body (cardiovascular, respiratory, etc.), which ensure its activity. The difficulty of work is characterized by a physical dynamic load, the weight of the cargo that is lifted and displaced, the total number of stereotypical movements, the size of the static load, the posture, the degree of inclination of the body and body movements.

Labour tension is a characteristic of the labour process, which reflects the load on the central nervous system, the organs of sensation, the emotional state of the worker. The factors, which characterize the intensity of work include: intellectual, sensory and emotional stress, the degree of monotony of loads, the mode of operation.

When a person performs his/her labour duties, there is a set of factors of the production environment that are classified as *harmful* and *dangerous* according to the nature and possible consequences of the negative influence.

Harmful production factoris an undesirable phenomenon, which accompanies the production process. Its impact on the worker can lead to the deterioration of person’s health, reduction of the labour efficiency, production-related or occupational diseases and can even cause death as a result of the disease.

The disease is a violation of the normal functioning of the organism due to functional and / or morphological changes. *A production-related disease* is a disease, the course of which is worsened by the labour conditions and the frequency of which exceeds its spreading among the workers who are not exposed to certain professional harmful factors. *Occupational (industrial) disease* isa disease that arises as a result of professional activity and is caused exclusively or mainly by the influence of harmful substances, certain types of labour activity and other factors related to the labour process.

Dangerous production factor is an undesirable phenomenon that accompanies a production process and which, under certain conditions, can lead to an injury or other sudden deterioration of the health of the worker (acute poisoning, acute illness) and can even cause a sudden death.

Industrial injury is a damage to fibers, disturbance of the anatomical integrity of the human body or its functions as a result of the influence of production factors. Typically, an occupational injury is a consequence of an accident at work. *Accident at work* is a time-limited event or sudden impact of a dangerous production factor on the worker or environment that has occurred in the process of performing his employment duties, resulting in damage to health or death.

The classification of adverse factors of the production environment into harmful and dangerous is caused by the different nature of their effects on the human body, the fact that they need different measures and means to combat them and prevent the damage caused by them. At the same time, it is sometimes difficult to draw a clear line between harmful and dangerous production factors. The same factor can cause injury and occupational disease (for example, a high level of ionizing or thermal radiation can cause burns or even lead to instantaneous death, and a long-lasting effect of a relatively low level of these same factors can lead to the disease; the dust penetrating into the lungs can cause a disease called pneumoconiosis). Thus, all unfavorable production factors are often considered as one notion – a dangerous and harmful production factor (DHPF).

According to the origin and nature, the DHPF can be divided into 5 groups: physical, chemical, biological, psychophysiological and social.

Physical DHPF includes machines and mechanisms or their elements, as well as products, materials, workpieces, etc., which are moving or rotating; collapsing constructions; systems, equipment or elements of equipment that are under high pressure; increased dustiness and gas pollution; elevated or lowered air temperature, surfaces of premises, equipment, materials; increased levels of noise, vibration, ultrasound, infrasound; elevated or lowered barometric pressure and its sharp fluctuations; increased and lowered humidity;

increased speed and increased ionization of air; increased level of ionizing radiation; increased voltage in the electrical network; elevated levels of static electricity, electromagnetic radiation; increased electric and magnetic fields; absence or lack of light; insufficient illumination of the labour zone; increased brightness of light; reduced contrast; direct and reflective shine; increased pulsation of light flux; elevated levels of ultraviolet and infrared radiation; sharp edges, bumps, roughness on the surface of workpieces, tools and equipment; location of the workplace at a significant height from the ground (floor); slippery floor; weightlessness.

Chemical DHPF includes different chemical substances that can enter one and another way into the labour zone and its air.

Biological DHPF includes pathogenic microorganisms (bacteria, viruses, rickettsia, spirochetes, fungi, protozoa) and products of their functioning, as well as macroorganisms (animals and plants).

To psychophysiological DHPF belong both physical (static and dynamic) overload and neuropsychological overload (mental strain, strain analysers, monotony of work, emotional overload).

Social DHPF includes a low-quality organization of labour process, overtime work, the necessity of work in a team with poor relationships among its members, social isolation, changing biorhythms, dissatisfaction with work, physical and / or verbal personal image.

One and the same DHPF according to the nature of its effects may belong simultaneously to different groups.

The factors of the labour process and the production environment, which affect the health and efficiency of a person during the labour process determine the labour conditions. First of all, the labour conditions must be safe. "Safety" means the protection of the individual and society from the risk of damage.

The production process in most cases is accompanied by harmful and dangerous factors and has certain industrial risks. *Occupational risk* is a probability of damage to the worker's health during the labour process, which is caused by the degree of harmfulness and / or danger of labour conditions and the scientific and technical level of production, which also determines the degree and intensity of labour.

Labour protection stands for such labour conditions that exclude the effect of dangerous and harmful production factors on the worker, as well as the negative characteristics of the labour process.

Considering the fact that in life of the individual and especially during the production process, total safety cannot exist, it would be unreasonable to demand a complete absence of injury during the production production, excluding the possibility of any disease. But it is realistic and reasonable to consider the issue of minimizing the impact of objectively existing occupational risks. This task is solved by the ***labour protection*** – *a system of legal, socio-economic, organizational and technical, sanitary and hygienic, therapeutic and preventive measures aiming to preserve the life, health and labour efficiency of the person in the process of the labour activity.*

Such definition is adopted according to the current Law of Ukraine "On Occupational Safety" [4]. Firstly it outlines the fact that labour protection is a complex of laws, norms, rules, standards, etc., as well as a complex of various measures and means of ensuring the preservation of life, health and labour efficiency of people in the process of fulfilling their labour obligations. Secondly, the Law emphasises the fact that care for the health of the worker is one of the crucial functions of the state. The modern concept of occupational safety is based on the fact that accidents at work and occupational diseases should be omitted. The most important functions of labour protection include the creation of conditions, the main purpose of which would be the labour process aiming to prevent injuries and occupational diseases, restoring the health of victims at work, ensuring social rights and guarantees for victims. On this basis, the labour protection solves two main tasks at the same time.

One of them is an engineering and technical task, which involves preventing dangerous events during the labour process through the replacement of dangerous materials with less dangerous ones; the transition to new technologies that reduce the risk of injury and disease; design and construction of the equipment in accordance with labour safety requirements; development of means of individual and collective protection. Organizational measures and means that are directly used by enterprises and organizations to improve conditions and increase the level of hygiene and safety at work are very important for solving this problem. They include three directions:

- industrial sanitation is a complex of organizational, hygienic and sanitary-technical measures and means aimed to prevent or reduce the impact of dangerous and harmful production factors on the worker;
- industrial safety is a complex of organizational and technical measures and means aimed to prevent or reduce the exposure of dangerous and harmful production factors on the worker;
- fire safety at the places and objects of economic activity (POEA) is a complex of organizational and technical measures and means aimed to prevent inflammations, fires and explosions in the production environment and premises of the facility, as well as to reduce the negative effects of dangerous and harmful production factors, in case of their occurrence.

The second task of labour protection – the social one – is related to the reimbursement of a material, moral or social damage caused by work in harmful conditions, an accident or occupational disease, that is, the protection and guarantee of worker's rights.

2.2. Air of the Labour Zone

Air of the labour zone is an important element of the production environment, the state of which affects the state of health and the labour efficiency of the worker. The term "**labour zone**" means a certain space, where workplaces are located for permanent or non-permanent (temporary) use by the workers.

Analysis of the state of the air in the labour zone involves not only the determination of the microclimatic conditions, but also the assessment to the purity of the air production environment.

2.2.1. Sources and Standardization of the Labour Microclimate

The microclimate of industrial lodgements are the conditions of the internal environment of these areas, which influence on the heat exchange of labour environment with the surrounding one. Microclimate is one of the main factors of the production environment, which determines the thermal state of the human body in the labour process.

Microclimate characteristics. Microclimate conditions of industrial lodgements are characterized by the following characteristics:

- air temperature (°C),
- relative humidity of the air (%),
- air speed (m/s),
- the intensity of thermal (infrared) radiation (W/m^2) from the surfaces of equipment and active zones of technological processes (in foundry production, during the welding process, etc.).

During the labour process, certain physiological (biological) processes take place in the human body, which support the functioning of the whole organism. The intensity of these physiological processes depends on the overall physical expenses. They are accompanied by a thermal effect, while part of the heat is consumed by the human body itself and excess heat must be transferred to the environment.

In the process of production activity the increase and decrease of microclimate characteristics can be observed as a result of equipment operation, technological processes, drafts. This significantly affects the state of health and the labour ability, which may change the level of injury rate and labour efficiency. Thus, the prolonged action of high air temperature, which is accompanied by the increase of humidity leads to an increase of body temperature to 38–40 °C (hyperthermia). As a result, the variety of physiological changes in the human body come around – metabolic and cardiovascular system disorders, impairment of the functioning of the internal organs (liver, stomach, gallbladder, kidneys) and respiratory system, central and peripheral nervous systems. The increase in temperature leads to excessive sweating, which, as a result, cause a sharp violation of the water-salt metabolism. A significant amount of salt exudes with sweat, mainly sodium chloride, potassium and calcium exude from the human body. The content of lactic acid and urea in the blood increases. As a result, the secondary characteristics of blood change, the blood thickens, which is very dangerous for a person. With an increase in body temperature, the blood pressure and pulse rate increases too (up to 100–180 impulses per minute). Overheating of the human body is accompanied by headaches, dizziness, nausea, general weakness, occasional convulsions and even loss of consciousness.

The negative effect of high temperature increases with an increase in humidity, since it reduces the process of sweat evaporation, in other words, the heat dissipation from the human body deteriorates. Negative changes in the human body in case of high body temperatures are definitely reflected in the person’s labour ability. Thus, an increase of temperature in the air of the industrial environment from 20 °C to 35 °C leads to a decrease in the labour efficiency of a person by 50–60 %.

Significant physiological changes in the human body also occur when the body is over-cooled (hypothermia). The most marked reaction to the low temperatures is a narrowing of the vessels of the muscles and skin. This reduces the pulse, while the amount of breath and oxygen consumption increases. Prolonged action of lowered temperatures leads to such diseases as radiculitis, neuralgia, articular and muscular rheumatism, inflammations of the respiratory tract, allergies, etc.

Insufficient air humidity (below 20 %) leads to the drying of the mucous membranes of the respiratory tract and eyes, which results in a decrease of their protective ability to withstand microbes and infections.

Standardization and Control of Microclimate

Sanitary-hygienic standardization of microclimate conditions is carried out according to SSN 3.3.6.042-99 [5], which establish the optimal and acceptable characteristics of the microclimate depending on the total energy consumption of the body during the labour processes and the period of the year, taking into account the type of workplace (permanent, non-permanent).

According to the sanitary-hygienic standardization of labour conditions, two periods of the year are distinguished – a warm period (average daily temperature of the environment is higher than 10 °C) and a cold period (average daily temperature of the external environment does not exceed 10 °C); and two labour types – permanent (labour process at the workplace takes at least 50 % of the total labour time, or at least 2 hours continuously) and non-permanent (labour process at the workplace takes less than 50 % of the total labour time or less than 2 hours continuously).

According to SSN 3.3.6.042-99, all labour types, are divided into five categories depending on the total energy consumption of the body: light labour (category I), moderate labour (category II) and heavy labour (category III). In turn, the category I is divided into two subcategories (Ia and Ib), and the category II – into IIa and IIb.

Optimal microclimatic conditions are defined as a combination of such characteristics of a microclimate that ensure the preservation of the normal thermal state of body without activating the mechanisms of thermoregulation with prolonged and systemic effects on a person. They provide a thermal comfort and create prerequisites for a higher level of labour efficiency.

The optimal microclimate conditions are fixed for the permanent labour, while the characteristics of the microclimate should not exceed fixed values for certain category of labour.

The temperatures of the internal surfaces of the labour zone (walls, floor, ceiling, protective screens, enclosing structures, etc.) and external surfaces of the technological equipment shall not exceed 2 °C beyond the limits of the fixed air temperatures for this category of labour.

During the labour process of the operator type, associate with significant neuro-emotional stress (control posts, rooms with computer facilities, etc.), only the fixed conditions of the microclimate must be observed at workplaces.

Acceptable microclimate conditions are defined as a combination of such characteristics of a microclimate, which can cause changes in the thermal state of the human body with prolonged and systemic effects on a person, but quickly disappear, normalize the state of body and are accompanied by the stress of the thermoregulation mechanisms within the limits of physiological adaptation. Thus, there are no injuries or traumas, however, there appear uncomfortable thermal feelings, as well as a deterioration of the state of health and decrease in labour efficiency. The values of the indicators of acceptable microclimate conditions are fixed for both permanent and non-permanent labour.

Acceptable microclimate characteristics are fixed for a workplace only in case when it is impossible to provide the comfort temperature of the microclimate for technological features of the production.

Acceptable temperature, relative humidity and air velocity in labour zones of industrial premises should not exceed the limits regulated by SSN 3.3.6.042-99.

The difference in the temperature of air at the height of the labour zone at the time of providing the acceptable conditions of the microclimate should not exceed 3 °C for all categories of labour, and the horizontal labour area must not go beyond the acceptable temperatures for this category of labour during the labour shift.

The temperature of the interior surfaces of the labour zone (walls, floor, ceiling, protective screens, enclosing structures, etc.) and external surfaces of technological equipment shall not exceed the limits of the acceptable values of the air temperature for this category of work.

The intensity of thermal radiation of heat-treated surfaces of technologic equipment and lighting devices should not exceed 35.0 W/m^2 – when radiating 50 % and more of the human body, 70 W/m^2 – when irradiated from 25 % to 50 % of the body, and 100 W/m^2 – when radiating less than 25 % of the body.

If possible, dealing with the sources with an intensity of 35.0 W/m^2 or more, the air temperature at permanent workplaces should not exceed the upper limits of the definitive values for the warm period of the year; on non-permanent ones – the upper limits of acceptable values for permanent labour.

When there are open sources of radiation (heated metal, glass, open flame) an intensity of radiation can reach the point up to 140,0 W/m^2. The magnitude of the area that is irradiated should not exceed 25 % of the surface of the worker's body with the obligatory use of personal protective equipment (overalls, glasses, shields).

2.2.2. Sources and Standardization of Air Pollution by Harmful Substances

The problem of reducing the pollution of the environment is very important and relevant for all humanity. About 60 thousand chemicals are used in the process of human activity. Among the ingredients of air pollution (both neutral and harmful to the human body) – thousands of chemical compounds exist in the form of aerosols (solid, liquid) or in gaseous form.

Harmful substances are those substances that can cause disease when contacting with the human body. Those harmful substances can be distinguished by modern methods, both in the process of contact with them and in the long term, including subsequent generations.

The most common types of contaminants are solid suspensions (dust, ashes, smoke), carbon oxides, nitrogen and sulfur, hydrocarbons, ammonia, oxides and salts of heavy metals etc.

Apart from causing direct effects on human health and polluting the atmosphere, harmful substances have a negative effect on the environment (flora and fauna, water environment, soil, construction structures and technological sphere), which leads to direct secondary action of harmful substances on a human body (for example, through food chains), and to great economic losses (reduced yields of agricultural products and livestock, corrosion of materials, violations in technological processes, increasing shortages of manufactured products, etc).

Power plants, air and road transport, metallurgy and welding, manufacturing of building materials, chemical enterprises are the most harmful to the environment and, especially, to the air. Industrial emissions and emissions from the means of transport lead to significant changes in the climate of large cities.

Polluting the atmosphere, harmful substances can cause various diseases, acute poisoning (including fatal consequences) contacting with the body. Harmful substances penetrate the human body mainly through the respiratory tract, as well as through the skin and the gastrointestinal tract. The toxic effect of various substances depends on the amount of substance that has penetrated into the body, its physical and chemical properties, the duration of toxic effect. Especially important is the form of the interaction of this substance with biological media (blood, enzymes). Poisonous action depends on the ways of penetration into the body and withdrawal, distribution in the body; on the sex of a person, his/her age, individual susceptibility and other causative factors. General toxic effects can cause various actions depending on the type of substance : neuroparalytic (bronchospasm, ejaculation, cramp, paralysis), general toxicity (cerebral edema, paralysis, convulsions), asphyxiation (toxic pulmonary edema), irritation (irritation of the mucous membranes) psychotic (violation of mental activity and consciousness), skin-resorptive (local inflammation).

Standardization and Control of Harmful substances

The composition and degree of air pollution by various substances are estimated by the mass (in mg) per unit of air (m^3). Thus, the concentration (C, mg/m^3), in addition to the unit of measurement, – mg/m^3, can be measured in – %, and – $million^{-1}$ or “ppm” (the number of particles per million particles of air).

Hygienic normalization of harmful substances is carried out concerning maximum allowable concentrations (MAC, mg/m^3). MAC is the maximum concentration that can not cause diseases or health abnormalities detected by modern methods during daily work (except weekends) for 8 hours or another duration, but no more than 41 hours per week during the entire period of probation (25 years).

In accordance with the normative documents: for workplaces the maximum acceptable concentration for the labour zone is determined – MAC_{lz} (AUSS 12.1.005-88); in the atmosphere of the labour zone – the maximum MAC_{lz} (the highest, registered for 30 minutes of observation), the average daily – $DMAC_{lz}$ (average for 24 hours with continuous impact) and roughly safe levels of exposure – Roughly Safe Levels of Exposure (list of MAC pollutants number 3086-84 in Additions, ADI 201-97). Hygienic regulation requires that the actual concentration of the pollutant does not exceed the MAC (Effect / DMAC -1).

By the degree of negative effect on the body, the harmful substances are divided into four classes of danger:

Class 1 MAC – Extremely dangerous substances having a MAC_{lz} of less than 0.1 mg/m^3 in the air (lethal concentrations in the air less than 500 mg/m^3);

Class 2 – Highly dangerous substances having a MAC_{lz} = 0,1...1,0 mg/m^3 (lethal concentration in the air – 500...5000 mg/m^3);

Class 3 – moderately dangerous substances having a MAC_{lz} = 1,1...10,0 mg/m^3 (lethal concentration in the air of 5000...50000 mg/m^3);

Class 4 – very dangerous substances with a pH of more than 10.0 mg/m^3 (lethal concentration in the air > 50000 mg/m^3).

In a production environment, combined action often takes place of harmful substances. In most cases, the action of harmful substances rises (additive action). However, it is possible when the action of one substance is enhanced by the action of another (potentiating action), or the possible effect of the combined effect is less than expected (antagonistic action).

If there are several substances in the air that have the effect of summation (unidirectional action), then the air quality will meet the established standards, provided that:

$$C_1 / MAC_1 + C_2 / MAC_2 + C_3 / MAC_3 + ... + C_n / MAC_n \leq 1. \qquad (2.1)$$

The summation effect possess such substances as sulfur dioxide and nitrogen dioxide, phenol and sulfur dioxide, etc. Until recently, the MAC of chemicals was evaluated as the amount maximum for one-off action. Recently, for substances that have cumulative properties (the ability to accumulate in the body, for example, copper, mercury, lead, etc.), a different value is introduced for hygienic control – the average change concentration. For example, the average change concentration of the lead is 0.005 mg/m^3.

The degree of negative effects of dust (aerosol with a size of solid particles from 0,1 to 200 microns) on the human body depends not only on the chemical composition, but also on the size of the particles (disperse composition), the shape of the particles and their electrical properties. According to the size of the particles, the dust is divided into three categories: coarse-sized (the size of the particles exceeds 10 microns), medium (the size of the particles varies from 5 to 10 microns) and finely divided (the size of the particles is less than 5 microns). The particles of the dust are quickly deposited on the floor and other surfaces after the formation. Particles with size less than 10 microns are preserved in the air for a longer period of time. The greatest danger lies in particles with the size of 1...2 microns, because these fractions are largely deposited in the lungs when a person is breathing.

According to the nature of the action on the human body, the hygienists distinguish a specific group of dust – dust fibrogens. The peculiarity of the action of such a dust on the body is that when it enters the lungs, such abrasive insoluble dust causes the formation of fibrous nodes in the lung tissues – areas of hardened pulmonary tissues, resulting in the lungs losing the ability to perform their functions. Such diseases are practically non-curative and only when they are timely detected, the disease might be stopped by changing the labour conditions.

Measures and Means of Standardization of the Air of the Labour Zone

The standardization of the air of the labour zone, as well as the protection of workers, takes into account both characteristics to maintain the regulatory characteristics of the microclimate and measures to ensure regulated air purity. They include:

- maintenance of standardized characteristics of the microclimate due to the complex of construction planning, organizational, technological, sanitary-technical and other measures of collective defense;
- removal of harmful substances in technological processes, replacement of harmful substances with less harmful ones;

- improvement of technological processes and equipment;
- automation and remote control of technological processes and equipment;
- sealing of production equipment, localization of harmful emissions due to local ventilation and aspiration coverings;
- preliminary and periodic medical examinations of workers that work in dangerous conditions, preventive nutrition, observance of rules of personal hygiene;
- control of the content of harmful substances in the air of the labour zone;
- use of personal protective equipment;
- the use of ventilation.

The most common and effective means of regulating the air quality of the labour zone at the operating enterprise is ventilation.

2.2.3. Measures and Means of Standardization of the Air of the Labour Zone. Ventilation of industrial premises

Ventilation is one of the most effective means of normalizing the air environment of the labour zone both in terms of its purity and meteorological characteristics.

Ventilation is an organized and regulated air exchange, which provides removal of contaminated air from the room and its replacement with a fresh one. The purpose of ventilation is to ensure air purity and the specified meteorological conditions in the production premises.

According to the air movement, 3 types of ventilation systems are distinguished: natural, mechanical and mixed ventilation. The main characteristic property of ventilation is the air exchange, including such parameters as the amount of air being removed from the room (L_r) and the inflow air (L_i).

For the effective functioning of ventilation, one must adhere to the following requirements:

- The volume of inflow air L_i in the room should correspond with the volume of removed air L_r. The difference between these volumes should not exceed 10–15 %. It is possible to organize the air exchange with a help of the difference of the inflow and removed air, when the volume of the inflow air exceeds the volume of the removed air. In this case, excess pressure appears in the room, which makes the infiltration of pollutants in this room impossible. Such an organization of ventilation is carried out in industries, which are subject to increased requirements for clean air (for example, the production of electronic equipment). To exclude leakage from premises with a high level of pollution, the volume of air removed from them should exceed the amount of inflow air. In such a room, a slight decrease in pressure comparing to the pressure of the external environment is created.

- When organizing the air exchange, fresh air must be supplied to those parts of the premises where the concentration of harmful substances is minimal, and the removal of air is necessary to be carried out from the most polluted zones. If the density of harmful gases is lower than the density of air, the removal of contaminated air is carried out from the upper part of the room, with the removal of harmful substances with a density greater than the air – from the lower zone.
- The ventilation system should not create additional harmful and dangerous factors (overcooling, overheating, noise, vibration, fire and explosion hazards).
- The ventilation system must be reliable in operation and economical.

Unorganized natural ventilation (infiltration) is carried out by the change of air in the premises due to looseness in the elements of building structures due to the difference in pressure outside and inside the room. Such type of air exchange depends on a number of random factors (force and direction of the wind, the difference in temperature of the external and internal air, the area through which the infiltration occurs). The infiltration rate is the volumetric flow rate of outside air into a building, typically in cubic feet per minute (CFM) or liters per second (LPS). The air exchange rate, (I), is the number of interior volume air changes that occur per hour, and has units of 1/h. The air exchange rate is also known as air changes per hour (ACHs).

ACH is the hourly ventilation rate, divided by the building volume. It can be calculated by multiplying the building’s CFM by 60, and then dividing by the building volume. (CFM x 60)/volume

Natural ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure differences arising from natural forces. There are two types of natural ventilation occurring in buildings: wind driven ventilation and buoyancy-driven ventilation. Wind driven ventilation arises from the different pressures created by wind around a building or structure, and openings being formed on the perimeter which then permit flow through the building. Buoyancy-driven ventilation occurs as a result of the directional buoyancy force that results from temperature differences between the interior and exterior.

The benefits of natural ventilation include:

- improved Indoor air quality (IAQ);
- energy savings;
- reduction of greenhouse gas emissions;
- occupant control;
- reduction in occupant illness associated with Sick Building Syndrome;
- increased worker productivity.

Typically, organized natural general ventilation of industrial premises is carried out as a result of both inflow and removal of air through the window frames and aeration either with or without direct channel. Air exchange is regulated by different degrees of opening of the transom (depending on the temperature of the outside air or the speed and direction of the wind). This method of ventilation is applied in industrial buildings, which are characterized by technological processes with large heat emission (rolling, foundry, blacksmith shops).

The main advantage of aeration is the ability to carry out large air exchanges without using mechanical energy. The disadvantages of the aeration include the fact that during the warm period of the year its efficiency can be significantly reduced because of the decrease in the temperature difference of external and internal air and, what is more, the air flowing inside the room is not subject to preliminary purification, heating or cooling, depending on the time of the year, and the air being removed in some cases can pollute the air atmosphere.

Mechanical (artificial) ventilation is a ventilation, through which the air flows into or is removed from the premises with the use of mechanical impellers of air movement.

If the mechanical ventilation system is designed to supply air, then it is called an inflow mechanical ventilation, if it is designed to remove air, then it is called an exhaust mechanical ventilation. It is possible to organize air exchange with simultaneous inflow and removal of air – forced and exhaust ventilation. In some cases, ventilation systems with partial recirculation are used to reduce the operating costs of air heating (fresh air is mixed with air extracted from the room).

According to the place of action, the ventilation can be general and local. In case of general ventilation, the required air characteristics are maintained inside the room. It is advisable to use such system in case when harmful substances are distributed throughout the room. If each workplace has a fixed location, then for economic reasons, you can arrange air ventilation only for places where people are staying. The cost of air exchange is greatly reduced if you capture the harmful substances in the places of their formation, without allowing them to spread to the entire space of the room. For this purpose, collection devices (exhaust cabinets, shelter-boxes, exhaust and open type suckers, etc.) are installed beside the zone of formation of harmful substances. Such ventilation is called a local one.

In industrial premises, where there might be a sudden emission of a large number of harmful substances, an emergency ventilation is envisaged.

In mechanical ventilation systems, the air is driven mainly by fans – the blower machines (axial or radial) and, in some cases, ejectors. The axial-type fan is a blade wheel located in a cylindrical body. When the air is flowing into the fan, the blades are moving in the axial direction. The advantages of axial fans include simplicity of construction, high productivity and the ability to reverse the flow of air. Their main disadvantages include low pressure (30–300 Pa) and increased noise. Radial fans displace an average volume of air and are meant for high pressure systems. Radial fans have the advantage that they are very energy efficient and can realize high pressure. Disadvantages of radial fans are the weight and the dimensions. Radial fans are particularly suitable to displace air in over-pressure situations and ensure a stable laminar air flow in a channel. The pressure of fans of this type can exceed 10,000 Pa. Depending on the composition of the moving air, fans can be made of different materials with a normal, dust-proof, anticorrosive or explosion-proof characteristics.

Choosing a fan one need to know the required performance, the created pressure and, in some cases, the constructive execution.

Ventilation system (inflow, exhaust, both inflow and exhaust) usually consists of air intake devices and devices for emitting air (located outside the house or premises), devices for air purification from dust and gases, heaters – for heating the air during the cold period, air ducts, fans, inlet and outlet apertures, chokes and latches.

Air-conditioning systems (ACS) provide automatic maintenance of temperature, humidity, purity and speed of air movement in the room despite any external conditions (permanent or variable) according to a certain program. In accordance with the requirements for specific premises, air is heated or cooled, moisturized or dried, purified from pollutants or disinfected, deodorized, ozonated. Air-conditioning systems should provide normalized meteorological characteristics and air purity in the room at specified outdoor air characteristics for the warm and cold seasons according to SSS 3.3.6.042-99.

The ACS include cooking facilities (cooling, heating, humidifying, ozonation, etc.), transfer and distribution of air, means of automation and remote control. The main apparatus of the ACS is usually an air conditioner.

Means of Personal Protection against the Influence of Harmful Substances and Characteristics of the Microclimate

According to GOST 12.1.005-88 [6], in case of exceeding the maximum acceptable concentrations of harmful substances in the air of the labour zone, the workers are obliged to use personal protective equipment (PPE), which is one of the most effective measures to prevent the negative impact on the labour process and harmful and dangerous factors of the production environment.

Respiratory equipment, industrial gas masks and insulating respiratory devices that provide air purification from harmful substances to a level that does not exceed the MAC in accordance with GOST 12.1.005-88 shall be included in the means of personal protection of the respiratory organs from the action of suffocating and toxic gases, vapors and dust and meet the requirements of serias of DSTU EN Standarts.

Field measurement results showed that the respirators are the most recent and the most unreliable means of protection. The effectiveness of respiratory protective equipment is unstable and unpredictable. Respirators cannot substitute other measures, that reduce the impact of air pollution on the staff (sealing equipment, ventilation and so on), but only supplement them. Respirators are not convenient, they create discomfort and irritation, and prevent communication. The reduction of the field of view leads to an increase in the risk of accidents

RPE reinforce overheating at a high air temperature. These and other deficiencies often prevent use of respirators in the polluted atmosphere without interruptions. But if the RPD is not used, it becomes useless.

Workers using respirators partially lose performance. Industrial hygienists know many cases where harmful substances enter the body not through the respiratory system, but in other ways (through skin). Even the timely use of a respirator may not be sufficient for reliable protection of workers.

Among the domestic products the most widespread units are the following: anti-dust respirators “PULS-K” and “PULS-M”; respirators “ROSTOK”, “ROSTOK-1” and “ROSTOK-3”; gas respirators “TOPOL-A” and “TOPOL-KD”, “KLEN-GP”, “SNEZHOK-GP” and “MRIYA”; respirator SB-1 “LEPESTOCK-200”; respiratory apparatus on compressed air ASP-2; respiratory air apparatus for rescue services on chemical enterprises; respirators with chemically bound oxygen RX-4P, RX-4E; self-supporting shaft insulators ShSR-1P, ShSR-1N and ShsR-1U; universal insulating mask UIP-1; air isolating apparatus for firefighters AIR-317.

If it is not possible to provide the acceptable hygienic standards of thermal irradiation at the workplaces by means of technical facilities, the protective cloths shall be used – overalls, special footwear, PPE for the protection of the head, eyes, face, hands. According to purpose, the following PPE are on visaged:

- for permanent work in hot shops – the overalls, during repairing processes of hot stoves and aggregates – with an automatic system of individual cooling, complete with felted overalls;
- during emergency work – a heat-reflective set of workwear made of metallized fabric (anti-warm clothing);
- for the protection of feet from thermal radiation and spray of molten metal and contact with heated surfaces – the special leather special gloves for working in hot workshops;
- for the protection of hands from burns – special gloves, overall fabrics (combined with leather handles);
- for the protection of head from thermal radiation, sparks and splashing of metal – a felted hat, a protective helmet with a shimmer and polycarbonate helmets;
- for the protection of eyes and face – a shield of a heat-resistant steel with protective safety glasses with light filters, protective masks with a transparent screen, protective glasses, a visor with filters.

Special protective clothing must comply with the general requirements of DSTU EN 340-2001 and DSTU ISO 13688-2001, having mechanical properties in accordance with DSTU ISO 13996-2001 and DSTU ISO 13997-2001, protective properties that exclude the possibility of overheating its interior surfaces any place, to a temperature of 313 K (40 °C) in accordance with DSTU ISO 366-2001.

In conditions of high temperature, in addition to the use of PPE, it is also advisable to drink distilled water during the labour process, which prevents significant losses of water drink by the human body, as well as salts and trace elements necessary for the organism. At the same time, it is recommended to increase the consumption of protein containing products.

Means of individual protection of workers from overcooling are used when working in a cold microclimate – a combination of microclimate parameters, in which there is a change in the body's heat exchange, which leads to a general or local heat deficiency in the body (< 0.87 kJ/kg) as a result of lowering the temperature "nucleus" and (or) "outer skin" of the body (the temperature of the "core" and "shell" of the body – the temperature of the deep and superficial layers of the tissues of the body).

According to DSTU EN 342-2001 and DSTU EN 343-200, the protection of the workers from the overcooling and bad weather should be carried out with "normal" clothing with appropriate thermal insulation or "special heating" clothing, for example from electric sources.

2.3. Acoustic Factors of the Production Environment

2.3.1. Sources, Evaluation and Protection against Noise

Noise is a random combination of sounds of changeable frequency and intensity, being within the frequency range of the sensory organs of the human hearing. Ultra and infrasound are also considered as sound vibrations, but, unlike noise, their frequency range lies beyond the sensitivity of human hearing. From the physical point of view, noise is a vibration that typically propagates as an audible wave of pressure, through a transmission medium such as gas, liquid or solid. The sources of sounds can be, for example, mechanical oscillations of structures or parts, non-stationary phenomena in gaseous or liquid media, etc.

The main characteristics of such oscillations are the amplitude of the sound pressure (p, Pa) and the frequency (f, Hz).

Sound pressure is the difference between the instantaneous indication of the full pressure in the environment in the presence of sound and the average pressure in this environment in the absence of sound It is the local pressure deviation from the ambient (average or equilibrium) atmospheric pressure caused by sound wave. The propagation of the sound field is accompanied by energy transfer, which can be determined by the intensity of the sound J (BT/M2), that is, the ratio of the energy of the sound wave propagated through a plane perpendicular to the direction of propagation of the wave to the area of this plane. In a free sound field, the intensity of sound and the sound pressure are interconnected

$$J = p \cdot V = p^2 / (\rho \cdot C), \tag{2.2}$$

in which J is an intensity Sound, W/m^2; p is a sound pressure, Pa; V is velocity, m/s (this is the rate at which the particles of the medium − gas, liquid, or solid in comparing to their equilibrium position, fluctuate with the ratio $V = p / (\rho \cdot C)$); ρ is a medium density, kg/m^3; C is the velocity of the sound wave in this medium, m/s.

Usually, sound vibrations are divided into three ranges: infrasonic with oscillation frequency less than 20 Hz, sound (those we hear) – from 20 Hz to 20 kHz and ultrasonic – more than 20 kHz. The propagation velocity of the sound wave C (m/s) depends on the properties of the medium and, above all, on its density. Thus, in a pneumatic medium under normal atmospheric conditions, $C \approx 344$ m/s; the speed of the sound wave in water is ≈1,500 m/s, in metals ≈ 3000...6000 m/s.

A person perceives sounds that he/she can hear (hereinafter – “the sound”) in a wide range of sound pressure and intensity (from the lower threshold of sensitivity to the upper – pain threshold), while the sounds of different frequencies are perceived differently. The biggest value of the sound which a person can perceive takes place in the range of 800–4000 Hz. The smallest lies in the range of 20–100 Hz.

The dynamic range of sound pressure in which a person perceives a sound without harming his health can reach 10^7 (this is the ratio of the sound pressure of the upper pain threshold to the audible pressure of the lower threshold of sensitivity at a frequency of 1000 Hz), with the equivalent dynamic range of intensity equal to 10^{14}. Considering that the auditory perception of a person is proportional to the logarithm of the amount of sound energy, the logarithmic values of the level of sound intensity (L_i) and the level of sound pressure (L_p), measured in decibels (dB), at absolute values are equal to each other ($L_i = L_p$).

Thus, the level of intensity and the level of sound pressure are determined by the following formulas:

$$L_i = 10Lg\,\frac{J}{J_0},\ \text{dB}; \qquad (2.3)$$

$$L_i = 20Lg\,\frac{P}{P_0},\ \text{dB}; \qquad (2.4)$$

in which J_0 − the value of the intensity of the sound at the lower threshold of human hearing at a frequency of 1000 Hz, $J_0 = 10^{-12}$ W/m^2; P_0 − the value of the sound pressure at the lower threshold of human hearing at a frequency of 1000 Hz, $P_0 = 2 \cdot 10^{-5}$ Pa.

At the upper pain threshold at a frequency of 1000 Hz, the intensity value is $J_p = 10^2$W/m^2, and the sound pressure $P_p = 2 \cdot 10^5$ Pa.

According to the nature of the spectrum, the following types of noise are distinguished: broadband – with a continuous spectrum of noise exceeding one octave wide; discrete (tonal) – when in the spectrum of noise there is a pronounced discrete tone.

According to the time characteristics, noise is divided into permanent and non-permanent.

Permanent noises include noises in which the sound level during the labour day varies by no more than 5 dBA.

Non-permanent noises include noises, the volume of which changes over a labour day by more than 5 dBa.

Permanent noise is also divided into noises with time fluctuations, intermittent and impulsive. Noises with time fluctuations are noises, the sound level of which constantly changes over time. Intermittent noises are those, the sound level of which can change dramatically (by 5 dBa or more), and the length of the intervals when the level remains constant is 1 s or more. Impulsive noises include noises that represent one or more sound signals of less than 1 s each.

The source of noise is characterized by the sound power W, which refers to the amount of energy emitted by this source in the form of sound per unit time.

The sound power level (dB) of the source is determined by the formula

$$L_W = 10Lg\,\frac{W}{W_0}, \text{dB}, \qquad (2.5)$$

in which W_0– threshold sound power equal 10^{-12} W.

In case when the source emits sound energy in all directions uniformly, the average intensity of sound an any point of space is determined by the following formula

$$J_a = \frac{W}{4\pi r^2}, \qquad (2.6)$$

in which r − the distance from the center of the sound source to the surface of the medium, which is distant to a sufficiently long distance so that the source can be considered as an point. If the radiation occurs not in the medium, but in a limited space, this is called the angle of radiation Ω which is measured in steradians. In this case

$$J_a = \frac{W}{\Omega r^2}. \qquad (2.7)$$

If the source of the noise is a device which is located on the surface of the earth, so Ω = 2π, for a dihedral angle Ω = π, and for a triangular angle Ω = π/2.

Noise characteristics are necessarily fixed in standards or technical specifications for cars and are indicated in the passports. The value of the noise characteristics is established, according to the requirements of ensuring the acceptable levels of noise at/for the workplace, adjacent residential areas and buildings.

Any noise in the production environment negatively affects the health of people and reduces their ability to work, and in some cases, due to the deterioration of the perception of external information under the impact of noise, may even lead to injuries, especially while performing dangerous technological operations.

Noise is one of the main harmful factors in modern production. The increase in equipment capacity, use of high-speed mechanisms in the production process, the sharp increase in number of vehicle lead to an increase in noise levels both in life and in production process.

The harmful effects of noise on the human body are quite diverse. The reaction and the perception of noise by a person depends on several factors: intensity, frequency (spectral composition), duration of action, time characteristics of sound signals, state of the organism.

The noise irritation is transmitted to the central and autonomic nervous systems via fibers of the auditory nerves and this is negatively effect on person and on her mental state. Through the central and peripheral nervous systems noise affects the internal organs, resulting in significant changes in the functional state of all the organism.

Moreover, the influence of noise on the nervous system is detected even at small levels of sound (30...70 dBA). In addition, if a person gets prolonged exposure to intense noise (above 80 dBa) it can even lead to a partial or complete loss of hearing.

Because of the prolonged noise exposure, there may occur deterioration of memory, dizziness, fatigue, irritability, etc. The objective symptoms of a noise illness are: reduction of auditory sensitivity; change in the digestion functions, which is expressed in problems/breach of acid-base balance in the stomach; cardiovascular problems; neuroendocrine disorder. Disorders in the work of the visual and vestibular apparatus also take place.

Standardization and Control of Noise

Sanitary-hygienic valuation, control of noise measurements are carried out in accordance with SSN 3.3.6.037-99 [7].

Harmfulness of noise as a factor of the production environment and the human life environment leads to the need to limit its levels. Sanitary-hygienic normalization and measurements of noise are carried out by the method of boundary spectra (BS) and the method of sound levels (SL).

The method of boundary spectra used for the regulation, control and measurement of constant noise and involves limiting the levels of sound pressure in octave frequency bands with average geometric values of 31.5; 63; 125; 250; 500; 1000; 2000; 4000 and 8000 Hz.

The sum of these boundary octave levels is called the boundary spectrum. Denote the boundary spectrum is devoted by the level of its sound pressure at a frequency of 1000 Hz. For example, "DS-75" means that this limit spectrum has a sound pressure level of 75 dB at a frequency of 1000 Hz.

The method of sound levels is used for indicative hygienic assessment, control and measurement of both permanent and non-permanent noise, for example, external noise of vehicles, urban noise, etc.

Thus, for the accurate estimation of the permanent broadband noise at workplaces it is allowed to use such a parameter, as a sound level in (dBA), which is measured on the time characteristic of the "slow" noise meter and is determined by the formula $L_A = 20\ell g P_A/P_0$, dB, in which P_A is average square sound pressure, taking into account the correction of the "A" noise meter, (Pas). In this case, noise is measured in accordance with the sensitivity of the human hearing apparatus, the total sound pressure level throughout the frequency range corresponding to the octave bands listed above. The sound level measured in this way enables to characterize the noise by nine-digit levels of sound pressure, both in the method of boundary spectra, and method of sound levels.

To characterize non-permanent noise at workplaces, a parameter of the equivalent sound level is introduced, which is an integral characteristic and is determined by the formula:

$$L_{A\text{eqv}} = 10\ell g \frac{1}{T}\int_0^T \left(\frac{P_A(t)}{P_0}\right)^2 dt, \qquad (2.8)$$

in which $L_{A\text{eqv}}$ − equivalent sound level, dBA; T − the duration of the noise; $P_A(t)$ − average square sound pressure, taking into account the correction "A" of the noise meter, Pa; P_0 − sound pressure values at the lower threshold of audibility ($P_0 = 2 \cdot 10^{-5}$ Pa).

An equivalent sound level (dBEq) for non-permanent intermittent noise is determined by the simplified formula

$$L^{\text{eqv}} = 10\ell g\, 1/T \sum_{i=1}^{n} t_i \cdot 10^{0,1L_j}, \qquad (2.9)$$

in which L_{eqv} is an equivalent sound level, dBA; T is the duration of the noise; t_i is a duration of the e-level; L_j is a sound level, dBA e-level; n is the number of non-permanent intermittent noise levels.

The procedure for measuring levels of sound using the noise level and the procedure for calculating the equivalent sound level is regulated by the SSN 3.3.6.037-99.

The impulse noise is standardised according to the maximum noise level (dBA).

Noise control at workplaces in accordance with the requirements of the SSN 3.3.6.037-99 shall be carried out at least once a year.

Noise can be measured by using a standard noise meter that includes a microphone, amplifier, filters (correction, octave) and indicator, and also with the help of modern computer equipment.

The total sound pressure level of several sources of noise can be determined by the formula

$$L_{sum} = 10 lg \sum_{i=1}^{n} 10^{0,1 L_j}, \tag{2.10}$$

in which L_j is an octave level of sound pressure of the investigated source, dB; i is the number of source; n is a total number of sources in the room.

If the number of sources is n > 2, so using the nomogram (Table 2.1), it is necessary to add successive levels starting with the maximum. First determine the difference between the two communicated levels, then add to the higher of the total levels. After that, the additive should be added to the more advanced levels.

*Table 2.1.*Table for calculating the sum of the sound level intensity (sound pressure)

L1-L2	0	1	2	3	4	5	6	7	8	9	10	15	20
△L	3,0	2,5	2,0	1,8	1,5	1,2	1,0	0,8	0,6	0,5	0,4	0,2	0

Measurement of the total noise value at the workplace shall allow to estimate the state of noise pollution and, if necessary, to select effective measures to control this harmful factor.

Measures and Means of Protection against Noise

The issue of noise control should be considered and analysed at the design stage of the enterprise, workplace, equipment. Usually, in order to solve this issue, organizational, technical and medical-preventive measures are used.

Organizational measures include the optimal location of production sites, equipment and workplaces, constant monitoring of the periods of labour and rest of the workers, restrictions of the use of equipment and workplaces that do not comply with sanitary and hygiene norms. These methods are effectively implemented on the basis of determining the total noise value in the specific production conditions, taking into account the type, specifications and quantity of equipment.

Technical measures enable to significantly reduce the level of noise the workers are exposed to and are divided into the following groups: applied to the source of origin (structural and technological), measures to stand in the way of distribution (sound insulation, sound absorption, noise silencing, soundproofing shelters) measures applied to the zone of perception (means of collective and individual protection).

Noise protection must be ensured, first of all, by the use of sound equipment, and just in case of the impossibility of solving this issue, through the use of measures and means of collective and individual protection.

In order to reduce the noise, it is necessary to use primarily the design and technological noise reduction techniques applied to the source of the sound itself. Highly effective method of reducing noise in the source of its occurrence in some cases may be a change of technology, for example, by replacing the shock interaction with a non-impact (replacing riveting by welding, forging – stamping, literary printing method – laser, etc.). When constructing mechanical equipment, first of all, one should try to reduce the level of fluctuations of the structure or its elements.

To reduce the noise of mechanical origin in the nodes in which the shock processes are carried out, it is necessary to reduce the perturbation forces, increase the contact time of the elements interacting with each other, increase internal losses in oscillatory systems, reduce the area of sound radiation, etc. This can be achieved by:

- replacement of reciprocating rotary movement;
- improvement of the quality of the balance of rotating parts;
- improvement in lubrication;
- replacing of rolling bearings with bearings of sliding;
- using other materials (for example, plastics);
- using vibration damping materials (mastics);
- implementation of vibration insulation of machines from their bases;
- using flexible joins;
- using gears with a special profiles.

Sources of aerodynamic noise may occur as a nonstationary phenomenon in gaseous and liquid media. Means of reducing aerodynamic noise in the source of its occurrence are achieved by:

- reduction of gas velocity;
- smoothing of hydraulic shock effects, by increasing the opening time of the shutters;
- reduction of vortices in jets due to the right selection of profiles;
- splitting of jets by means of nozzles;
- using ejectors that reduce radiation noise.

In hydrodynamic installations (pumps, turbines), it is necessary to prevent the occurrence of cavitation, which causes hydrodynamic noise.

It is also possible to reduce the level of subjective perception of noise by shifting the frequency spectrum into the zone of low frequencies or ultra-sound zone, which are inaccessible to human hearing.

The sources of electromagnetic noise are the mechanical vibrations of electrotechnical devices or parts that are stirred by alternating magnetic and electric fields. Methods for controlling such noise include the use of ferromagnetic materials with low magnetostriction, the decrease in the density of magnetic fluxes in electric machines with the help of the proper choice of these parameters, good tightening of the package of plates in the centers of transformers, chokes, anchors of engines, etc.; the slot grooves for windings in the stators and rotors of electric machines, which reduce the pulses of the forces of interaction of windings and stretch these impulses in time.

If the noise level in the source is still high, then the methods of reducing noise in the propagation path shall be applied, including the method of isolating the source or the workplace.

To reduce the sound reflected from the surfaces in the middle of the room, materials with high absorption of sound are used, that is, using the so-called method of noise reduction by sound absorption.

There are several types of noise, which penetrates the room in different ways: through the partition, which, under the influence of alternating pressure of the incident wave, fluctuates, emitting noise in the adjoining room; directly through the air through cracks and openings; due to the vibrations generated in building constructions. In the first two cases, we deals with the sounds that propagate through the air (air noise). In the third case, energy arises and propagates due to the elastic fluctuations of structures (walls, ceilings, pipelines), and such oscillations are also called structural or shock sounds.

Sound insulation from air noise is carried out with the help of enclosures, screens, partitions. Soundproofing barriers reflect the sound wave and in such way prevent the spread of noise. They may be both single-layered and multilayered.

The increase in the sound insulation of the fence maintaining its original mass is achieved by the following ways:

- the usage of fences that consist of two or more layers separated by air gaps or a layer of light fibrous material;
- changing its rigidity by increasing the internal friction in the structure with the help of the use of the corresponding fence material or applying a vibration damping layer, which allows to reduce the effect of resonant oscillations in the structure.

The reduction of sound transmission through partitions may also be carried out by:

- the elimination of all kinds of gaps and cracks, especially in doors and windows, as well as at the points of connection of different structures (for example, adjoining the ceiling to the wall);
- sealing the vestibules, double and triple glazing, placing tambourines near the door, etc., that is, by means of careful acoustic insulation of the "weak link" of the fences – windows and doors;
- reducing indirect transmission of sound (selection of appropriate building structures, installation of elastic elements and elements that absorb vibrations on the way of sound propagation, rational arrangement of structures with small and large masses, hinged design of structures instead of rigid ones, etc.).

In order to protect the workers of industrial sites with noisy technological processes or those, who work with especially noisy equipment special cabins for surveillance and remote control are arranged and installed. Those cabins are made of ordinary building materials in the form of insulated premises, equipped with ventilation, inspection windows, doors with tight fittings and vibration isolators to prevent the structural noise from entering the cabin, etc. The ceiling or part of the ceiling in the cabins may also be covered with sound absorbing materials. Particular attention is paid to the smudging of slots and holes in the passageways of communications.

The easiest and the cheapest means of reducing noise in industrial premises is the use of soundproofing enclosures that completely cover the most noisy aggregates. The essential advantage of this means is the ability to reduce noise in large volumes. Those soundproofing enclosures may be removable, collapsible, including mast-covered windows and doors. They are made of steel, duralumin, plywood, and other similar materials. The inner side of the casing must be faced with sound absorbing materials with the thickness of 30–50 mm.

Sound insulation from air noise is provided with the ordinary building materials – bricks, ordinary and reinforced concrete, metal, plywood, wood chips, glass, etc.

Such soundproofing materials as mats and slabs of glass fibers, soft wood chipboards, cardboard, rubber, metal springs, insulated linoleum etc. may be used in ceiling structures to reduce the transmission of structural (shock) sound, mainly in residential and public buildings.

If one needs to further reduce the sound energy reflected from the interior surfaces of the room, it is necessary to use sound absorbing structures and materials. These are, as a rule, constructions, which are made of brush materials. In such materials the energy of the sound waves is converted into heat energy.

Sound absorbing materials are applied by facing the interior surfaces of premises or appear in the form of independent structures – artificial absorbers, which are usually suspended to the ceiling. Drapery, soft armchairs, etc. are also used as artificial absorbers.

The use of sound absorbing structures can provide the effect of reducing the noise by 12–15 dB near these structures. Close to the source of the noise, the effect of noise reduction does not exceed 2–5 dBA. However, at the same time, due to the change in the structure of the sound field, discomfort acoustic conditions are reduced and the auditory adaptation of the human in the room improves.

The method of noise reduction by sound absorption is used in cases when it is impossible to provide normal acoustic conditions by means of noise reduction at the source of the noise and by means of sound insulation. It is advisable to apply this method in case when the proportion of direct and reflected sound in the room is almost equal to one another (diffusion acoustic field) and when there is a possibility to cover more than 60 % of the indoor surfaces with sound absorbing material.

To reduce the noise of gas-dynamic equipment, the silencers of noise are usually applied.

Mufflers are an integral part of plants with internal combustion engines, gas turbines and pneumatic motors, fan and compressor units, aerodynamic devices, etc. The mufflers are divided into two types: the mufflers with sound absorbing material (active ones) that absorb sound energy; the mufflers without sound absorbing material (reactive ones), which reflect the sound energy back to the source. Mufflers with absorbent materials (tubular, plate, screen mufflers) are used in compressor and ventilation installations. At high frequencies, their efficiency can reach 10–25 dB. Mufflers without sound absorbing material are used mainly in piston machines, pneumatic and rotary engines and internal combustion engines. Their construction is tuned to individual frequency bands that have the highest energy of radiation, and have a noise reduction effect of up to 30 dB.

The means of personal protection against noise is applied in cases where other (constructive and collective) methods of protection do not provide acceptable levels of sound. Personal protective equipment (PPE) can lower the sound pressure levels by 7–45 dB. The inserts in the form of tampons that are inserted into the auditory canal are the most widely-used. However, the silent headphones that cover the auricles outside, as well as helmets and caps are quite commonly used too. For example, in order to reduce the mid-frequency and high-frequency noise, the most appropriate way of protection is the use of headphones of the type PSH-B and VTSNIIOT-2M, or inserts of PUZ type “Berlushi ST-1” or “Fungus” type. To name a few, the following domestic examples of PPE are used for protection against noise: PSH-B silent headphones that are designed to protect hearing aids from the effect of mid-frequency and high-frequency noise levels up to 115 dBA and have efficiency (average noise reduction), depending on the frequency from 5 to 32 dB; fireproof inserts “Berushi ST-1”, which are designed to protect hearing aids from industrial and domestic noise and are disposable products with a warranty period of 5 years from the date of manufacture.

2.3.2. Sources, evaluation and ultrasound and infrasound protection methods

Ultrasound is used in a variety of industries. For example, in technology the ultrasound is used for dispersing liquids, cleaning surfaces, welding plastics, metal defectoscopy, purifying gases from harmful impurities, etc.

For the treatment of liquid melts, purification of castings and in devices for gas purification, the sources of ultrasound are the generators that operate in the frequency range from 12 to 22 kHz.

In galvanic workshops, ultrasound occurs during the process of cleaning and degreasing baths. Its effects may be observed at a distance of 25–50 m from the equipment. A contact effect of ultrasound appears in the process of loading and unloading parts.

Ultrasonic generators are also used for plasma and diffusion welding, metal cutting, metal spraying. Ultrasound of high intensity occurs during the process of removing the contaminants with the help of chemical etching, blown by a jet of compressed air when cleaning parts and their assembly.

Ultrasound affects the human body mainly during the direct contact with the equipment that generates ultrasound, as well as through the air. **Ultrasound causes functional disorders of the nervous system, headaches, changes in blood pressure and the composition and properties of blood, causes loss of auditory sensitivity and increased fatigue.** However, after taking some safety precautions, ultrasound shall not affect the state of person's health.

All mechanisms that operate at rotational speeds less than 20 rpm emit infrasound. Thus, when the car accelerates to 100 km/h and more it becomes a source of infrasound, which appears due to the air flow repulsing from its surface. In the machine-building industry, infrasound occurs during the functioning of fans, compressors, internal combustion engines, diesel engines, etc.

Infrasound is one of the most unfavorable factors in the production environment. It is characterized by high penetrating and biological abilities. When the levels of sound pressure exceed 110–120 dB, there occurs a very negative effect on human health.

External oscillations of a frequency of less than 0.7 Hz violate the normal functioning of the vestibular apparatus of people. Infrasonic vibrations (less than 16 Hz) affecting a person's health, suppress the central nervous system, causing anxiety and fear. At a frequency of 6...7 Hz and with a certain intensity, the infrasonic vibrations may affect intravascular organs and circulatory system, which can cause injuries, rupture of the arteries, and even serious traumas.

Valuation of Ultra- and Infrasound, Ultrasound and Infrasound Control

According to SSN 3.3.6.037-99 [7], the ultrasonic frequency range is divided into a low-frequency range (from $1{,}12 \cdot 10^4$ till $1{,}0 \cdot 10^5$ Hz), when ultrasonic vibrations are distributed both by air and by direct contact, and high frequency range (from $1{,}0 \cdot 10^5$ till $1{,}0 \cdot 10^9$ Hz), when ultrasonic vibrations are distributed only by direct contact.

Acceptable levels of ultrasound pressure are fixed according to SSN 3.3.6.037-99, and are fixed considering eight-hour labour day (Table 2.2).

Table 2.2. Acceptable levels of ultrasound pressure

Average geometric frequency of octave bands, kHz	16	31,5	63 and higher
Acceptable pressure levels, dB	88	106	110

The acceptable levels of ultrasound for the contact areas of the worker's body and the moving parts of machinery should not exceed 110 dB.

Under the condition of the continuous action of ultrasound from 1 to 4 hours per shift, the normative value can be increased by 6 dB, with exposure from 1/4 to 1 hour – by 12 dB, from 5 to 15 minutes – by 18 dB, from 1 to 5 minutes – by 24 dB.

In order to evaluate the ultrasound, the measuring point is taken at the level of the human head at a distance of 5 cm from the ear. The microphone should be directed towards the source of the ultrasound and the distance between that source and the person, who performs the measurement should not be less than 0.5 m.

The measuring equipment includes a microphone, 1/3 octave filters and a measuring device with standard time characteristics.

When measuring the levels of ultrasound at the point of contact with the solid medium, the ultrasonic oscillation sensor is used instead of the microphone.

In order to determine the ultrasonic characteristics of the ultrasonic equipment, the measurements are performed at control points at an altitude of 1.5 m from the floor, at a distance of 0.5 m from the equipment and not less than 2 m from the surrounding surfaces. The number of control points must not be less than four and the distance between them should not exceed 1 m.

According to SSN 3.3.6.037-99, the following characteristic property of the constant infrasound at workplaces is applied: the level of sound pressure in the octave bands of frequencies with average geometric frequencies 2; 4; 8; 16 Hz in decibels.

For non-constant infrasound, the standard parameter is the total equivalent level of sound pressure on the “linear” noise meter in dBlin. An equivalent level is determined according to the applications.

Acceptable levels of infrasound pressure in octave bands are shown in Table 2.3.

Table 2.3. Acceptable levels of infrasound pressure in octave bands

Acceptable sound pressure levels in dB in octave bands with geometric frequencies, Hz				Total sound pressure level, dB lin
2	4	8	16	
105	105	105	105	110

Methods of ultrasound and infrasound protection

In order to reduce the harmful effects of the high levels of ultrasound, to decrease the harmful radiation of sound energy at the source and to localize the impact of ultrasound, the constructive and planning decisions, as well as the organizational and preventive measures shall be carried out. The decrease in harmful radiation at the source can be achieved, for example, by increasing the nominal operating frequencies of ultrasound sources and eliminating parasitic radiation of the sound energy. To localize the effect of ultrasound, constructive and planning solutions are applied: soundproofing housings, semi-shades, screens; separate rooms and cabins with ultrasound equipment; ultrasound generator and remote control; lining of premises and cabins with sound absorbing materials. The organizational and preventive measures include a briefing about the nature of the action of the high levels of ultrasound and the protection against them, as well as the organization of a rational schedule of labour and rest.

For personal ultrasound protection, as a rule, the double gloves with an air layer and ear defender against ultrasound are used.

Labour protection requirements for the usage of ultrasound equipment are regulated by GOST 12.2.051-80 [8].

Due to the very small damping of infrasound in the air, it propagates over very large distances. It is almost impossible to stop the infrasound with the help of building structures during its distribution. Personal protection is also ineffective. The only effective protection method is lowering the level of infrasound at the source of its radiation. That is, the introduction of constructive changes in the structure of the sources, which allows to move from the region of infrasonic vibrations to the area of sound, for example, by increasing the rotational speeds of shafts up to 20 and more revolutions per second; increase of stiffness of constructions; eliminating the causes of low-frequency vibrations and resonance phenomena; application of sound insulation and sound absorption; reduction of intensity of aerodynamic processes, etc.

2.3.3. Sources, Rating and Methods of Vibration Protection

Vibration is any mechanical oscillation of elastic bodies or oscillatory motion of mechanical systems, exerted in its movement in space or in change of its shape. In the manufacturing various technological processes, machines, auxiliary mechanisms, electric motors, fans, shakers, transformers, pumps, compresses, etc. can be the sources of vibration. From a physical point of view there is no fundamental difference between vibration and noise. The difference is in person’s perception of these phenomena. We perceive the noise by the organs of the ear, and the vibration we perceive haptically, by the skin, or the entire body due to the vestibular system. For a person, vibration is a kind of mechanical impact, which has very negative consequences for the health.

The main reasons why the vibration occurs are unbalanced forces and shock processes in the operating mechanisms. Creation of high-performance powerful machines and high-speed vehicles while reducing their material intensity inevitably leads to an increase in the intensity and expansion of the spectrum of vibration and vibroacoustic fields. Widespread usage of vibration in the industry and the construction of highly effective mechanisms also facilitates this.

Except negative influence on a person, the action of vibrations can lead to the transformation of the internal structure and surface layers of materials, changes of friction conditions and wearing out on the contact surfaces of machine parts, heating of the constructions. Due to the vibration dynamic loads in the elements of structures and joints increases, the load bearing capacity of the parts reduces, cracks are initiated, equipment destruction occurs. All this leads to a decrease in the service life of the equipment, an increase in emergencies probability and the growth of economic costs. It is believed that 80 % of accidents in machines and mechanisms is a result of vibration. In addition, oscillations of structures are often a source of undesired noise. Vibration protection is a complex, multifaceted scientific and technical problem that needs to be solved.

To determine the nature of the vibration effect, first of all, it is necessary to determine the intensity of its oscillations, frequency or spectral composition, duration of influence and direction of action.

Indicators of intensity of vibration are the rms or amplitude values of vibration acceleration (*a*), vibration velocity (υ), vibration displacement (*x*). Parameters x, υ , a – are interconnected, and for sinusoidal vibrations the value of each of them can be calculated by the values of another by the correlation:

$$a = \upsilon(2\pi f) = x(2\pi f)^2, \tag{2.11}$$

where: $2\pi f$ – is a circular frequency of vibration, ω.

The logarithmic scale (dB) is used to estimate the vibration levels. Logarithmic levels of vibration velocity (L_υ) in dB can be determined by the formula:

$$L_\upsilon = 20 \lg \frac{\upsilon}{\upsilon_0}, \tag{2.12}$$

where: υ is the Rms value of vibration velocity, m/s,; υ_0 is the bearing value of the vibration velocity equal to $5 \cdot 10^{-8}$ m/s (for the local and general vibrations).

Logarithmic vibration acceleration levels (L_a) in dB are determined by the formula:

$$L_a = 20 \lg \frac{a}{a_0}, \qquad (2.13)$$

where: a is the Rms value of vibration acceleration, m/s^2; a_0 is the bearing value of vibration acceleration equal to 3 x 10^{-4} m/s^2.

By the method of transmission to the human body there are two types of vibration: general and local. General vibration is the one that causes fluctuations in the entire body, while the local one draws only the individual parts of the body (arms, legs) into oscillatory movements.

Local vibration, affecting person's hands, is formed by many hand-held machines and mechanized tools, as well as while driving vehicles or machines or during a construction and assembly work.

There are three categories of vibration by the source:

Category 1 – transport vibration, which effects on a person dealing with of self-propelled and hauling machines, vehicles during their movement in the area, agricultural backgrounds and roads (also during their construction).

The sources of transport vibration include, for example, agricultural and industrial tractors, self-propelled agricultural machines, lorries (including scrapers, graders, rollers, etc.), snow removers, self-propelled mining rails, etc.

Category 2 – transport-technological vibration, which effects on people dealing with limited-mobility cars and the ones that are able to move only on specially prepared surfaces of industrial premises, industrial and mining sites.

The sources of transport-technological vibration include, for example, excavators (including rotary), industrial and construction cranes, open-hearth furnaces (forging), mining combines, self-propelled drill carriages, road machines, concrete pavers, transport of industrial premises.

Category 3 – technological vibration, which effects on a person at the workplace of stationary machines or can be transferred to workplaces that do not have sources of vibration.

The sources of technological vibration include, for example, machine tools and metal, woodworking and press-forging equipment, casting machines, electric machines, separate fixed electrical installations, pump units and fans, well drilling equipment, drilling rigs, machines for Livestock breeding, cleaning and sorting of grain (including dryers), equipment for building materials industry (except concrete workers), plants for chemical and petrochemical industry, etc.

In turn, the total technological vibration by the place of action is divided into the following types:

a) on permanent workplaces of industrial premises of factories;

b) at workplaces at warehouses, dining rooms, household, duty and other industrial premises, where there are no sources of vibration;

c) at the workplaces of plant managements, design bureaus, laboratories, educational centers, computer centers, medical centers, office premises, work rooms and other premises for employees of mental work.

By source, the local vibration can be transmitted from:

- hand-held machines or manually mechanized tools, machinery and equipment control systems;
- hand-held tools without motors (for example, rivet hammers) and processed parts.

By the direction of action, general and local vibrations are characterized taking into account the axes of the orthogonal coordinate system X, Y, Z.

By time characteristics general and local vibrations are divided into:

- permanent, for which the value of vibration acceleration or vibration velocity varies less than 2 times (less than 3 dB) per working shift;
- impermanent, for which the value of vibration acceleration or vibrational velocity varies at least 2 times (3 dB or more) per shift.

The influence of vibrations on a person depends on its spectrum composition, activity direction, place of application, duration of the influence, as well as on individual characteristics of a person. In assessing of the vibration effects, it should be taken into account that oscillatory processes are inherent to living organisms. In this manner, cardiac activity, blood circulation and flow of bioelectric currents of the brain are based on rhythmic vibrations. The internal human organs can be regarded as oscillatory systems with elastic bonds, herewith their own resonant frequencies are in the range of 3...6 Hz. As for the own resonance frequencies of the shoulder girdle, the hips and the head in relation to the support surface (standing position), they are 4...6 Hz, and the head in relation to the shoulder (sitting position) 25...30 Hz. Thus, when external fluctuations (forces, shakes, vibrations) influence on a person, their interaction with internal wave processes occurs, it leads to the appearance of resonant phenomena.

Vibration that affects human has a very wide range of frequencies – from tenths quotient to several thousand Hz. Characteristic features of vibration harmful effects on a human constitute possible changes in person's functional state. This is, first of all, an increase of fatigue, an increase in the motor reaction time, a violation of the vestibular reaction. Medical research has established that vibration is an irritant on peripheral nerve endings located at the areas of the human body that perceive external oscillations.

An adequate physical criterion for assessing its effects on the human body is the oscillating energy that occurs on the contact surface, as well as the energy absorbed by the fibers and transmitted to the locomotor apparatus and other organs. As a result of the influence of vibration there are neurovascular disorders, lesions of the bone and articular and other systems of the body. There are, for example, changes in the function of the thyroid gland, the genitourinary system, the gastrointestinal tract.

As medical studies in this area have shown, workers, who undergo vibration, meet significant changes in the bone and joint system, which are expressed in functional restoration of bone fiber, regional osteoporosis, cystic formations in bones, chronic fractures. The timing of vibration occupations workers' bone changes varies from 6–8 months to 2–5 years.

It should be noted that the harmfulness of vibration increases with simultaneous influence of such factors as reduced temperature, increased noise levels, air pollution, prolonged static tension of the muscles, etc.

Modern medicine considers industrial vibration as a significant stress factor that has a negative impact on psychomotor efficiency, emotional sphere and mental activity of a person, increases the probability of various diseases and accidents. Prolonged exposure of vibration is particularly dangerous for female body. This wide range of pathological deviations caused by the effects of vibration on the human body is qualified as a vibration disease.

Studies have shown that the vibration illness can go unnoticed for a long period of time, while patients remain productive and do not seek medical assistance. Eventually the systematic effect of vibration causes an exacerbation of an already existing disease, which may have three stages (degrees) of severity. It is noted that effective treatment of vibration illness is possible only in the early stages, wherein the restoration of violated functions proceeding, as a rule, is very slowly and, in some cases, there are irreversible changes that lead to disability. Thus, the vibration has a very negative impact on both the ability to work and the health of a person. Among professional pathologies, vibration disease is one of the most frequent.

Standardization and control of industrial vibration

For the hygienic assessment of vibration affecting a person in the production environment, it is recommended to use one of the following methods of analysis:

- frequency (spectral) analysis of its parameters;
- an integral estimation by the spectrum of the frequencies of standardized parameters;
- the dose of vibration.

Under the action of a constant local and general vibration, the normalized parameter is the rms value of the vibration velocity ($\upsilon_{\text{av sq}}$) and vibration acceleration (a) or their logarithmic levels L_υ, L_a y dB in the range of octave bands with average geometric frequencies f_{av}: 8,0; 16,0; 31,5; 63,0; 125,0; 250,0; 500,0; 1000,0 Hz – for local vibration; 1,0; 2,0; 4,0; 8,0; 16,0; 31,5; 63,0 Hz or in the range of 1/3 octave bands 0,8; 1,0; 1,25; 1,6; 2,0; 2,5; 3,15; 4,0; 5,0; 6,3; 8,0; 10,0; 12,5; 16,0; 20,0; 25,0; 31,5; 40,0; 50,0; 63,0; 80,0 Hz – for general vibration.

The rms value of vibration velocity ($\upsilon_{\text{av aq}}$) for period T is determined by the formula:

$$\upsilon_{\text{av aq}} = \sqrt{\frac{1}{T} \cdot \int_{t}^{t+T} \upsilon^2 (t) dt} . \qquad (2.14)$$

The geometric frequency is determined by the formula:

$$f_{gf} = \sqrt{f_u \cdot f_l}\ , \tag{2.15}$$

where: f_u, f_l – are the upper and the lower limits of the frequency band.

The normalized parameters, with an integrated evaluation of the spectrum of frequencies, are the corrected value of vibration velocity (υ) or vibration acceleration (*a*), or log logarithms (*L*), which are measured by means of correction filters or are calculated.

Corrected value of vibration velocity or vibration acceleration is determined by the formula:

$$\sum_1^n V = \sqrt{\sum_1^n (\upsilon_i \times K_i)^2}\ , \tag{2.16}$$

where: υ_i – rms value of vibration velocity or vibration acceleration in the i-th frequency band; *n* – the total number of frequency bands (1/3 or 1/1 octave) in the normalized frequency range; K_i – the weight coefficient for the i-th frequency band (according to the absolute values of the vibration velocity and vibration acceleration of local and total vibration, are given in the SSN 3.3.6.039-99) [9].

In the case of a non-constant vibration (other than a pulse), the normalized parameter is the vibration load (vibration dose *D*, equivalent to the corrected level) obtained by the worker during the change and fixed by a special device or calculated for each direction of vibration action (*X*, *Y*, *Z*) by formulas:

$$D = \int_0^t V^2(t)dt. \tag{2.17}$$

In the case of non-permanent vibration (except pulse), the normalized parameter is the vibration load (vibration dose *D*, equivalent corrected level $L_{corr.eq.}$):

$$L_{corr.eq} = L_{corr} + 10\ lg\ (t/t_{ch}), \tag{2.18}$$

where: *D* – vibration dose; $L_{corr.eq.}$ – Corrected value of vibration levels, dB; *V*(*t*) – Adjusted by frequency of the value of the vibration parameter (vibration velocity or vibration acceleration); T – vibration time, *h.*; $t_{ch.}$ – Duration of change; *h*.

An equivalent corrected vibration velocity or vibration acceleration is calculated by power addition of levels based on the duration of each of them.

Under the action of pulsed vibration with a peak vibration acceleration from 120 to 160 dB, the normalized parameter is the number of vibrational pulses per shift (hour), depending on the duration of the pulse.

Normative values of vibration are established according to SSN 3.3.6.039-99 providing its operation during working hours 480 minutes (8 hours).

Methods and means of vibration protection

The main measures of protection human from the harmful effects of vibration in the manufacturing environment can be divided into technical, organizational, therapeutic-preventive, collective and individual.

The technical measures include:

• reduction of vibration at the source of its occurrence (choice at the design stage of kinematic and technological schemes, which reduce the dynamic loads in the equipment, etc.);

• reduction of active vibration on the way of propagation from source (vibration absorption, vibration dampening, vibration isolation).

The organizational measures include:

• organizational and technical (timely repair and maintenance of equipment according to the technological regulations, control of acceptable levels of vibration, remote control of vibro-dangerous equipment);

• organizational and regime (implementation of the appropriate regime of work and rest, the prohibition of engaging in vibrational work people younger than 18 years, etc.);

The medical and preventive measures include:

• periodic medical inspections;

• therapeutic procedures (physiological procedures, vitamin- and phyto-therapy).

The most important direction of protection against vibration is the use of constructive methods for reducing the vibrational activity of machines and mechanisms, for example, by reducing the operating forces in the design and changing its parameters (stiffness, reduced mass, friction, use of damper devices).

The main methods of the machine vibrations control are:

• reduction of vibration in the source due to reduction of existing variable forces (F_m) (for example, at the expense of balancing the masses, replacing impact technologies with non-impact ones, using special types of coupling in drive machines, etc.);

• detection of resonance regimes due to rational choice of reduced mass m (when $\omega > \omega_0$) of stiffness q (when $\omega < \omega_0$) of the system or the change in the frequency of excitatory force (ω);

• vibration damping – an increase in mechanical losses (μ) with fluctuations near resonance modes, for example, due to the use of materials with large internal friction: plastics, manganese and copper alloys, application of elastic-viscous materials to the vibrational surfaces, etc.;

• dynamic quenching – the insertion of additional masses into the oscillatory system and a change in its rigidity, which allows attachment to the vibrating object, an additional vibrational system that moves in the "antiphase" with the fluctuations of the object itself.

Vibration isolation is widely used to reduce the vibration impact on equipment and people, which is the inserting into the oscillatory system an additional elastic bond, which weakens the vibration transmission of the object that is protected. For vibration isolation of machines with vertical agitation force, vibro-insulating supports are used in the form of springs, elastic linings, for example, rubber, and its combinations.

Vibration isolator is pretty simple in design, which is a rubber bar placed between metal plates that can be glued to this bar. The height is chosen by the size of the required static compression, taking into account the stability and strength of the rubber bar, and the size of the metal plate, determined on the basis of acceptable load on a single vibration isolator. With a significant increase in the size of the plate compared to the height of the bar, the rigidity of the vibration isolator increases rapidly and its work becomes ineffective. For the same reason, ineffective vibration isolators, which consist of continuous thin rubber sheets. Instead, it is better to use rubber mats made of industry manufactured corrugated rubber.

In general, rubber and rubber-metal vibration isolators are used extensively and have many modifications. The advantages of rubber vibration isolators are the simplicity of their construction and low cost, and the disadvantages are the rapid aging of rubber, the possibility of its destruction by petroleum products, low efficiency in protecting against low-frequency vibrations.

For protection against low-frequency vibrations the springs which provide the required static compression and low own resonant frequency of the system are used. The shock absorber makes friction in the oscillatory system and softens the transmission of impulses and impacts due to the nonlinear dependence of the friction force on the deformation rate.

Effective additional protection measures, for example for tractor drivers, are vibration isolators that are installed between the cabin and the frame, as well as between the controls and the cabin.

In cases where the technical means can not reduce the level of vibration to the norm, the provision of the workers with personal protective equipment is provided. Personal protective equipment (PPE) can be used for the entire body of a person, and separately for the legs and hands. As such means, vibration insulating gloves and vibration insulating shoes, which have elastic pads and protect the worker from the effects of high-frequency local vibration are used. The effectiveness of such gloves and shoes is not very high, because the thickness of these pads cannot be large enough. Because of this, they do not significantly reduce the vibration at low frequencies, and at high (more than 100 Hz) their efficiency is reduced due to the wave properties of the tissues and fibers of the human body. Personal protective equipment against harmful effects of general and local vibration (footwear, gloves, etc.) must meet the requirements of GOST 12.4.024-76 [10]. To reduce the impact of local vibration, which operates when working with punches and punch hammers, special devices to control bodies are used. These may be devices with elasticity elements that can be bent, compressed or twisted, or devices with telescopic or hinged elements.

2.4. Electromagnetic fields and radiation

2.4.1. Sources, evaluation and protection measures from electromagnetic fields

Electromagnetic fields (EMF) – a special form of organization of matter. As you know, our planet for already billions of years is penetrated by the streams of electromagnetic radiation – the cosmic, near-Earth and terrestrial origin. The wavelengths of the electromagnetic spectrum of these emitters lie in the range from tenths of a millimeter to thousands of kilometers, with each of the sections of this extremely wide spectrum playing its unique role in the development of the Earth's biosphere.

Characteristics of the electromagnetic field of the Earth's biosphere (natural and artificial electromagnetic background)

Earth's electric field. The electric field of the Earth is directed perpendicularly to the earth's surface (charged negatively relative to the upper layers of the atmosphere). The voltage of the electric field near the surface of the $E_{Earth} \approx 130$ V/m and decreases with height according to the exponential law (at a height of 9 km $E_{Earth} \approx 5$ V/m). The changes in the E_{Earth} during the year are similar in character throughout the globe: the magnitudes of E_{Earth} reach a maximum in January-February (up to 150...250 V/m) and a minimum in June-July (100...120 V/m). Daily changes in the electric field of the atmosphere are related both to the total, and to the local lightning activity on the globe.

Earth's magnetic field. The tension of the magnetic field of the Earth is characterized by two components. The horizontal component is maximal near the equator (20...30 A/m) and decreases in the direction of the poles (to units A/m). The vertical component at the poles is 50...60 A/m, decreasing in the direction of the equator to a meager value. There are separate regions on the globe where the magnitude of the vertical component is much higher (positive anomalies) or below (negative anomalies) of the mean value.

EMF of the atmosphere. The frequency spectrum of atmospherics ranges from hundreds of hertz to tens of megahertz. The maximum of their intensity is at a frequency of about 10 kHz and decreases with frequency. The intensity of thunderstorm activity is always and everywhere minimal in the morning and rises closer to night. During flares on the Sun, the activity of the EMF of the atmosphere is greatly enhanced.

Radiation of the Sun and the galaxies. The radiation spectrum of the Sun and the galaxies occupies a plot of approximately from 10 MHz to 10 GHz. In a calm state, the intensity of the sun's radiation is in the range of 10^{-10} to 10^{-8} W/m^2. During bursts of radiation, the radiation increases several dozen times. The spectrum and intensity of the radio emission of galaxies are close to the spectrum and intensity of the calm Sun.

Components of the EMF of the biosphere mentioned above form the so-called natural electromagnetic background of the Earth.

Artificial sources of EMF. The most powerful artificial sources of the EMF of the radio frequency range, in the first place, are television stations and broadcasting stations, space and cellular communication systems, radar and radio relay stations, etc. The intensity of the radio emission of such artificial sources is directly dependent on the power of generators, the proportion of energy transmitted to the radiation, as well as the ratio of the radiation action of the radiators and the distance to the radiators. The intensity of the antenna fields can vary (depending on the listed factors) from the fractions of microwatts to several watts per square centimeter, from hundreds of micro-volts to hundreds of volts per meter. The intensity of radiofrequency of artificial sources is also influenced by the so-called “parasitic” radiation of equipment, which is determined by the effectiveness of their shielding.

Unlike the natural one, the characteristic feature of this type of radio frequency is high coherence – frequency and phase stability, which also means high energy concentration in very narrow areas of the spectrum (for example, dozens of dents for a telegraph, units of kilohertz for a radio-telephone, units of megahertz for radar equipment, etc.)

The sources of the electrostatic field and the permanent magnetic field are diverse industrial and technological equipment, including electric power and DC motors, magnetic devices and materials, video terminals of electronic computers on electron-beam tubes, etc.

Sources of electromagnetic fields of industrial frequency are electrical equipment and transmission lines of any kind, especially high-voltage transmission lines.

Classification of electromagnetic radiation by frequency is given in the table 2.4.

Table 2.4. Classification of electromagnetic radiation by frequency

Name of the frequency range	Limits of the frequency range	Limits of the wave range
Static electric and magnetic fields	0 Hz	–
Infrared IRF	0,3…3 Hz	1000…100 Mm
Extremely low ELF	3…30 Hz	100…10 Mm
Super low SLF	30…300 Hz	10…1 Mm
Ultra-low ULF	0,3…3 kHz	1000…100 km
Very low VLF	3…30 kHz	100…10 km
Low LF	30…300 kHz	10…1 km
Medium MF	0,3…3 MHz	1…0,1 km
High HF	3…30 MHz	100…10 m
Very high VHF	30…300 MHz	10…1 m
Ultra-high UHF	0,3…3 GHz	1…0,1 m
Super high SHF	3…30 GHz	10…1 sm
Extremely high EHF	30…300 GHz	10…1 mm
Tremendously high THF	300…3000 GHz	1…0,1 mm

Variants of the ENF influence on bio ecosystems, including humans, are very diverse. For example, it can be continuous and intermittent irradiation of EMF, general and local, combined from several sources and interacting with other adverse environmental factors.

Mechanisms of interaction of EMF with living organisms are also very diverse and proceed on all levels: molecular, cellular, organism and population. In this case thermal effect, morphological and functional changes shall be distinguished.

If such a fiber is placed in a constant electric field, then it is polarized to varying degrees, and charged particles – ions that are always present in liquid media of the fibers, due to the electrolytic dissociation of the molecules, will be displaced along the lines of the field to the opposite sides of the poles. In relation to them charges. In the case of dipole molecules, they will also receive an appropriate orientation. In the variables of the EMF, the electrical properties of living fibers predominantly depend on the frequency of these fields, and increasing the frequency they lose the properties of dielectrics growingly and acquire the properties of conductors.

The existence of loss of energy of EMF on conduction currents and displacement in fibers of human body during its irradiation of EMF leads to heat release.

The presence of reflection on the edge of the “air-fabric” leads to a reduction in the thermal effect at all frequencies approximately the same.

Taking into account the coefficient of reflection at the separation limit, ρ absorbed energy will be equal to

$$E_{abs} = E_0(1-\rho)\,, \tag{2.19}$$

where E_0– the energy of the EMF falling on the human body.

The depth of penetration of EMF in the depths of fibers depends on the resistive and dielectric properties of fibers and on the frequency (Table 2.5).

Table 2.5. Depth of penetration of EMF in different fibers in the particles of wavelengths

Fiber	Wavelength λ, sm							
	300	150	75	30	10	3	1,25	0,86
Brain	0,012	0,028	0,028	0,064	0,048	0,053	0,059	0,043
Lens	0,026	0,03	0,056	0,098	0,05	0,057	0,055	0,043
Glandular body	0,007	0,011	0,019	0,042	0,054	0,063	0,036	0,036
Fat	0,068	0,083	0,12	0,21	0,24	0,37	0,27	–
Muscles	0,011	0,015	0,025	0,05	–	0,1	–	–
Skin	0,012	0,018	0,029	0,056	0,066	0,063	0,058	–

Numerous studies on the biological effects of EMF have made it possible to determine that the most sensitive systems of the human body are nervous, immune, endocrine and sexual. These organism systems are critical to the effects of EMF and the responses of these systems must necessarily be taken into account in the assessment of the risk of EMF exposure.

With prolonged influence of EMF functional changes in the human body can be manifested in the form of headaches, disturbance of sleep, increased fatigue, irritability, sweating, loss of hair, pain in the area of the heart, decrease in sexual potency, etc.

It should be borne in mind that the biophysical and physiological mechanisms of EMF activity in the conditions of long-term effects tend to accumulate in the human body. As a result, development of long-term consequences, including irreversible processes in the activity of the central nervous and cardiovascular systems, blood cancer (leukemia), brain tumors, hormonal diseases, hypotension, bradycardia, liver disease, etc., is possible.

Quantitatively, the risk of an electromagnetic field influence per person can be estimated by the amount of electromagnetic energy absorbed by the body in the unit of time (*W*) or the specific energy absorbed per unit time by one unit of body weight (W, W/kg). Thus, to assess the risk of an electromagnetic field from radiotelephones and cellular and satellite telephones, the power of the EMF absorbed per kilogram of brain is determined by the SAR (Specific Absorption Rate) parameter.

Standardization and control of electromagnetic fields

The standardization of EMF is carried out according to GOST 12.1.006-84 [11]; SSN No.239-96 [12]; SSN No 476-2002 [13]. Electric field of industrial frequency. Permitted levels of tension and requirements for conducting control at workplaces; GOST 12.1.045-84 [14].

According to the documents, the normalization of EMF is carried out as follows:

- constant electric and magnetic fields, as well as EMF variables of frequency 50 Hz (industrial frequency), are normalized by the intensity of the magnetic H and electric E fields; The unit of magnetic field intensity is an ampere per meter (A/m), and the electric field – volts per meter (V/m);

- the electromagnetic fields of the radio frequency range with frequencies of 1 kHz to 300 MHz are normalized according to the intensity (voltage of electric E and magnetic component H) and the energy load of electric and magnetic fields, taking into account the time of influence (EH_E, EH_H); The electric field strength is the unit of electric field intensity is V/m, the magnetic field is A/m, the energy load is the product of the square of the EMF intensity at the time of its influence, which has the dimension (W/m) 2h – for the electric field and $(A/m)^2$·year – for a magnetic field;
- the electromagnetic fields of the radio frequency with frequencies of 300 MHz to 300 GHz are normalized by the intensity (energy density fluctuation EDF) and the energy load of the energy density fluctuation (EL_{EDF}); The unit of measurement of EDF is W/m^2; Energy load – the product of the EDF of incident radiation at the time of its influence during the working shift in hours (h) is expressed in W·h/m^2.
- in the case of pulsed-modulated radiation, the normalized parameter characterizing the intensity of the EMF's influence is the mean value of the EDF.

Electrostatic fields. The threshold limit value (TLV) of the electrostatic field (E_{tl}, kV/m) depends on the time of the action of this factor on the human body during the labour day.

$$E_{tl} = 60/\sqrt{t}\ , \qquad (2.20)$$

where E_{tl} (kV/m) is the threshold limit value of the electric field intensity in the controlled zone, t (h) – the time of the electrostatic field effect on the human body.

According to normative documents, the surface electrostatic potential of the VDT should not exceed 500 V, and the electrostatic field strength at the works with VDT should not exceed 20 kV/m.

Constant magnetic fields. Threshold limit value (TLV) of a permanent magnetic field (H_{tl}, kA/m) during a labour day should not exceed 8 kA/m.

For **magnetic fields created by straightened three-phase current**, the maximum acceptable level is determined by the formula.

$$H_{tl} = \left(EH_{Htl}/T\right)^{1/2}, \tag{2.21}$$

where H_{tl} (kA/m) is the Threshold limit value of the magnetic field strength; EH_{Htl} (kA^2·year/m^2) – the maximum acceptable value of the energy load during the labour day, which is equal to 144 kA^2·h /m^2; T (h) – time of influence of a magnetic field created by straightened three-phase current.

EMF of industrial frequency. According to the existing norms, the threshold limit value (TLV) of the EMF of the industrial frequency (50 Hz) is determined by the Threshold limit value of the tensions of its electrical and magnetic components, that is, electric and magnetic fields, and this value depends on the time of the effect of this factor on the human body during the labour day.

Staying in an electric field of industrial frequency with a voltage of 5 kV/m inclusive is allowed during an 8-hour labour day.

The time of staying in an electric field of industrial frequency from 5 up to 20 kV/m inclusive is determined by the formula:

$$T_{st} = \frac{50}{E} - 2, \tag{2.22}$$

where T_{st} (h) is the acceptable time of staying in the electric field of the industrial frequency at a given level of electric field intensity (E) in the controlled zone; E (kV/m) is the intensity of the electric field of the industrial frequency in the controlled zone.

If the tension of the electric field of industrial frequency is from 20 to 25 kV/m, the time of staffing in a controlled area shall not exceed 10 minutes.

Staying in the electric field of industrial frequency exceeding 25 kV/m without the use of means of protection is prohibited.

These norms should be fulfilled under the additional condition: another time of the day a person should be in places where the electric field intensity does not exceed 5 kV/m, and also the possibility of influence on the human body of electrical discharges is excluded.

For the magnetic field of the industrial frequency, the maximum acceptable levels of its intensity at constant influence should not exceed 1.4 kA/m during the labour day (8 hours).

The time of a person's stay in a magnetic field with tensity of more than 1.4 kA/m is regulated by a table 2.6.

Table 2.6. Dependence of the duration of human stay in a magnetic field from its level

Time of staffing, h	1	2	3	4	5	6	7	8
Magnetic field tension, kA/m	6,0	4,9	4,0	3,2	2,5	2,0	1,6	1,4
Magnetic induction, mT	7,5	6,13	5,0	4,0	3,13	2,5	2,0	1,75

EMF radiofrequency range. According to the existing norms, the threshold limit value (TLV) EMF in the frequency range of 1 kHz to 300 MHz is determined by the threshold limit value of the stresses of its electrical and magnetic components, i.e. electric and magnetic fields, and these values depend on the time of EMF on the human body during the labour day and the threshold limit energy load and is determined by the formulas:

$$E_{tl} = (EH_{Etl} / T)^{1/2}; \qquad (2.23)$$

$$H_{tl} = (EH_{Htl} / T)^{1/2}, \qquad (2.24)$$

where E_{tl} (W/m) i H_{tl} (A/m) – threshold limit values of the electric and magnetic field strengths; T (h) is the time of EMF exposure; EH_{Etl} ((W/m)^2· h) and EH_{Htl} ((A/m)^2· h) – threshold limit energy load during the labour day, respectively, for the electrical and magnetic components of EMF.

Threshold limit value of electrical (E_{tl}) and magnetic (H_{tl}) constituent pulsed electromagnetic fields (PEMF) in the spectral range of up to 1000 MHz at workplaces of personnel are also determined basing on the threshold limit energy load (EH_{Etl}, EH_{Htl}) and time of influence by formulas 2.23–2.24.

According to the existing rules, the threshold limit EMF value of the radio frequency range at frequencies 300 MHz–300 GHz is determined by the maximum allowable value of the density of the flow of energy EMF, depends on the time of the action of this factor on the human body during the labour day and the threshold limit energy load and is determined by the formula

$$EFD_{tl} = K \cdot EL_{TEFtl} / T, \qquad (2.25)$$

where EFD_{tl} (W/m^2, mW/sm^2, mkW/sm^2) – the threshold limit value of the energy flux density; EL_{TEFtl} – the threshold limit value of energy load, which according to norms is 2 W·h/m^2 (200 mkW·h/sm^2); K – The coefficient of relaxation of biological efficiency, which is: 1 – for all cases of influence, except the radiation from rotating and scanning antennas; 10 – for cases of irradiation from rotating and scanning antennas with a frequency of not more than 1 Hz and sparavity not less than 50; T – time of stay in the radiation zone for the working shift, h.

In all cases the threshold limit value of EFD_{tl}should not exceed 10 W/m^2 (1 mW/sm^2).

For the population of the TLV, the EMF of the radio frequency band and the industrial frequency are standardized in accordance with the requirements of the SSNR No.239-96 “State Sanitary Norms and Rules for Protecting the Population from the Influence of Electromagnetic Radiation”.

The threshold limit value of EMF (E_{tl}, V/m), which are created by television radio stations in the frequency range from 48 to 1000 MHz, are determined by the formula

$$E_{tl} = 21 f^{-0,37}, \qquad (2.26)$$

where f (MHz) – carrying frequency of the television channel.

The threshold limit levels of electromagnetic fields for the population in the frequency range >300 MHz (EFD_{tl}) should not exceed 2.5 mW/cm^2.

In the populated areas, the threshold limit levels of EMF of industrial frequency (E_{tl}, V/m) should not exceed 5 kV/m, and within residential buildings – 0,5 kV/m.

The procedure for the control and measurement of EMF is regulated by GOST 12.1.006-84, according to which, monitoring and measurement of EMF intensity should be carried out periodically at least once a year in the current sanitary-hygienic supervision, as well as in the following cases:

- when commissioning new installations emitting electromagnetic energy;

- when introducing changes in the design of existing plants emitting electromagnetic energy;
- when changing the design of protection against the effects of EMF;
- when making changes to the scheme of connection of radiating elements and modes of operation of installations emitting electromagnetic energy;
- when organizing working place;
- after carrying out repairs on the installations emitting electromagnetic energy.

Measurement must be performed at the highest power of the EMF source. In cases where the source has several operating modes, measurements must be made in each mode.

Measurement of EMF from rotating and scanning antennas should be carried out at a stopped antenna oriented to the workplaces and places of possible personnel location.

The results of the measurements must be recorded in a special log or in a protocol which has to contain:

- date of measurement;
- the name, type and serial number of the installation in the numbering system of the manufacturer;
- year of manufacture;
- power, frequency;
- operating mode of the installation;
- source of EMF;
- place of measurement;
- level of the measuring point from the floor or surface of the ground;
- measurement results;
- electrical component intensity, W/m;
- intensity of the magnetic component, A/m;
- EFD EMF, W/m^2 ($\mu W/cm^2$);
- measuring instruments that were used;
- conclusions.

The protocol must be signed by the head of the district (shop, department), representative of the labour protection service, a person appointed by the administration of the enterprise for the measurement.

Sanitary and hygienic control and measurement of EMF levels at workplaces are carried out by certified attestation commission of the Ministry of Health of Ukraine by sanitary laboratories of enterprises and organizations.

Measures and Means of Protection against the Action of Electromagnetic Fields

Protection of personnel against the impact of EMF is achieved through organizational, engineering and technical measures, as well as the use of personal protective equipment.

Organizational measures include: the choice of rational modes of operation of installations, limitation of place and time of staffing in the radiation zone, etc.

Engineering and technical measures include the efficient placement of equipment, the use of means limiting the penetration of electromagnetic energy into the workplaces (absorbing materials, shielding, etc.).

The main measures for protection against EMF include: time protection, distance protection, shielding radiation sources, reducing radiation power in the source of radiation, allocation of radiation zones, shielding workplaces, the use of personal protective equipment (PPE).

Time protection involves limiting the time person spends in the work area and applies only when there is no way to reduce the intensity of radiation to acceptable values.

Distance protection applies only when there is no other way to weaken the action of EMF by other measures, including time protection. In this case, the spacing between the EMF emitter and the staff increases. The acceptable distance to the source of EMF, which provides the threshold limit values of the intensity of radiation, is necessarily checked by experimental measurements of EMF levels at workplaces.

Reducing the power of radiation in the source of radiation can be realized by the following measures.

In communication systems, this is, first of all, increased sensitivity of receiving devices, the use of interfering types of coding and signal modulation in transmitting and receiving systems, the application of close to optimal signal processing algorithms and the choice of frequency range with minimal external radio interference. All this allows you to reduce the transmitter radiation power and at the same time obtain the necessary resistance to radio interference and provide the range of communication systems.

Thus, the reduction of the radiation power in the source of radiation itself is usually achieved through the use of special devices: power absorbers, antenna equivalents, as well as attenuators, directional cutters, power dividers, waveguide amalgamators, bronze gaskets between the flanges of the waveguides, throttle flanges, etc.

For each unit that emits EMF above the threshold limit values, zones should be allocated in which the intensity of radiation is dangerous for a person. The limits of such zones, where the intensity of EMF may exceed the threshold limit values, is determined experimentally for each particular case of placement of the installation or equipment during their work on the maximum radiation power. In addition, dangerous radiation zones with the intensity of EMF more than the threshold limit value are fenced and warning signs with the inscription: “Do not go, it's dangerous!” Also, if necessary, these zones may be additionally marked along the borders with wide red lines on the floor of the premises or territories, as well as apply a warning signal.

In order to reduce the radiation of EMF personnel in accordance with the requirements of SSN No.476-2002 [13], EMF radiation zones located near installations should not be overlapped or these installations should work on radiation at different times.

Screening of radiation sources is used to reduce the intensity of EMF in the workplace. It should be emphasized that shielding protection is considered as the main and most effective method of protection.

Screens are divided into reflective and absorbing. Of course, such a division is rather conditional, because any screen to a greater or lesser extent reflects and absorbs the incident on it electromagnetic wave. The power of the incident on the screen of the electromagnetic wave (EFD_{inc}) is divided by the power of the reflected wave from the screen (EFD_{refl}), the power of the wave absorbed in the screen (EFD_{abs}) and the power of the wave that passed through the screen EFD_{pass}. Depending on which part of the incident power of EMF predominates, reflected or absorbed, the screen is classified as reflecting or absorbing.

The absorption of EMF on the screen increases with increasing field frequency, thickness, magnetic permeability and conductivity of the screen material, and reflection is mainly determined by the inconsistency of the wave characteristics of the air and screen material. That is why reflecting screens, as a rule, are made of metals as they have wave supports, which differ significantly from the air resistance of the wave.

For constructive implementation, reflective screens are divided into solid and mesh.

Solid screens are made of sheets of copper, aluminum and some grades of steel. In order to increase the conductivity of the screen, and therefore, through fading, the screens on the side of the emitter are covered with a layer of silver. The location of the installation and the shape of the screen are determined by the mutual arrangement of the radiating elements (antennas) and workplaces and the orientation of their orientation patterns.

Personal protective equipment (PPE) should be used in cases where the use of other methods of prevention of exposure to EMR is impossible. Radioactive clothing and glasses are used as PPE. As a material for radio-protective clothing, a special radio engineering fabric is used, which is built on the principle of a mesh screen and is a cotton fabric with micro wire. In the structure of such fabric, thin copper wire is twisted with cotton threads, which protect it from external influences and at the same time is an isolator. The relaxation of the EMF field with this fabric in the frequency range of 600–10000 MHz is 40 to 20 dB.

From protective cotton fabric with micro wire the following devices, such as radio-protection hood (helmet), a radio-protective gown, a radio-protective overalls, etc., are manufactured. At the mid-frequency of the microwave range, such individual protective devices provide a total attenuation of 25–30 dB, at their extreme microwave frequencies their protective properties are somewhat reduced.

As an example, the following is the appearance of a PPE from the EMR of the microwave band and the EMR of the industrial frequency. This is a protective suit of domestic production for protection against electromagnetic radiation personnel of radar stations, radio broadcasting and television centers when working with sources of EMR of increased power in the microwave range, as well as individual individual shielding sets from the EMR of industrial frequency.

In the case of intensive irradiation of the face of the EMF, radiopharmaceutical glasses are used, which are used separately or sewn in a helmet costume. These can be mesh glasses that have a half-mask design with a copper or brass net, or RPG-5, which uses a special radio-protection glass coated with tin dioxide. The protective properties of such glasses are estimated on the basis of data on the general easing of the applied glass, which is usually within 25–35 dB.

2.4.2. Sources, evaluation and protection against infrared radiation

Infrared (IR) radiation is a dangerous radiation of the optical range. This thermal radiation occurs everywhere, where the temperature is higher than absolute zero, and is a function of the thermal state of the radiation source. The heated bodies give their heat less heated in three ways: heat conduction, thermal radiation and convection. About 60 % of the heat lost in a heated body accounts for exactly the proportion of thermal radiation. Since most of the production processes are accompanied by the release of heat, the sources of which are the production equipment, materials, work pieces, etc., then as a result of the absorption of the emitted energy the temperature of the human body, facilities, equipment, which greatly affects the meteorological parameters of the air of the labour zones in production facilities.

Sources of IR radiation are divided into natural (natural radiation of the sun, sky) and artificial – any surfaces of technological equipment, constructions of the building, materials, the temperature of which is higher than the irradiated surfaces. For a person, this is a surface with a temperature t° > 36–37 °C.

By the physical nature of IR radiation is a stream of material particles, which is characterized by both quantum and wave properties. Infrared radiation covers the area of the spectrum with a wavelength of 0.76...540 μm. The energy of quanta lies within the range 0.0125. 1.25 eV.

By the law of Stefan-Boltzmann, the integral radiation flux density (W/m^2) of an absolutely black body is proportional to the fourth degree of its absolute temperature

$$q_i = C_o(T/100)^4, \quad (2.27)$$

where C_o = 5,67 W/m^2; T – absolute body temperature, K.

The radiation density of various materials is described by the equation

$$q_v = EC_o(T/100)^4, \quad (2.28)$$

where E – the degree of material blackness.

The radiating power or the spectral density of the energy luminosity of the body is called the value E_w, which is numerically equal to the surface density of the heat radiation of the body in the frequency range of the single width (spectral characteristic of thermal radiation).

In practice, the radiation is integral, because the body emits simultaneously different wavelengths. However, the maximum of radiation always corresponds to waves of a definite length. As the body temperature increases, the wavelength decreases. Between the temperature T and the wavelength λ, the Wien ratio is executed

$$\lambda \cdot T = b, \quad (2.29)$$

where b = 0,002898 m·degree.

The spectrum of thermal radiation of solid and liquid bodies is continuous and is characterized by a range of wavelengths of radiation and wavelength λ_{max}, which corresponds to the maximum intensity of radiation. The radiation spectrum of gases having at least three atoms in the molecule (carbon dioxide, water vapor, etc.), is striped.

On a body the infrared radiation predominantly has a thermal effect. The effect of infrared radiation depends on the wavelength, which determines the depth of its penetration. In this regard, the range of infrared radiation is divided into three sections: A (λ = 0.76–1.5 μm), B (λ = 1.5–3.0 μm) and C (λ > 3 μm). The first section (A) has a high permeability through the skin and is denoted as shortwave. Plots B and C refer to long-wave. Long-wave infrared radiation is absorbed in the epidermis of the skin, and short-wave – in the layers of the dermis and subcutaneous fatty fiber. The effect of infrared radiation absorbed in different layers of the skin is reduced mainly to its heating. This activates metabolism, increases the content of sodium and phosphorus in the blood, and decreases the number of leukocytes. IR radiation also affects the functional state of the central nervous system, leads to changes in the cardiovascular system, increases pulse and respiration, increases body temperature, increases sweating. Infrared radiation has a negative effect on the mucous membrane of the eyes, lens and can lead to pathological changes in the organs of vision – clouding of the cornea and lens, conjunctivitis, retinal burn. The most severe defects are caused by short-wave IR radiation. In the case of intense exposure of this radiation to the uncovered head so-called heat stroke, headache, dizziness, increased heart rate and respiration, fainting, violation of coordination of movements, damage to the brain fiber up to meningitis and encephalitis may occur.

Standardization and Control of Infrared Radiation

The intensity of the infrared radiation must be measured at the workplace or in the labour zone near the source of radiation. Standardization of infrared radiation is carried out in accordance with the sanitary norms of the SSN 3.3.6.042-99.

- IR radiation is standardized in three characteristic areas A, B, and C (range 760 nm – 540 μm):
- area A (wavelength from 760 nm to 1500 nm);
- area B (wavelength from 1500 nm to 3000 nm);
- area C (wavelength greater than 3000 nm).

Thermal radiation with a radiation flux density of 560–1050 W/m^2 is the limit value that can still be tolerated by a person.

According to the current sanitary norms, the acceptable density of the flow of infrared radiation in industrial premises should not exceed 350 W/m^2.

The intensity of thermal irradiation of heat-treated surfaces of technological equipment, lighting devices and isolation from glazed fences shall not exceed: 35 W/m^2 – with irradiation of 50 and more % of the body surface; 70 W/m^2 – with the size of the irradiated body surface, from 25 to 50 %; 100 W/m^2 – with irradiation no more than 25 % of the working surface of the body.

In the presence of sources with an intensity of 35 W/m^2 or more, the temperature of the air in permanent workplaces should not exceed the upper limits of the optimum values for the warm period of the year, in non-permanent workplaces – the upper limits of the acceptable values for permanent workplaces.

In the presence of open sources of radiation (heated metal, glass, open flame) the intensity of irradiation is allowed up to 140 W/m^2, while the size of the irradiated area should not exceed 25 % of the body surface working with the obligatory use of personal protective equipment (overalls, glasses, shields).

To measure the radiation flux density at the workplace, an actinometer is used. To determine the spectral intensity of infrared radiation spectrometer (IRS-10) is used.

Protection from Infrared Radiation

The main methods of protection against infrared radiation are the following: time protection, distance protection, removal of heat source, thermal insulation, screening and cooling of hot surfaces, the use of personal protective equipment.

The first three methods are obvious and follow from the above dependencies and the table dependence $q=f(t)$. As for other methods, we will consider them more detailed.

Thermal insulation and shielding are the most effective and most economical measures to reduce the levels of infrared radiation, prevent burns, and reduce fuel consumption.

According to the present SN, the temperature of the heated surfaces of equipment and enclosures should not exceed 45 °C.

To reduce the temperature of the working surfaces of structures and equipment, internal thermal insulation – lining is used.

Depending on the principle of action, heat-protection agents are divided into:

- heat-reflective – metal sheets (steel, aluminum, zinc, polished or covered with white paint, etc.), which can be single or double; tempered glass with film coating; metalized fabrics; fiberglass film material, etc.;

- heat-collecting – steel and aluminum sheets or boxes with insulation from asbestos cardboard, chamotte brick, felt, vermiculite plates and other heat insulators; Tempered silicate organic glass; Steel mesh (single or double with tempered silicate glass); etc.;
- heat-shrinkable – water cooled screens (from a metal sheet or boxes with running water), water curtains, etc.;
- combined.

Depending on the features of the technological processes, transparent and translucent screens are used.

The choice of heat-protective agents is determined by the intensity and spectral composition of radiation, as well as the conditions of the technological process.

Heat shields must provide normalized exposure to workers; Be comfortable in operation; Do not complicate the inspection, cleaning and lubrication of aggregates; To guarantee safe work with it; Be strong and reliable; Comfortable in manufacturing and montage; Have a long enough lifetime; In the process of exploitation, keep their heat-protective qualities.

To reduce the intensity of radiation from external surfaces, water cooling is used. The disadvantage of the method is the danger of explosion in the case of the water contact with liquid metals and materials that are heated to very high temperatures.

When it is impossible to provide acceptable hygienic norms of exposure at workplaces by technical means, means of personal protection (PPE) – overalls, special footwear, PPE to protect the head, eyes, face, hands are used.

Depending on the destination, the following PPE are provided:

- for permanent work in hot workshops – overalls (men’s felted suit), while during repairs of hot furnaces and units – autonomous individual cooling system complete with felted suits reused;
- during emergency work – heat-reflective kit made of metalized fabric are used;

- to protect the feet from thermal radiation, sparks and spray of molten metal and contact with heated surfaces – leather shoes special for workers in hot workshops are used;
- to protect the hands from burns – thermal protective gloves, mittens dress, canvas and combined with leather handles are used;
- to protect the head from thermal irradiation, sparks and metal splashing – a felted hat, a protective helmet with shimmer, textiles or polycarbonate helmets are used;
- to protect the eyes and face – a shield of a heat-shrinkable steelworker, with protective glasses equipped with filters, protective masks with a transparent screen, protective goggles with filters are used.

2.4.3. Sources, assessment and UV protection

UV radiation also refers to dangerous optical radiation emissions. The frequency spectrum of ultraviolet (UV) electromagnetic radiation is located between the light visible and ionizing (X-ray) radiation. The wavelength of the UV radiation lies within 400–10 nm, and the quantum energy is 3.56-123 eV. By the way of generating UV radiation, they relate to thermal radiation, since anything begins to generate UV radiation at temperatures above 1900 °C, and on the action of matter – the UV radiation is closer to the action of ionizing radiation, although at the same time there is also a thermal effect. Of course, in relation to ionizing radiation, UV radiation causes ionization to a much lesser extent. At the same time, the energy of the quantum of UV radiation is already sufficient to violate the bonds of some atoms. Thus, the energy of chemical bonds those hold atoms in the molecules of most of the chemical compounds that are part of the human body, as a rule, does not exceed 4 eV. Thus, photons of UV radiation with energy of 12–15 eV can cause ionization, for example, water, hydrogen atoms, nitrogen, and carbon. Proceeding from the fact that water and listed atoms form the basis of living fiber, UV radiation with energy of 12 eV quantum can be considered as the lower limit of ionization for highly organized biological systems.

The intensity of UV radiation and its spectral composition in the workplace primarily depends on the temperature of the radiation source, as well as on the presence of gases (ozone), dust and the distance from the workplace to the radiation source. Dust, gas, and smoke intensively absorb UV radiation and change its spectral composition. Thus, the air is practically non-transparent for UV radiation with a wavelength of $\lambda < 185$ nm due to its absorption by oxygen. Due to the fact that UV radiation is intensively dissipated and absorbed in dusty environments and in gases, it is very difficult to calculate the levels of UV radiation at a certain distance from its source. As a rule, only experimental measurement of UV radiation levels is used in production conditions.

UV radiation occurs during the operation of electro vacuum devices, mercury rectifiers, the operation of OQG, the maintenance of mercury-quartz lamps, welding operations, etc.

The presence in the air of the labour zone of UV radiation causes changes in the composition of the production atmosphere. Ozone forms, nitrogen oxides, hydrogen peroxide, as well as ionization of air. The chemical and ionizing effect of UV radiation also results in the formation of condensation nuclei in the atmosphere of the production premises, which results in the appearance of fogs that scatter light and reduce the level of illumination of the workplace.

UV radiation has a low penetrating power and directly affects only the upper layers of biological fiber. Among the bimolecular capable of absorbing UV radiation, proteins and nucleic acids are most important. An important role in absorption is played by the pyramiding ring of nucleic acids and the aromatic amino acids of proteins tyrosine and tryptophan (the maximum absorption spectrum of nucleic acids is 265 nm, tyrosine – 275 nm, tryptophan 280 nm). In nucleic acids, under the action of UV radiation, there are atypical molecular bonds that violate the encoding properties of DNA and cause mutations.

The action of UV radiation on the human skin causes the appearance of dermatitis, eczema, edema, etc. The degree of skin damage by UV radiation depends on the amount of energy absorbed. For a barely noticeable reddening of the skin, a sufficient flow of energy is 30 J/cm^2 (in some cases, 8 J/cm^2). In order to characterize the biological effect of UV radiation on the skin, a concept such as the minimum erythema dose (MED) is the lowest energy dose, which, after 8 hours after irradiation, leads to redness of the skin (erythema) that disappears the next day. The maximum erythemal effect is UV radiation with a wavelength of 260 nm. At wavelengths $\lambda < 290$ nm, UV radiation is almost completely absorbed by the upper layers of the skin. Deeper fibers reach only 10 % of the energy of UV radiation with a wavelength of 290–320 nm and up to 50 % at $\lambda = 320–380$ nm. The multiple, prolonged years of UV irradiation accelerates the aging of the skin and increases the likelihood of developing skin cancer.

The biological effect of repeated UV exposures is significantly different from the effects of a single exposure, it has a cumulative nature. In general, the effect of UV radiation on the human body can be beneficial (tonic, tan, vitaminizing, anti-scar fiber), and harmful (erythemal, carcinogenic) depending on the spectrum and radiation dose.

Due to the limited penetrating power of UV radiation, the primary effects of radiation are induced primarily in the skin and the organs of vision. The organs of vision, due to their focusing properties, are particularly exposed to the harmful effects of UV radiation.

Special studies have found that the cornea of the eye is most sensitive to UV radiation with a wavelength of 270–280 nm. UV radiation with wavelengths exceeding 290 nm reaches the lens of the eye and can interact with its fibers. The greatest influence on the lens creates UV radiation in the wavelength range 295–320 nm. It is necessary to take into account the fact that not only the powerful single exposure to UV radiation, but also its long low-intensity action can induce changes in the transparency of the lens. So, the UV component of solar radiation can also be the cause of the cataract of the lens. One type of cataract, the so-called nuclear cataract, is most likely initiated by the photochemical effect of UV radiation on the amino acid tryptophan, which leads to the formation of a characteristic brown pigment and the development of turbidity of the lens. This effect is most pronounced when exposed to UV radiation with a wavelength of 300 nm, but only in case of exceeding the threshold limit dose value.

With ultraviolet irradiation with a wavelength of 280–303 nm, there is the highest probability of developing cancerous tumors. UV radiation also effects on the central nervous system of the person, as a result, there are symptoms such as headache, fever, tiredness, nervous disorders.

Taking into account the fact that, together with the negative effect of UV radiation, there is also a beneficial effect, namely, antimicrobial, therapeutic and tonic, in accordance with the requirements of SN in industrial premises where there is insufficient level of UV radiation, for example, when using only artificial lighting, it is necessary to apply Along with general lighting as well as additional ultraviolet lighting with special erythemal lamps. The amount of erythemal irradiation is determined by the surface density of the erythema flow in mEr/m^2, for which the acceptable value in accordance with the requirements of the SN is equal to 7.5 mEr/m^2. For medical radiation UV radiation is also used by special light-treatment clinics – radiationtherapyroom.

Standardization and control of UV radiation

- The normalization of UV radiation is carried out according to SN 4557-88 [15].
- Due to the fact that spreading in the air of UV radiation in the wavelength range from 10 to 200 nm is impossible, due to significant absorption of oxygen by it, the normalization of UV radiation is carried out in three characteristic regions A, B and C (range 200-400 nm):
- UV-A (long wave), with a wavelength from 400 to 315 nm;
- UV-B (medium Wave), with a wavelength from 315 to 280 nm;
- UV-C (shortwave), wavelength from 280 to 200 nm.

Acceptable intensity of irradiation of workers in the presence of unprotected areas of the skin surface is not more than 0,2 m^2 and the irradiation period to 5 minutes, the duration of pause between them is not less than 30 minutes and the total duration of exposure for a change to 60 minutes should not exceed:

50.0 W/m^2 – for the area UV-A; 0,05 W/m^2 – for the area UV-B; 0.01 W/m^2 for UV-C area.

Acceptable intensity of ultraviolet irradiation of workers exposed to unprotected areas of the skin surface is not more than 0,2 m^2 (face, neck, hands, etc.), the total duration of exposure to radiation is 50% of the working change and the duration of single exposure for more than 5 minutes and more should not exceed: 10.0 W/m^2 – for the area UV-A; 0.01 W/m^2 – for the UV-B area.

Radiation in the UV-C region for a specified duration is not allowed.

With the use of special clothes and means of protection of the face and hands that do not transmit radiation (unions, leather, fabrics with film coating, etc.), the acceptable intensity of irradiation in the area UV-B + UV-C (200...315 nm) must not exceed 1 W/m^2.

In case of exceeding the allowable intensity of radiation, measures for reducing the radiation intensity of the source or protecting the workplace from exposure (shielding), as well as additional protection of the leather covers of the workers should be provided.

UV protection

For protection against excessive UV radiation, anti-sunlight screens that can be chemical (chemical substances and UV absorbent-containing coatings) and physical (various obstacles that reflect, absorb or disperse the rays) are used. A good way of protecting is special clothing made from fabrics that least pass the UV radiation (for example, from the poplin).

For eye protection under industrial conditions, use filters (glasses, helmets) from dark green glass. Full protection against UV radiation of all wavelengths provides flint glas (glass containing lead oxide) in a thickness of 2 mm.

Reducing the intensity of irradiation UV radiation and protection against its effects is achieved by protecting the distance, shielding radiation sources; Job shielding; Means of personal protection; Special room coloration and rational placement of workplaces.

If, under the conditions of the production process, it is not possible to reduce radiation directly in the emitting devices or to shield it, a shielding of the work space should be used.

To shield workplaces screens, shields, or special cabins are used. Walls and screens are painted in light tones (gray, yellow, blue), apply zinc and titanium white to absorb ultraviolet radiation.

When shielding workplaces, the power and nature of the radiating device and associated workflow should be taken into account. So, if the workplace is located near the source of radiation, the screening device will reflect the radiation in the direction of the source. To eliminate the reflection effect of the screen in the workplace, it must also be covered with absorbent material from the side of the source of radiation.

When arranging the premises, it is necessary to take into account that the reflectivity of different finishing materials for the UVR is different than for the visible light. Polished aluminum and chalk whitewash are well UVR reflectors, while zinc oxides and titanium, oil-based paint are bad.

Also, in order to protect against the influence of OR of the entire spectrum, proper attention should be paid to the rational location of workplaces in the production facilities.

2.4.4. Sources, evaluation and laser radiation protection measures

Laser radiation, together with IR and UV radiation, belongs to the dangerous radiation in the optical range. In the modern production industry laser technology is very widely used. Nowadays optical quantum generators are used in more than 200 branches. They are used in data-transmission systems, television, spectroscopy, in electronic and computer technologies, biology, medicine, metalworking, metallurgy, in construction industry for the maintenance of thermonuclear processes during the processing of solid and superhard materials, during welding operations, etc. The small angular divergence of the laser radiation allows it to focus on areas of very small dimensions (comparable with wavelengths) and to obtain a power density of light flux, which is sufficient for the intense warming and evaporation of materials (the density of the radiation power reaches 10^{11} –10^{14} W/cm^2). The high locality of heating allows the use of lasers for the assembly of microcircuits (welding of metal terminals and semiconductor materials, etc.). In the microelectronic industry, with the help of laser beams the melting of the multilayer materials, the accession of resistors and capacitors, printed circuit boards, etc. can be carried out. Moreover, optical quantum generators are widely used to obtain micro holes in superhard materials.

The principle of laser radiation is based on the use of generated electromagnetic radiation, which is received from the working substance as a result of the excitation of its atoms by the energy of an external source.

The main properties of laser radiation:

- the high degree of coherence (the constancy of phase differences between the fluctuations);
- monochromaticity (bandwidth up to 2 Hz);
- small divergence of the beam (22" – theoretical, 2" – practical);
- significant power density (up to 10^{14} W/cm^2).

Depending on the nature of the working substance, the following basic types of optical quantum generators are distinguished: solid-state (working substance – ruby, glass with neodymium, etc.); semiconductor (ZnO, CaSe, What, Pb, etc.); liquid (with rare earth actuators, etc.); gas (He-Ne, Ar, Xe, C02, etc.).

The density of laser radiation on a small area of an object is determined by the formula:

$$P_s = \frac{P \cdot D^2}{\lambda^2 \cdot f^2}, \tag{2.30}$$

where: P is the output power of the laser radiation; D is the optical system object's diameter; λ is wavelength; f – is the focal length of the optical system.

The voltage of the electric field (E_p) of the laser radiation is determined by the formula:

$$E_p = \sqrt{\eta_0 \cdot \rho_s} = \sqrt{2 \cdot \rho_s \cdot \sqrt{\mu / \varepsilon}}, \tag{2.31}$$

where: μ is the magnetic permeability of the medium (for air $\mu_0 = 4\pi \cdot 10^{-7}$H/m); ε – dielectric permeability of the medium (for air $\varepsilon_0 = 8.85\ 10^{-12}$ F/m).

Due to the high density of power, laser radiation can destroy and evaporate materials. Simultaneously, in the area of the drop of laser beam, light pressure in hundreds of thousands megapascals is being created on the surface of the material, since the laser beam is a stream of photons, each of which can possess the energy and the force pulse. The temperature in the area of the drop of laser beam can reach several million Kelvin. During the focusing of laser beam, a high-temperature plasma originates in the gas, which is a source of long-wave x-ray radiation (1 nm).

When the beam of the optical quantum generator passes through an inhomogeneous medium, such as air, the divergence and wandering is happening due to the effect of reflection. There are mirror and diffuse reflection of a laser beam. To estimate the diffuse reflection of laser radiation, the geometric dimensions of the surface (point or long), which laser beam reflects, should be taken into account.

The biological effect of laser radiation usually stands for a set of structural, functional and biochemical changes, which occur in a living organism under the influence of such radiation. Laser radiation effects on the skin, internal parts of a body and is especially dangerous for the ocular organs. The result of the influence of the laser radiation is defined both as the physiological properties of individual tissues (reflecting and absorbing capacity, heat capacity, acoustic and mechanical properties), and by the characteristics of laser radiation (energy in momentum, power density, wavelength, duration of action, area of radiation).

Under the influence of laser radiation on biological objects thermal and shock effects are usually distinguished.

Thermal (heat) effect. This effect is similar to thermal burn – when the tissue necrosis takes place. The thermal defeat of laser radiation is characterized by the sharp limits of the affected areas and by the possibility of concentration of the energy of the laser radiation in the deep layers of the tissue. The nature of the damage is strongly influenced by the degree of pigmentation of the tissue, its microstructure and density. The most exposed to the damage are tissues with a colorless substance, melanin (skin pigment), which has a maximum absorption at wavelengths λ_{max} = 0.5 – 0.55 μm, that is, in the radiation range of the most common optical quantum generators. The specificity of the liver and spleen is that they have the maximum absorption at λ = 0.48 and 0.51 μm – representative frequency of argon optical quantum generators (blue-green color). For optical quantum generators with λ = 0.48–10.6 μm the laser energy density limit for biological tissue is equal to 50 J/cm^2.

The dependence of the degree of thermal damage of biological tissue on the laser radiation power is close to the linear one.

Manifestations of the laser radiation thermal action vary from burn blisters and evaporation of the surface layers of the tissue to the defeat of the internal parts of a body. The degree of defeat of the surface of the body and, first of all, the ocular organs depend on whether the focused or unfocused laser beam is. The focusing of laser beams has less value for the internal parts of a body.

Usually, the thermal effect of laser radiation is typical for the case of the use of optical quantum generators with a continuous mode of operation.

Shock effect. The cause of many types of lesions is shock waves. The sharp increase in pressure leads to a shock wave that propagates with supersonic velocity and can cause the destruction of the internal organs without any external manifestations. The interaction of laser radiation with biological tissue leads to the appearance of not only shock waves, but also ultrasonic waves, which can cause cavitation and tissue destruction. Shock effect is typical for the pulse laser operation mode.

The influence of the laser radiation with low intensity leads to various functional changes in the cardiovascular system, endocrine glands, central nervous system. Symptoms of increased fatigue, high jumps in blood pressure, headaches, etc. may appear.

With local action, the greatest risk of the laser radiation is for the ocular organs. For λ < 0.4 μm and λ > 1.4 μm uttermost effects on the cornea of the eyes and the skin, and in values λ = 0.4 – 1.4 μm – on the retina of the eye. This happens due to the fact that the lens of the eye acts as an additional focusing lens, which increases the concentration of energy on the retina of the eye. All this significantly, in 5–10 times, reduces the maximum acceptable level of irradiation for the pupil of the eye.

Standardization and control of laser radiation.

Standardization of laser radiation is carried out according to GOST 12.01.040-83 [16]. According to the norms for the design of laser technology, there should be a crucial principle of the absence of the effects on human beings of direct, mirror and diffuse reflected radiation.

When determining the hazard category of laser radiation, it is necessary to take into account the spectral range of laser operation: I – 180nm < λ < 380 nm, II – 380 nm < λ < 1400 nm, III – 1400 nm < λ < 10^5 nm.

The rationed parameters for laser radiation in terms of danger are the energy *W* (J) and the power *P* (W) of the radiation passing through the limiting aperture with diameters d_a = 1,1 mm (in the spectral ranges I i II) and d_a = 7 mm (in the range III); radiant exposure *H* and intensity of irradiation *E*, averaged over the limiting aperture:

$$H = W/S_a;\ E = P/S_a, \qquad (2.32)$$

where: S_a is an area of restrictive aperture.

According to the standards, the laser equipment is divided into 4 classes by degree of danger:

1 class – completely safe lasers that do not have harmful effects on the eyes and skin;

2 class – lasers that pose a danger to the eyes and skin in the case of the direct action by a collimated, i. e., closed beam in a small angle, but the mirror or diffuse reflected radiation of such lasers is safe for human being;

3 class – these are lasers that operate in the visible range of the spectrum and poset a danger to the eyes (direct and mirror reflected radiation at a distance of 10 cm from the reflecting surface) and the skin (only direct radiation);

4 class – the most powerful lasers that are dangerous for eyes and skin at the diffused reflected radiation at a distance of 10 cm from the diffuse reflecting surface.

Protection against the laser radiation

Exploitation of the optical quantum generators is accompanied by a whole set of harmful and dangerous factors.

In addition to the effect of a laser beam (direct, mirror and diffuse reflection), these are:

- high voltage of charging devices, which powers the battery of condensers with large capacity;

- the pollution of air by the chemical substances formed during pumping of optical quantum generators (ozone, nitrogen oxide) and during evaporation of the target material (carbon monoxide, metal oxides, etc.);
- UV radiation of pulsed lamps and gas discharge tubes (conduit);
- light radiation during the operation of pumping lamps;
- X-ray radiation (secondary accompanying);
- formation of particles of high energies during the irradiation of the target;
- ionizing radiation, which is used for pumping the optical quantum generators;
- EM field generated during the operation of high-frequency alternators;
- noises during the operation of mechanical shutters, pumps, noise of the shock waves;
- toxic fluids (working fluid in liquid optical quantum generators), for example, chlorine oxides, phosphorus, etc.

Thus, the operation of lasers requires the implementation of various protective measures.

Existing optical quantum generators should be placed in separate, specially designated areas, which should not have mirrored surfaces. The surfaces of the premises should have a reflection coefficient of no more than 0.4. The walls, ceiling and the floor should have a matte surface. The room should have a high level of illumination (daylight factor > 1.5 %, E_{gen} > 150 lx).

It is necessary to arrange the premises with general and local ventilation when using powerful optical quantum generators.

It is forbidden to direct the beam on windows and doors.

The access of the third parties to optical quantum generators is strictly limited.

Warning signs and the signaling system on optical quantum generators work are being established.

Different types of screens (metal, plastic) are applied to prevent the laser beam from reaching the staff.

Appropriate signs in places of safe and dangerous zones are hanging (GOST 12.4.026-76).

To prevent eye damage, PPE is used – special glasses with filters. Anti-laser glasses contain:

- absorbing glass and plastics;
- reflective dielectric films, which reflect 90–95 % of the incident light energy (titanium oxides, etc.);
- combinations of absorbing and reflective materials.

The light filters should have high selectivity of the position and reflection, as well as significant thermal resistance. In this regard, multilayer filters have beat indicators. Their breakdown limit value can reach 1015 W/m^2. It is necessary to select glasses with the corresponding characteristics for each wavelength of the optical quantum generators. For instance, SZS-22 type glasses have the maximum efficiency in the λ = 0.69–1.6 nm range.

Along with protective glasses in laboratories, where optical quantum generators are used, protective clothing must be clad to prevent the transferring of laser radiation into the open areas of the skin. Significant damage to open areas of the skin is already observed at a density of a fluency of 50 J/cm^2. Felt clothes and leather gloves are usually applied to protect the skin.

It is necessary to select the appropriate walls colour of the workspace to reduce the flux density of the reflected energy of the laser. Thus, the dark blue oil paint reflects 16 % of energy in the case of using optical quantum generators with a wavelength of 1.06 μm and 12 % with the use of optical quantum generators with a wavelength of 0.69 μm. Dark green wall painting in the case of using the optical quantum generators with a wavelength of 0.69 μm reflects 15 % of energy. It is recommended to use black dense fabrics that have a maximum absorption of the laser radiation in the wavelength range of 1.06–0.69 μm to create the shielding curtains.

2.4.5. Sources, evaluation and protection measures against ionizing radiation in the production environment

Ionizing radiation is the radiation, which interaction with the medium leads to the formation of the electrical charges of different character in the last one, i. e., to its ionization. The main characteristics of the ionizing radiation sources are radioactivity, half-life, and radiation energy. Such concepts as the attenuation distance, ionizing ability, radiation dose (absorbed, equivalent, exposure), radiation dose rate, etc. are used to assess the effect of the ionizing radiation.

Radioactivity is the unwanted transformation (decay) of atomic nuclei of certain chemical elements (uranium, thorium, radium, etc.), which leads to a change in their atomic and mass numbers. Such elements are called radioactive.

Radioactive substances have a strictly defined half-life, i. e., the time during which half of all atoms of this radioactive substance are being decomposed. Radioactive decay cannot be stopped or accelerated.

The number of nuclei of the element, which is decomposed per unit of time (A), is proportional to the total number of nuclei N, i.e.

$$A = -dN/dt = \lambda N, \qquad (2.33)$$

where: λ is a constant of the radioactive decay, which characterizes the probability of decay in one nucleus per unit of time. The moreλ is, the higher the rate of decay is.

This process can also be determined by the formula:

$$N_t = N_0\,(-\lambda t), \qquad (2.34)$$

where: N_0 i N_t are the numbers of radioactive nuclei at the initial time and after time t, respectively.

The decay rate (A) characterizes the activity of radionuclides. In the SI system, one nuclear transformation per second is adopted per unit of the activity. This unit is called becquerel (Bq). The non-system unit for measuring the activity is curie (Ci). This is the activity of radionuclides in the source, where $3.7 \cdot 10^{10}$ decay events per second take place. Curie activity unit corresponds to the activity of 1 gram Ra.

The particles, produced by the radioactive source, form a stream, which is measured by the number of particles per unit of time. The flow per unit of surface (square centimeter) is the density of the flux of particles (particles/(min • cm^2), particles/(sec • cm^2)).

The massic A_m (Bq/kg), volumetric A_v (Bq/m^3) and surface A_s (Bq/m^2) activities of the sources activity is used in dosimetry.

The constant of the decay of λ is connected with the half-life $T_{1/2}$, i. e., the period of time for which the number of active nuclei decreases by half by the ratio:

$$T_{1/2} = 0.693/\lambda. \quad (2.35)$$

Each isotope has its own denotation of $T_{1/2}$. For instance, for potassium – 40 $T_{1/2} = 1.28 \cdot 10^9$ years, for cesium – 137 $T_{1/2} = 30$ years, for strontium – $T_{1/2} = 28$ years, for iodine – $T_{1/2} = 8$ days.

Ionizing radiation occurs because of the transformation of radioactive substances, and it is conventionally divided into corpuscular, e.g., α-(alpha), β-(beta) and η-(neutron), and electromagnetic, e.g., γ-(gamma) and R-(x-ray). All of them have different energy parameters and the ability to ionize the environment.

α-radiation is a stream of positively charged particles (nuclei of helium atoms), which are formed during the decay of nuclei or nuclear reactions. They have a great ionizing effect, but low penetrating power.

β-radiation is a stream of negatively charged particles (electrons) or positively charged particles (positrons) that are reproduced during the decay of nuclei or unstable particles. The run of β-particles in the air is 3.8 m/MeV. The ionizing ability of β-particles is two orders of magnitude lower than α-particles.

γ-radiation is a short-wave electromagnetic radiation (photon). It is formed during the changes in the energy state of atomic nuclei, as well as during the nuclear transformations.

X-ray radiation also refers to electromagnetic radiation (photon), which is formed during the changes of the energy state of the electron shells of an atom, or during the braking electrons with high kinetic energy in the electrostatic field of nuclei (braking radiation). γ-radiation and X-rays have a small ionizing effect, but a very high penetrating power.

Ionizing radiation, passing through substances, interacts with their atoms and molecules. Such interaction leads to the violation of atoms and the excretion of individual electrons from the electron shells of a neutral atom.

As a result, an atom deprived of one or more electrons becomes a positively charged ion, i. e., ionization happens. The electrons, which as the result of multiple collisions have lost their energy, remain free or join any neutral atom, forming negatively charged ions. Thus, the energy of the radiation when passing through a substance is spent, mainly, on the ionization of the medium. The number of ion pairs produced by ionizing radiation in a substance per unit path is called specific ionization, and the average energy consumed by ionizing radiation to form one pair of ions is the average work of ionization.

As the charged portion moves into the medium, it loses the energy. The distance traveled by a particle from the place of origin to the place, where it has lost its excess energy, is called the run length.

The dissemination of radiation in a substance can be characterized by the concept of "half-value layer", i. e., the thickness of a layer of a certain substance, when passing through intensity of radiation is weighted twice.

Thus, it is possible to determine the required number of half-value layer n to reduce the intensity of radiation in K times:

$$K = 2^n;\ n = 3{,}322\ lg\ K, \tag{2.36}$$

Degree, depth and form of radiation damage that develop in tissues of biological objects when they are exposed to ionizing radiation, first of all, depend on the amount of absorbed energy of radiation. The concept of absorbed dose (D_{abs}), i. e., the energy absorbed by the unit of mass of the substance, being irradiated, is used to characterize this indicator:

$$D_{abs} = dE/dm, \tag{2.37}$$

where: dE is the average energy transmitted to the IB substance in the elemental volume; dm is the elemental mass of a substance.

Per unit absorbed dose of radiation is taken Joule per kilogram (J/kg) – Gray (Gy). Gray is the absorbed dose of radiation, namely the energy in 1 J of any ionizing radiation, which is transmitted to one kilogram of the irradiated substance. A non-system unit of absorbed dose was used in radiobiology and radiation hygiene. Rad is a non-system unit of absorbed dose, and it is very widespread in radiobiology and radiation hygiene. Rad is the absorbed dose, when the amount of energy absorbed per 1 g of any substance is 100 erg, regardless of the type and energy of radiation, 1 rad = 0.01 erg.

The so-called exposure dose (D_{exp}) of the X-ray (R) and γ-radiation – a quantitative characteristic of X-ray (R-) and γ-radiation, based on their ionizing action and expressed by the total electric charge of ions of one mark, formed in unit of volume of air in conditions of electronic equilibrium is used to characterize the dose of ionizing radiation by the ionization effect in the air:

$$D_{exp} = dQ/dm, \tag{2.38}$$

where: dQ is the increase of the total charge of all ions of the same sign, which were formed in the elemental volume of air; dm is the mass of the elemental volume of air.

A coulomb per kilogram (C/kg) is taken for a unit of exposure dose of X-ray (R-) and gamma (γ-) radiation.

Pendant per kilogram is the exposure dose of X-ray (R-) or gamma (γ-) radiation, in which the corpuscular emission per kilogram of dry atmospheric air coupled with this radiation forms in the air ions that carry a charge of 1 C of electricity per sign.

Roentgen (R) is the off-system unit of the exposure dose of X-ray (R-) and gamma (γ-) radiation.

Roentgen is the unit of the exposure dose of photon radiation, which passes through 0.001293 g of air and because of the completion of all ionization processes in the air, ions that carry one electrostatic unit of the amount of electricity of each sign are formed. 0.001293 g is the mass of 1 cm^3 of dry atmospheric air under normal conditions (temperature 20 °C and pressure of 1013 MPa (1 atm physical or 760 mmhg), where the primary processes of photon interaction with air occurs. According to definition, 1 R corresponds the charge of 1 CGSE = nq, where n is the number of ions, q is the charge of the ion ($q = 4.8–10^{-10}$ CGSE).

Thus, in order to obtain an exposure dose of 1 R, the amount of ionization consumed in 1 cm^3 (or 1 g) in the air should correspond to

$$1R = 0.114\ erg/cm^3 = 87.7\ erg/g. \qquad (2.39)$$

The values of 0.114 erg/cm^3 and 87.7 erg/g are called energy equivalents of roentgen. The ratio between the absorbed dose of X-ray (R-) and gamma (γ-) radiation, expressed in rads, and the exposure dose of X-ray (R-) and gamma (γ-) radiation, expressed in roentgens, has such air formula:

$$D_{exp} = 0{,}877\ D_{abs}. \qquad (2.40)$$

Absorbed or exposure dose of radiation, which are classified as a unit of time, are called the power of absorbed or exposure dose (R), respectively. It characterizes the rate of accumulation of dose, which can subsequently increase.

If for some interim dt the dose increase is equal to *dD*, then the average value of the dose power for a given time period is defined as:

$$P = dD/dt. \qquad (2.41)$$

Different types of ionizing radiation have different biological effects on biological objects. In order to assess the biological effect of various types of ionizing radiation, the notion of radiation weighing factor – W_R was introduced. It shows by how many times this type of ionizing radiation has a stronger biological effect than X-ray (R-) or γ-radiation with the same absorbed dose. For instance, forα-radiation W_R is 20, for β-radiation – 1, and for neutron radiation – 5–20.

In order to assess the possible effects of ionizing radiation human beings, taking into account its ionizing capacity, the concept of the equivalent dose (*H*) of ionizing radiation is introduced:

$$H = D_{abs} \cdot W_R. \qquad (2.42)$$

The unit of measurement of the equivalent dose in SI is Sievert (Sv), 1 Sv = 1 J/kg. The non-system unit of the equivalent dose is rem, 1 rem = 0.01 Sv.

If the equivalent doses are the same, the degree of damage to individual organs and tissues of the human body depends on the radiation sensitivity of these organs and tissues. In order to assess the degree of radiation damage of a person, taking into account the radiation sensitivity of its individual organs and tissues, the notion of the effective dose (E) is introduced. It is determined by the formula:

$$E = \Sigma H_T W_T, \tag{2.43}$$

where: H_m is the equivalent dose in a tissue or an organ; W_T is a tissue weighing factor that characterizes the relative stochastic risk at the irradiation of individual tissues (W_T for gonads – 0.2; for red bone marrow, intestine and lungs – 0.12; for most internal organs – 0.05; for skin and bones – 0.01).

Rationing and control of ionizing radiation

Acceptable levels of ionizing radiation at workplaces are regulated by the RNBU-97 [17], which is the main regulatory document that establishes the radiation and hygiene requirements for ensuring acceptable permissible levels of ionizing radiation for both an individual person and society in general.

RNBU-97 regulates the situations of human irradiation by the sources of ionizing radiation under the conditions of:

- normal exploitation of industrial sources of ionizing radiation;
- medical practice;
- radiation accidents;
- irradiation according to technogenically-amplified sources of natural origin.

According to this normative document, irradiated people are divided into the following categories:

A – personnel – people who permanently or temporarily work directly with sources of ionizing radiation;

B – personnel – people who are not directly involved in the work with the sources of ionizing radiation, but due to the placement of their workplaces in premises and industrial sites near the objects with radiation-nuclear technologies may receive additional radiation;

C – the whole personnel.

RNBU-97 regulates the following values: dose limit, permissible levels, control levels, recommended levels, etc. To control practical activity, as well as to maintain a safe radiation state of the environment, the most important regulated value is the limit of the effective dose of irradiation per year (mSv/year). In addition, the limit of an annual equivalent dose of external irradiation of individual organs and tissues is established.

Protection against ionizing radiation

Basic protection methods against ionizing radiation:

- reduction of the activity of the ionizing radiation sources and use of sources with minimal ionizing radiation;
- reduction of the working time with ionizing radiation sources;
- removal of the workplace from the sources of ionizing radiation;
- shielding from the ionizing radiation sources;
- shielding the human location;
- application of the means of individual protection of the human being;
- introduction of sanitary-and-hygienic and preventive measures;
- implementation of organizational measures for the protection of personnel, who work with open and closed sources of ionizing radiation.

Justification and choice of the appropriate complex of measures of protection against the ionizing radiation in each particular case is based on the analysis of the actual features of radiation sources and radiation-hazardous factors.

The most common mean of protection against the ionizing radiation are screens. The screens may be mobile or fixed, intended to absorb or weaken the ionizing radiation. Screens can be containers walls for the transportation of radioactive isotopes, safes walls for their storage, etc.

Alpha particles are shielded by a layer of air a few centimeters thick, a layer of glass a few millimeters thick. It is also necessary to simultaneously protect people, who work with alpha-active isotopes, from both β- and γ-radiation.

Materials with a low atomic mass are used for the purpose of protection against β-radiation. It reduces the level of secondary ionizing radiation that occurs during the inhibition of β-particles in the electrostatic field of atomic nuclei. Typically, combined screens are used, in which from the side of the source of the ionizing radiation there is a material with a small atomic mass in the thickness, equal to the length of the run of the β-particles, and behind with a large atomic mass (for absorption of secondary ionizing radiation).

For the purpose of protection against X-rays and γ-radiation, materials with a high atomic mass and high specific density (lead, tungsten) are used.

For protection against neutron radiation, materials containing hydrogen and boron, as well as paraffin, beryllium, graphite, etc. are used. Neutron fluxes are accompanied by γ-radiation, combined protection in the form of layered screens of heavy and light materials (lead-polyethylene, etc.) should be used.

An effective protective mean against the ionizing radiation is the use of remote control, manipulators, and technical complexes using robots.

Different the means of personnel protection are being chosen depending on the nature of the executive work: bathrobes and hats from cotton fabric, protective aprons, rubber gloves, shields, respiratory protective devices (respirators), overalls, air suits, rubber boots.

Specific requirements are put forward to premises where the work with ionizing radiation sources is conducted. These premises should be located in separate buildings or in those parts that have a separate entrance with sanitary locks. Signs of radiation hazard and the classes of works carried out in these premises must be established and installed at the entrance. Entrance to such premises should be strictly forbidden for unauthorized personnel.

Various substances, both artificial and natural that can bind and remove radionuclides from the human body (radioprotectors) are used to protect human beings against the effect of ionizing radiation. These radioprotectors include: polyamides, citric and oxalic acid, sulfuric acid barium, ferrocyanide based sorbents, etc. The human mode, especially the use of products having radio-protection properties is very important in order to reduce the negative effects of radionuclides. These include, for instance, food that contains a significant amount of pectins (black currants, gooseberries, wild rose, cranberry juice, apples, etc.).

An effective factor in ensuring radiation safety is the dosimetric control of the levels of personnel production environment irradiation.

Radiation monitoring devices are distributed according to appointment into:

- dosimetric devices intended for measuring the ionizing radiation dose rate, for example dosimeters “Ros’”, “RKS-104”, “DK-02”, etc.;
- radiometric instruments that allow measuring the surface contamination and the specific activity of radionuclides, such as “Prypiat”, “Desna”, “Bryz”, “Bella”, “Beta” etc.;
- spectrometric devices that allow determining the spectrum (composition) of radionuclides on a contaminated object.

2.5. Industrial lighting

One of the essential factors in the production environment is the light, which provides a visual link between the worker and his environment. It is known that about 80 % of all information about the environment comes to a person through the eyes. Correctly organized lighting positively affects the activity of the central nervous system, reduces energy consumption of the human body to perform a certain work, which contributes to improving the efficiency and productivity of a person, the quality of products, as well as reducing occupational injuries, etc. For instance, an increase in the illumination from 100 to 1000 lx during the intense visual work leads to an increase of labourproductivity by 10–20 %, a reduction in the reject by 20 % and in the number of accidents by 30 %. It is believed that 5 % of injuries are caused by such occupational illness as a working myocopy (myopia).

Light radiation is the electromagnetic radiation of only a certain portion of the optical range that is perceived by human eyes and has a range of wavelengths from 380 to 760 nm. The optical radiation, which also includes ultraviolet and infrared radiation, occupies a range of wavelengths from 10 to 340000 nm.

Natural light, which in its spectral composition includes not only light, but also ultraviolet and infrared radiation, plays an especially important role in the human vital activity. It stimulates the biochemical processes in the human body, improves the metabolism, tightens the body, and because of the presence of the ultraviolet part of the spectrum it has an antibacterial effect.

In this regard, in the absence of natural light in the production environment, sanitary-hygienic standards require artificial light sources with an increased component of ultraviolet radiation – erythemal light sources.

Accented lighting is the lighting of individual parts on a less light background.

In the course of any work, eyes fatigue depends, basically, on the intensity of the processes that accompany the visual perception, the so-called visual tension, or the intensity of visual work. These processes include adaptation, accommodation and convergence.

Adaptation is the ability of the eye to adapt to different illumination by narrowing and enlarging the pupil of the eye in the range of 2–8 mm.

Accommodation is the adaptation of the eye to a clear vision of objects, which are located at a different distance from it, due to the change of curvature of the lens.

Convergence is the ability of the eye when looking at closely spaced objects to take the position, in which the visual axes of both eyes intersect on the subject.

Not only the quantity and the quality of lighting, but also the colour environment should be taken into account to create the optimal conditions for visual work. Affecting the eye, light emitters with different wavelengths cause different colour sensations. The boundaries of coloured light strips are: violet colour is the wavelength of light electromagnetic radiation 380–450 nm, blue – 450–480 nm, pale-blue – 480–510 nm, green – 510–550 nm, yellow – 575–585 nm, orange – 585–620 nm, red – 620–780 nm.

Yellow-green radiation with a wavelength of 555 nm is the most perceptible for the human eye. The spectral composition of the light affects the productivity of the mental state of a person. So, if the human efficiency in natural light is taken for 100 %, then it is only 76 % in red and orange lighting (wavelength 585–780 nm).

The light flux (F) is a flux of radiation, which is evaluated by its action on the human eye. The unit of light flux is lumen (lm). For instance, the incandescent lamp with a power of 40 W creates a light flux of 415–460 lm, and a luminescent lamp LD 40 of the same power – 2340 lm.

Light intensity (*I*) is the spatial density of the light flux, which is determined by the ratio of the light flux *F* (lm) to the cortical angle ω in which this stream extends:

$$I = F/\omega. \tag{2.44}$$

The unit of light intensity is candela (cd). Solid angle is part of the space of the sphere, limited by a cone, which is lean on the surface of the sphere with a vertex in its center. The unit of the solid angle is steradian (sr). The angle of 1 sr carves out the plane on the surface of the sphere equal to the square of the radius of the sphere. Candela is the force of light of a reference source with a plane of 0.5305 mm^2 in a perpendicular direction at a temperature of hardening of platinum 2046,65 K and pressure P = 101325 Pa.

Illumination (*E*) is the surface density of the light flux. With a uniform distribution of the light flux *F* perpendicular to the illuminated surface *S*, the illumination

$$E = F/S. \tag{2.45}$$

For example, the illumination of a surface in a full moon is equal to 0.2–0.3 lx, during a white night 2–3 lx, at noon (summer) – 68000–99000 lx.

The surface brightness (*B*) is the surface strength of light, determined as the ratio of the intensity of light I in the direction to the projection of the luminous surface on a plane perpendicular to the direction of observation.

$$B = I/(S\cos\alpha), \tag{2.46}$$

where α is the angle between the normal to the surface and the direction of vision. The unit of brightness is candela per square meter (cd/m^2 or nit). For instance, the brightness of the fluorescent lamps is $5 \cdot 10^3 – 10^5$ cd/m^2, of the incandescent lamps is $5{,}5 \cdot 10^6$ cd/m^2. The human eye is able to function in the brightness range of $10^{-6} – 10^4$ cd/m^2. For the effective vision of an object, the background brightness should be in the range of 10–500 cd/m^2.

The background is a surface directly adjacent to the object of distinction. It is estimated by the reflection coefficient. The background is considered to be light at $\rho > 0.4$, medium at 0.4 and dark at $\rho \leq 0.2$. The contrast (C) of the object of differentiation and the background is determined by the difference between the brightness:

$$C = (B_o - B_b)/B_b, \quad (2.47)$$

where B_o is the brightness of the object of differentiation and B_b is the background. Contrast is considered to be large at $C > 0.5$, average at $0.2 < C < 0.5$, small at $C < 0.2$.

Classification of types and systems and requirements for the industrial lighting

Depending on the light sources used in the production premises, lighting can be natural, artificial and combined.

Natural light is created by direct sunlight beams and light scattered by the sky.

Artificial lighting is created by electric light sources.

Combined lighting is a lighting, in which insufficient natural light is supplemented by the artificial lighting.

According to the purpose of use, artificial lighting is divided into:

- working – creates the necessary conditions for normal labour activity;
- alternate – has a reduced level of lighting, because it is used only during non-working hours, and it is allowed using part of the fixtures of other types of lighting for its implementation;
- emergency – switches on only when the working lighting is switched off, and emergency lighting lamps must only be powered from stand-alone electric sources and provide illumination of the working surfaces in the production premises at least 5 % of the working lighting, but not less than 2 lx for the interior premises and not less than 1 lx in the territory of the enterprise;
- evacuation – is activated in case of evacuation of people from the premises during a hazard and is installed in industrial premises with an amount of more than 50 workers, as well as in public and utility buildings of industrial enterprises, if they can simultaneously hold more than 100 people,

with illumination in The premises during evacuation must be not less than 0.5 lx, and outside the premises – not less than 0.2 lx;

● defensive – used along protected areas, and should provide illumination not less than 0.5 lx.

In turn, natural light is constructively implemented in the system of side, top or combination lighting:

● side (single or double) is carried out through light openings (windows) in the outer walls;

● top lighting – is carried out through openings (lanterns) in roofs and ceilings;

● combined is a combination of top and side lighting.

Artificial working lights are also divided into:

● general involves the placement of fixtures in the upper area of the room (not less than 2.5 m above the floor) for the implementation of general uniform or general localized lighting (taking into account the location of equipment and workplaces);

● local is created by fixtures, which concentrate the light flux directly r the workplace;

● combined consists of general and local and it is expedient to use it at high accuracy works, as well as if it is necessary to create a certain or alternate direction of light in the process of work.

The use of only one localized lighting at workplaces in industrial premises is prohibited.

Artificial lighting is used in all production and auxiliary premises of buildings, as well as in open work areas, people's passageways and traffic.

Regulation and control of lighting

The absolute value of illumination (*E*) on the working surfaces is the normative value at artificial lighting. According to DBN V.2.5-28:2018 [18], the rationing of the illumination of industrial premises of industrial enterprises is based on the dependence of the required level of illumination on the characteristic, discharge and subdivision of the visual work, which are determined by the smallest or equivalent size of the object of differentiation, the contrast between the object of differentiation and the background , and the background characteristics, as well as the dependence on the lighting system in the workspace (natural, combined, lateral, top, general).

For industrial premises, according to DBN V.2.5-28:2018, only eight discharges of visual work are determined. I discharge of visual work (the size of the object of differentiation is less than 0.15 mm.) provides the highest accuracy. The lowest, coarse or very small accuracy, have VI–VII discharges (the size of the object of differentiation is more than 5 mm.). VIII level of visual work is only a general observation of the production process. In turn, IV and VIII discharges have four sublayers (a, b, c, d), the first one – depending on the contrast between the object of differentiation and the background, as well as on the characteristics of the background (reflection coefficient of the working surface), and the last – depending on how the general observation of the production process (constantly, periodically, etc.) is carried out.

Lighting standards at workplaces should be increased by one degree of illumination scale according to table values of DBN V.2.5-28:2018 in the following cases:

- at visual work of I–VI discharges, if it is performed more than half a working day;
- at increased risk of injury, if the illumination from the system of general illumination is 150 lx or less;
- with special high sanitary requirements, if the illumination from the general lighting system is 500 lx or less;
- at the absence of natural light in the room and permanent residence of the workers in the production premises, if the illumination from the system of general illumination is 750 lx or less;
- at observing the parts rotated at a speed equal to or greater than 500 rpm or by objects moving at a speed equal to or greater than 1.5 m/min;
- at the constant search of objects of differentiation on a surface in the size of 0.1 m^2 or more.

The standards of illumination should still be raised to only one degree if the above signs are present at once.

In industrial premises, where works of IV–VI discharges are performed, the illumination rates should be reduced to one degree with short-term residence of people, or in the presence of equipment in the production premises that does not require constant maintenance.

Rationing of lighting in the premises of public, administrative and residential buildings and structures has its own features in comparison with the rationing of lighting in industrial premises.

The basis of rationing of lighting in the premises of public, administrative and residential buildings and constructions is the dependence of the required level of illumination on the characteristics of visual work, discharge and subdivision of visual work, which are determined by the smallest or equivalent size of the object of distinction and the relative duration of visual work in the direction of vision on the working surface, as well as the dependence on the lighting system, which is used.

According to DBN V.2.5-28:2018, eight levels of visual work (A, B, C, D, E, F, G, H) were determined for premises of public, administrative and residential buildings and constructions, depending on the characteristics of the visual work and size of the object of differentiation.The distinction of objects in a fixed and unfixed line of sight is the discharges A, B and C. Discharge A has the highest accuracy (the size of the object is distinguished from 0.15 mm to 0.3 mm), and C – the smallest, average precision (the size of the object of differentiation is more than 0.5 mm). An overview of the surrounding environment and general orientation in space is the discharges D, E, F, G and H. In turn, the discharges A, B and C have two subdivisions (1 and 2), depending on the relative duration of the visual work (%) in the direction of vision on the working surface (1 subdivision – not less than 70 %, 2 subdivision – less than 70 %). In addition, discharges G and H have two subdivisions (1 and 2), but already depending on the accumulation of people (1 subdivision – large, 2 subdivision – small).

Lightmeters (for example, U-116) are used for measuring the levels of illumination on working surfaces. The scales of these instruments are calibrated in units of illumination – luces, which makes it possible to directly estimate the magnitude of illumination on a given surface, directly on the instrument's indications.

Since the natural light is not constant in time, its quantitative estimation is carried out on the relative index - daylight factor (*DF*):

$$DF = (E_{in}/E_{out})\cdot 100\ \%, \qquad (2.48)$$

where: E_{in} (lx) is the natural light at a given point of the plane inside the room, which is created by direct sun beams and diffused light of the sky (direct or after reflection); E_{out} (lx) is the external horizontal illumination, which occurs at the same time at a fully open skies.

The minimum value of *DF* is standardized in the system of side natural lighting (through window slots in the walls). In the case of a side one-sided lighting system in industrial premises up to a depth of 6 m it is a *DF* at a point located at the intersection of the vertical plane of the characteristic section of the room and the conditional working surface at a distance of 1 m from the wall most distant from the light slits.

In the large industrial premises with a depth of more than 6 m with side lighting, the minimum value of *DF* is normalized at the point on the conditional working surface, which is far from light cuts:

- 1.5 m above the height of the floor to top of light cuts for the visual work of I–IV discharges;
- 2 m above the height of the floor to the top of the light cuts for the visual work V–VII discharges;
- 3 m above the height of the floor to the top of the light cuts for the visual work of the VIII discharge.

In the case of using the side double-sided lighting system, *DF* is at a point that is located at the intersection of the vertical plane of the characteristic section of the room and the conditional working surface and is centered between the opposite light cavities.

The average *DF* is rationed for the systems of the upper natural light (through the lanterns, the light ceilings on the roof of the building), or the combined system of the upper and side natural lighting. It is calculated from the results of measurements at n points (not less than 5) that are located at the intersection of the vertical plane of the typical section of the room and the conditional working surface (or floor). The first and last points must be located at a distance of 1 m from the surface of the walls. The average value of *DF* is determined by the formula:

$$DF_1 = (DF_1 / 2 + DF_2 + DF_3 + ... + DF_{n\text{-}1} + DF_n/2) / (n\text{-}1), \quad (2.49)$$

where: DF_n is the natural light intensity factor at the n control point; *n* is the number of control points in the plane of the characteristic section of the room.

The level of natural light of industrial premises is influenced, first of all, by the light climate, which depends on the geographical blurring of the place, the area and orientation of the light openings, the design of the windows, the purity of the glass, the geometric parameters of the premises and the reflective properties of its interior surfaces, as well as the external and internal shading the light by various objects.

The standardized value of *DF* (e_N) for buildings located in different regions of the light climate should be determined by the formula:

$$e_N = e_н \cdot m_N, \quad (2.50)$$

where: $e_н$ is the normal value of *DF* by DBN V.2.5-28:2018; m_N is the coefficient of light climate; *N* is the number of the group with natural light provision (separate for the Odesa region and for the rest of Ukraine, and depending on the type of light cavities and their orientation on the sides of the horizon).

The most rationed value of the coefficient of natural light for natural light is 4 % (discharge IV), and the smallest – 0.1 % (discharge VIII).

Combined lighting should be used in production premises with the visual work of I–III discharges. For the combined lighting, the highest value of the natural light factor is 6 % (discharge I), and the smallest – 0.1 (discharge VIII).

Combined lighting should be also used in the following cases:

● for the industrial and other premises in cases when, in the conditions of technology, organization of production or on-site climate, space-planning decisions that do not allow for the rationed value of the DF (multi-storey houses of large width, etc.) are required. As well as in cases when the feasibility of combined lighting compared to natural ones is confirmed by appropriate calculations;

- according to the regulatory documents on construction design of buildings and structures of individual industries approved in accordance with the established procedure.

Selection of light sources for lighting systems of industrial premises and operation of lighting installations

The choice of light sources for industrial lighting systems plays an important role in the system of measures to ensure comfortable and safe working conditions. The main characteristics of light sources are nominal voltage, power consumption, light output, specific light output and service life.

Artificial light sources. Luminescent lamps, which are energy efficient, should be preferred when choosing the light sources. In addition, they are as close to natural light as possible with spectral characteristics, which is important when using suppressed lighting.

The comparative characteristic of various artificial light sources by light output is given in Table 2.7.

Table 2.7. Comparative characteristics of lamps by light output

Type of lamp	Light output, lm/W
standard incandescent lamp	7–17
krypton	8–19
halogen	14–30
mercury	40–60
luminescent	40–90
sodium	90–150
light-emitting diode	130–146

If there are no warnings regarding the spectral composition of the emitted light, then from the economic point of view, LB luminescent lamps, which have the highest light output, are used.

Lamps of higher power should be used to reduce the initial costs for lighting installations and the costs of their operation. However, evenness of the illumination may deteriorate as the latter is inversely proportional to the distance between light sources.

In the general case, the uniformity of the illumination can be ensured when the distance between the centers of the lamps does not exceed the double height of their installation. At the same time, the height at which the lamps are installed depends on the height of the room, the power of the lamp, the class of the lamp and the lighting system. The smallest height of fixtures installation above the floor with the number of fluorescent lamps up to four is 2.6 m, and at four and more is 3.2 m.

The choice of the type of fixtures is made taking into account the characteristics of the room for which lighting is projected. However, it should be kept in mind that the lamps of this class create sharp falling shadows from foreign objects.

When lighting industrial premises, walls and ceilings of which have high reflective properties, it is expedient to use fixtures of predominantly direct light. Some decrease in the proportion of the light flux directly emitted in the lower hemisphere is offset by the improvement of the quality of the lighting and at the same time has little effect on the energy efficiency of the lighting installation, since such fixtures have a higher efficiency compared to similar direct light fixtures.

In administrative-office premises, it is expedient to use scattered light lamps, a large part of their light flux going to the walls and ceiling, and, reflecting from them, helps to eliminate sharp shadows, what is desirable for the nature of work for such premises.

In high premises, it is advisable to use fixtures with a concentrated or deep IDC, which direct the main part of the light flow directly to the working surfaces. In premises with large area and insignificant height, it is desirable to apply lamps with a wide form of IDC that allows ensuring even distribution of illumination on working planes even at considerable distances between the lamps.

The inconsistency of the lighting characteristics of the lamp with the size and nature of the processing of illuminated room causes an increase in installed capacity, a decrease in the quality of lighting. In turn, the discrepancy between the design of the lamp and the environment in the room reduces the durability and reliability of the lighting installation (aggressive, moist, dusty environment), and in some cases, it can cause a fire or explosion.

Therefore, the fixtures must be equipped with the necessary degree of protection against ambient conditions at the installation sites. Particularly rigorous requirements apply to fixtures that are installed in fire hazardous areas. In gas-discharge lamps, the balloon is filled with vapor mercury and inert gas, and the luminophor can additionally be applied on the inner surface of the cylinder. Depending on the manufacturing technology, gas-discharge lamps can be low (fluorescent) and high pressure. Fluorescent lamps have a long service life (more than 10000 h), greater light output (50-80 lm/W), less

light on the working surface than the incandescent lamps, and the best spectral composition of light, which is as close as possible to the daytime. The disadvantages of luminescent lamps include: increased pulsation of light flux, unstable operation at low temperatures, reduced voltage in the mains and more complicated circuit connection to the mains. The increased pulsation of the light flux of gas-discharge lamps negatively affects the state of human vision, and can also cause the so-called stroboscopic effect, which consists in the fact that parts of the rotating equipment seem to be stationary or rotating in the opposite direction, and this, in this can lead to an increase in the level of occupational injury. To reduce the negative effect of these phenomena on the workers, it is necessary to either activate adjacent gas-discharge lamps

in different phases of the power grid, which significantly reduces the

pulsation coefficient of their total light flux, or, taking into account the inertial characteristic of the formation of the visual image in humans, increase the frequency of the supply current of gas-discharge lamps up to 1 kHz and more.

In devices with gas discharge lamps, it is necessary to monitor the proper condition of the switching circuits and starters, the failure of which is indicated by significant noise of the throttle and flashing and blinking light. The current norms provide for the appropriate terms for cleaning fixtures and window glass, depending on the level of dust and gases in the air environment.

So, for a window glass - from two to four times a year; for fixtures - from four to twelve times a year. In addition, timely replacement of faulty lamps and lamps that have been working out their working time should be carried out. After replacing the lamps and cleaning the fixtures, it is necessary to check the level of illumination at the control points of the room at least once a year. Actual lighting levels at workplaces should be greater than or equal to the regulatory levels of illumination, taking into account the stock factor in accordance with the requirements of DBN V.2.5-28:2018.

There are several types of fluorescent lamps depending on the spectral composition of light: soft white, warm white, neutral white, cool white, daylight.

High pressure lamps are arc mercury (DRL) and sodium arc lamps (DNaT), having a service life of over 10,000 h and a light output of 50 and 130 lm/W respectively.

Gas-tube lamps belong to a group of gas-discharge lamps. They differ from luminescent lamps in that they do not have a phosphor and the light emits the gas itself inside the bulb. The most common example is neon lamps, often used for outdoor advertising and signage. Interesting fact: strictly speaking, only lamps, filled with neon and specifically lit red-orange light, which gives this gas, can be called neon lamps. Lamps of other colours are filled with other gases (blue – helium, lilac – argon, blue and white – krypton, blue-green – mercury vapor) and are commonly called neon only because of external resemblance.

Gas-tube lamps are very economical – that is why they are used in such quantity for street illumination.

In incandescent lamps, a high temperature heated thread of refractory material (most often – with tungsten) emits the visible light, which makes them easy to manufacture and reliable in operation. Their disadvantages include small light output (10–15 lm/W), a short service life (about 1000 hours), high temperature of the surface of the bulb and not very favorable for the human eye spectral composition of light, which is dominated by yellow and red colours with a lack of blue and violet compared to natural light, which obviously complicates the process of colour recognition. They consume a lot of electricity, while working at an average of 1000 hours. Frequent switching on and off of incandescent lamps, current fluctuations eliminate them even faster.

In halogen lamps, the bulbs are filled with halogens (iodine or bromine). By principle, they are divided into incandescent lamps, gas discharges and metal halides. Halogen lamps have a service life (2000–5000 h) and light output (20–75 lm/W). However, the heating temperature of the glass is significantly increased, so the halogen lamps are made of quartz material. They do not tolerate pollution on the flask. Linear halogen lamps are used in portable or stationary searchlights, which often have hand gauges.

LED lamps. The light emitted by the light-emitting diode lies in the narrow range of the spectrum. In other words, its crystal initially emits a specific colour (in the case of a LED visible-beam) – unlike a lamp that emits a wider spectrum, where the required colour can only be obtained using an external light filter. The radiation range of the LED depends largely on the chemical composition of the used semiconductors. When passing electric current through p-n transition in the forward direction, charge carriers – electrons and holes – are recombined with photon emission (through the transition of electrons from one energy level to another).

Compared to other electric light sources, LEDs have the following differences:

- High light output: Modern LEDs are compared by this parameter with sodium discharged lamps and metal halide lamps, reaching 146 lumens per watt.

- High mechanical strength, vibration resistance (no filament and other sensitive components).

- Long service life – from 30,000 to 100,000 hours (when working 8 hours per day – 34 years). But it is not endless – with prolonged work and/or poor cooling, there is a “degradation” of the crystal and a gradual drop in brightness.

- The number of turn-on cycles does not significantly affect the life of the LEDs (as opposed to traditional light sources – incandescent lamps, gas-discharge lamps).

• Spectral purity is achieved not by filters, but by the principle of the instrument of device.

• Low inertia – it is turned on immediately at full brightness, whereas in the mercury-phosphorous (luminescent-economic) lamps, the switching time is from 1 s to 1 min, and the brightness increases from 30 % to 100 % in 3–10 minutes, depending on ambient temperature.

• Safety – low LED temperature, usually not above 60 °C, no need in high voltages.

• Insensitivity to low and very low temperatures. However, as well as in any semiconductors, high temperatures are contraindicated in the LED.

• Environmental friendliness – the absence of mercury, phosphorus and ultraviolet radiation in contrast to fluorescent lamps.

The main "disadvantage" of these lamps is too high price. It is about 100 times the price of a conventional incandescent lamp.

The light source (lamps), along with the illuminated fittings, makes a lamp. It provides the fixing of the lamp, supplying it with electric energy, preventing contamination, mechanical damage, as well as the necessary degree of electrical safety and explosive and fire safety. The ability of a lamp to protect human eyes from excessive brightness is characterized by a protective angle (this is the angle between the horizontal and the line that connects the lower point of the light source and the lower edge of the reflective non-transparent surface of the lamp).

When designing lighting installations, it is necessary, observing the norms and rules of lighting of industrial premises, to determine the need for lighting equipment, building materials and structures, as well as the necessary volumes of electric energy consumption. The project, usually, consists of four parts: light engineering, electric, constructive and cost-financial.

Lighting part provides for the following works:

• acquaintance with the object of design, which is to assess the nature and accuracy of visual work at each workplace; at the same time it is necessary to establish the role of the vision in the production process, the minimum dimensions of objects of separation and the distance from them to the eyes of the working person; to determine the coefficients of reflection of working surfaces and objects of differentiation, the location of working surfaces in space, the desired orientation of light, the presence of moving objects, the possibility of increasing the contrast of the object with the background, the possibility of traumatically hazardous situations, stroboscopic effect; to identify the structures and objects on which the lighting devices can be located, as well as structures and objects that may form shadows, etc.;

- the choice of lighting system, which is determined by the requirements for the quality of lighting and efficiency of lighting installations;
- the choice of a light source determined by the requirements for the spectral composition of radiation, the specific light output, the unit power of the lamps, as well as the pulsation of the light flux;
- determination of lighting standards and other standard lighting parameters for this type of work in accordance with the accuracy of work, lighting system and selected light source;
- the choice of the lighting device, which is regulated by its constructive performance under the conditions of the environment, light distribution curve, efficiency factor and magnitude of illumination;
- the choice of the height of the lighting of the lamps is, usually, consistent with the choice of the variant of the location and is determined mainly by the most favorable ratio of the distance between the fixtures to the design height of the suspension (L: h), as well as the conditions of the dazzle (depending on the light distribution curve, which depends on the type of fixtures, the ratio L: h is taken from 0.9 to 2.0).

Lighting technical calculations begin after determining the main parameters of the lighting installation (normalized lighting, lighting system, type of lighting equipment and the layout of the location).

Actual indoor light can be determined by the following algorithm.

The degree of visual work is determined in the first stage, according to DBN V.2.5-28:2018, depending on the minimum size of the object of recognition, and the subdivision of visual work is determined based on the characteristics of the background and contrast of the object of recognition with the background.

Next, the normalized value of illumination at the workplace E_n for the installed lighting system, the discharge and subdivision of the visual work is determined.

Then, the value of the light flux F_l selected is based on the type and power of the lamps.

After that, the index of the premises is calculated:

$$i = ab / h (a + b), \qquad (2.51)$$

where: a is the length of the room, m; b is the width of the room, m; h is the height of the room, m.

Then, the coefficient of light flow **η** is determined on the basis of the index of the premises, the type of fixtures and the coefficients of reflection of the ceiling and walls (ρ_{cl}, ρ_{wl}).

Then, the actual illumination is determined, which is created in the room by a given system of artificial general lighting:

$$E_f = F_l N n \eta / S k_з z, \qquad (2.52)$$

where: N is the number of fixtures; n is the number of lamps in the fixtures.

Careful and regular care of natural and artificial lighting equipment is essential for creating rational lighting conditions at the workplace, and in the first place, to ensure the normalized values of illumination at the workplace without additional electricity costs.

2.6. Harmful psycho-physiological factors of the labour process

Characteristics of harmful psycho-physiological production factors

The harmful psycho-physiological factors of production include physical (static, dynamic and hypodynamic) and neuro-psychological overload (mental, visual, emotional).

The work of economists, financiers, workers of banking institutions, research and other institutions, as well as other workers in the non-productive sphere is characterized by a long hours (8 hours or more) work in a monotonous tense position, low motor activity with significant local dynamic loads.

The operating seated position is accompanied by a static load of a significant amount of muscle of the legs, shoulders, neck and hands, which is very tiring. The muscles are a long time in a reduced state and do not relax, which affects the circulation of blood. As a result, painful sensations in the hands, neck, upper legs, back and shoulder joints arise. Due to the dynamic load on the musculoskeletal system of the hands, there are pain sensations of varying strength in the joints and muscles of the hands; numbness and slow motion of the fingers; cramps of the muscles of the hand; aching pain in the wrists area.

As a result, there are local muscular strains, chronic stretching of traumatic muscles, which can cause occupational diseases: dissociation motor disorders, diseases of the peripheral nervous and musculoskeletal systems.

In addition, work in a seated position leads to a decrease in muscle activity – hypodynamia. Due to lack of movements, there is a decrease in the consumption of oxygen by tissues of the body and the deceleration of metabolism. It contributes to the development of atherosclerosis, obesity, can cause myocardial dystrophy, chronic headache, dizziness, insomnia, irritation.

Moderate gymnastic exercises can cause the activation of metabolism in the body.

The work of the worker of the non-productive sphere belongs to the category of works related to the use of large volumes of information, with the use of computerized workplaces, with frequent decision-making in times of shortage of time, direct contact with people of different types of temperament, etc. This causes a high level of neuro-psychological overload, reduces the functional activity of the central nervous system, and leads to frustration in its activities, development of fatigue, overwork, and stress.

Long work at computerized workplace leads to a significant load on all elements of the visual system and causes fatigue and fatigue of the visual analyser. The intense visual work causes “eye” (pain, burning and tingling in eyes, redness of the eyelids and eyes, redness in the supra-part, etc.) and “visual” (swaddling in front of the eyes, doubling of objects, flickering, rapid fatigue during visual work) problems, which can cause headache, increased nervous-psychic stress, and decreased working ability.

Excessive physical and neuropsychic overloads cause changes in the physiological and mental conditions of the worker, leading to the development of fatigue and overwork.

Fatigue is a set of temporary changes in the physiological and psychological state of a person, which appears because of intense or prolonged work and leads to deterioration of its quantitative and qualitative indicators or accidents. Fatigue can be common, local, mental, visual, muscular, etc. Since the human organism is a single entity, the boundary between these forms of fatigue is conditional and fuzzy. The course of increasing fatigue and its ultimate value depend on the individual characteristics of the worker, working regime, conditions of the production environment, etc.

Depending on the nature of the initial functional state of the worker, fatigue can reach a different depth; change into chronic fatigue or overwork. Exhaustion is a set of persistent adverse functional changes in the body for the health of workers, which arise because of fatigue accumulation.

The main difference between fatigue and overwork is the reciprocity of shifts at the fatigue and their incomplete reversibility at the overwork.

It is known that the development of fatigue and overwork lead to a disruption of coordination of movements, visual disturbances, inattention, and loss of vigilance and control of the real situation. In this case, the worker violates the requirements of technological instructions, make errors and inconsistencies in the work; the feeling of danger decreases. In addition, overwork is accompanied by a chronic hypoxia (oxygen deficiency), and a violation of the nervous activity.

Manifestations of overwork are headache, fatigue, irritability, nervousness, sleep disturbance, as well as diseases such as vegetative-vascular dystonia, arterial hypertension, reptic ulcer, coronary heart disease, and other occupational diseases.

Fatigue is characterized by physiological and mental parameters of its development.

Physiological indicators of fatigue development are arterial blood pressure, pulse rate, systolic and minute volume of blood, and changes in the blood composition.

Mental indicators of fatigue development are disorientated perception of stimuli, as a result of which the worker does not perceive individual stimuli, and others perceive late; reduced ability to focus attention, consciously regulate it; increased spontaneous attention to side-effects that distract an worker from the labour process; deteriorated memory and the difficulty of remembering information, which reduces the efficiency of professional knowledge; deferred processes of thinking, loss of their flexibility, latitude, depth and criticality; increased irritability, the appearance of depressive states; violated sensory-motor coordination, increased reaction time on stimuli; changed hearing and vision frequency.

The nature of fatigue depends on the type of work activity, because functional changes in the human body at fatigue are mainly localized in those parts of the body that carry the greatest load. Based on this, fatigue is divided into physical and mental by the ratio of the depth of functional changes in various analysers, physiological systems, central nervous system departments, etc.

As noted above, the feature of physical labour is that it causes the body's physical tension when performing work. In severe stress, the continuation of work becomes impossible, and its execution is automatically stopped, and the body immediately goes into the phase of recovery of working ability. Restoration of forces is intense and made in a relatively short period. Therefore, fatigue can be considered as formed during the evolution of the biological adaptation of the organism to the loads. However, depending on the severity of the work, some time is needed to rest.

Moderate mental work can be performed for a long time. The mental work has no clear boundaries between the stress of the body during work and the transition to a phase of recovery of forces. Fatigue during the mental work is manifested in nervous tension, reduced focus and its conscious regulation, deterioration of operational memory and logical thinking, slowing reactions to stimuli. Nervous tension affects the cardiovascular system, increasing arterial pressure and pulse rate, as well as the body's thermoregulation and emotional state of the worker.

Recovery processes after mental work develop more slowly than after physical labour. Unfavorable disorders in the body of the worker are often not eliminated entirely, but accumulated, turning into chronic fatigue, or overwork and various diseases. The most common diseases of mental workers are neuroses, hypertension, atherosclerosis, reptic ulcer, heart attacks and strokes.

Fatigue creates a condition that leads to errors in work, dangerous situations and bad accidents. Scientists cite data that indicate that every fourth accident was preceded by a clearly expressed fatigue.

But, as were noted earlier, industrial fatigue, as a consequence of the impact of the workload and the conditions of the working environment on the body of the worker, plays, first of all, a protective role and stimulates recovery processes. Therefore, measures aimed at preventing fatigue in any case should not be aimed at eliminating this phenomenon. They are directed to distance in the course of time the development of fatigue, to prevent deep stages of fatigue and overwork of the workers, acceleration of recovery of forces and the working ability.

When analysing the psycho-physiological hazardous and harmful factors, great importance is given to the stress arising from the long-term effects on the working combination of psycho-emotional overload and dangerous manufacturing factors.

Stress is a state of mental tension, caused by the dangers that arise in a human being when solving an important task.

Stress manifests itself as a necessary and useful reaction of the body to a sharp increase in the overall external load. It is characterized by an increase in the bioelectric activity of the brain, increase in the heart rate, increase in the blood flow, dilation of blood vessels, increase in the blood leukocyte content, i. e., a set of physiological changes in the body that help to increase its energy potential, to do complex and dangerous actions successfully. Therefore, stress is not only an appropriate protective reaction of the human body, but also a mechanism that promotes the success of work in conditions of obstacles, difficulties and dangers.

Consequently, stress positively affects the results of labour (mobilizes the body and helps to overcome the obstacles that arise in the process of labour) only until it exceeds a certain critical level. The so-called process of hypermobility, which causes violation of mechanisms of self-regulation and deterioration of the results of activities until its breakdown, develops in the human body, if this level is exceeded. Therefore, stress that exceeds the critical level is called distress.

Stress in labour activities, as were shown by the studies, is especially dangerous. The work of the economists, financiers, bank workers, managers, workers of state control and audit and tax services is related to the influence of negative stressors on them, such as: labour intensity; growth of the flow of information that needs to be worked out and used in everyday practice; shortage of time; responsibility for decision making; hypodynamia; various external influences (noise, pollution, radiation, etc.); monotony of labour; violation of a stereotyped system of work (breakdown of equipment), etc.

As were noted earlier, stressful effects can become the cause of physiological and psychological changes that lead to dangerous situations and bad accidents.

Physiological disorders may be accompanied by disorders of the nervous and cardiovascular systems, the gastrointestinal tract, etc.

Psychological disorders include aggression, frustration, nervousness, irritation, anxiety, indecision, rapid development of fatigue, etc. Frustration is the motivation to achieve the goal of an existing strong obstacle.

In addition, stress is the cause of many psychosomatic illnesses: psychoses, neuroses, cerebrovascular disease, cardiovascular diseases and myocardial infarction, hypertension, ulcerative-dystrophic lesions of the gastrointestinal tract, neurocirculatory dystonia, decreased immunity, and cancer. Stress affects the sexual function, the genetic apparatus of cells, leading to developmental disorders of children, etc. Scientists suggested that there was a link between stressful work and spontaneous abortion.

Detrimental effect of stress also manifests itself in the growth of alcoholism and drug addiction, increased levels of injury, increased numbers of people with disabilities and suicide cases.

At the present stage, a robust stress that affects the worker's condition and the possibility of a dangerous situation is mobbing.

Mobbing is a “war” at the workplace, which leads to the emergence of stress of a worker. Significant number of the workers and workers react to mobbing with physiological (stomach ulcer, cardiovascular and oncological diseases, etc.) and mental disorders, and sometimes it leads to injury and suicide.

Causes of the occurrence of mobbing:

- the process of constant modernization, rationalization of production, which requires concentration of the forces and attention in the process of labour, which results in high productivity and, consequently, social insecurity of the worker;
- fear of losing a job;
- psychological terror, caused by envy, vanity and, as a consequence, the creation of intrigues, gossips and physical influence. All this creates a poor production climate and affects labour productivity and the safety of its environment;
- boredom at work, when the process of work does not require creative efforts and creates conditions for the generation of gossips, blackmail, force threats, sexual harassment, speculation, disputes between all colleagues.

Mobbing and its consequences have become so widespread that they became the global problem of the 1990s. Scientists suggest considering mobbing as a psychosocial accident at the workplace.

Measures of protection against psycho-physiological factors

Struggling with fatigue mainly comes down to the improvement of the sanitary and hygienic conditions of the working environment (eliminating air pollution, noise, vibration, microclimate normalization, rational lighting, etc.). A special role in preventing tiredness of workers is played by professional selection, organization of the workplace, correct working position, the rhythm of work, rationalization of the labour process, the use of emotional incentives, the introduction of rational regimes of work and rest, etc.

In addition, specific methods are used to prevent fatigue of workers, which include the means of restoring the functional state of the visual and musculoskeletal system, reducing hypodynamics, enhancing cerebral circulation, and optimizing mental activity.

From the point of view of medicine, it is recommended to use exercises that include psychotherapy, physical and water-air procedures, physiotherapy procedures, massage, adequate nutrition, taking vitamins and minerals, relaxing music and exercises, meditation, autogenous training, etc. for preventing and rehabilitating the effects of psycho-emotional stress.

In order to reduce the impact of psycho-physiological hazards in the process of work, it is necessary to take into account the individual qualities of the worker, since the errors in the work, as well as accidents, are the result of the collision of human qualities with the specifics of a particular professional activity. In order to improve the safety and health of workers during work, it is necessary to conduct a professional psycho-physiological selection for a wide range of occupations.

Different ways must be sought to reinforce and strengthen the security motive in various organizations and institutions. This requires:

- stimulating materially and socially safe work;
- creating a psychological climate in a team at which the fall of authority due to violation of safety rules would minimize the material benefits that could be achieved through violations of safety rules.

One of the directions of improving safety is the organization of safe behaviour of the worker in the labour process. This requires:

- creating a psychological mood for safe behaviour;
- stimulating safe behaviour;
- teaching safe activities;
- enforcing and monitoring labour protection rules;
- educating safe behaviour;
- creating a comfortable psychological climate in a team.

The attitude of the leadership and, in particular, the head of the organization, institution, or enterprise to the issues of labour protection is manifested in the importance they attach to this issue in the overall process of work and to what extent the safety indicator is taken into account in assessing its effectiveness.

The worker believes in danger to the same extent as his/her supervisor does. Therefore, all parts of the production management must continuously show interest in ensuring safety of work, increased attention and care for the safety and well-being of workers. Moreover, the workers should constantly feel it.

The mood for safe work will appear at the worker when he/she sees that the company, organization or institution has strict control over the implementation of safety rules.

Unfortunately, today in the non-productive sphere and the non-state sector of the economy the state of labour protection is alarming. Most managers in these areas do not have special training and experience in professional safety. They show indifference to the problems of labour protection and the reluctance to seriously deal with them. The primary task of labour protection in the non-productive sector is the formation of employers' opinion that the protection of labour should be given priority attention. Then the worker will believe that the safety of his/her work is one of the key values of the enterprise, and this is one of the motives for his/her safe behaviour.

Safe behaviour in the labour process promotes stimulation as a mean of motivating labour protection. The term "stimulus" is defined as a motive for activating human actions, especially in those cases where there is a desire to receive rewards.

The use of incentives to motivate both workers and managers of enterprises, institutions and organizations is a common practice around the world. According to international experience, the next increase in wages (material incentives) for an worker is carried out taking into account work without violations of labour protection standards. Workers who violate labour protection standards do not have the chance of professional growth and are the first candidates for dismissal.

Small and medium-sized enterprises in the non-productive sector should develop and apply an effective system of stimulating workers for safe behaviour in the labour process.

Usually, for the education of safe behaviour in the process of labour, both negative – punishment for violating the safety rules (fines, deprivation of the premium, disciplinary punishment), and positive – encouragement for safe work (monetary allowances for wages, moral stimulation) stimulus are used.

In Ukraine, negative incentive for violating the rules of safety is mostly used. The most common cause of intentional violations of safety rules is the desire to attain all benefits (facilitation, acceleration, simplification of work). Despite the punishment, under such conditions, the worker will continue violating the rules until they cease to be a source of benefits. In such cases, the use of negative incentives should be made so that the costs of violating the safety rules exceeded the benefits received. Then it would be unprofitable to break them.

The punishments for the unintentional violation of safety rules, as psychological studies show, have little effect. It is useful to use such punishments in the process of learning, in shaping the skills for safe behaviour in the labour process. In such cases, punishment, firstly, will prevent the fixing of inappropriate and dangerous skills at work and, secondly, will contribute to creating motives for cautious behaviour.

The most expedient and effective way is to use positive incentives. The use of incentives for safe work, as evidenced by international experience, is the most effective means of improving labour protection.

The promotion of occupational safety should be individual. Criteria for assessing the safety level of each worker (points, coefficients, etc.) should be developed for the organization of stimulation. There is a need to periodically summarize the results of safe work. Indicators, conditions, forms and sizes of incentives for labour protection are specified in collective agreements, regulations on remuneration of labour, labour contracts, taking into account the peculiarities of the organization of labour in the enterprise, institution or organization.

The practical application of the system for promoting safe work shows that it contributes to a significant reduction in accidents, increases productivity and profits far outweigh the costs associated with such incentives.

The process of training workers on labour protection takes significant place in improving the safety of work and in the organization of safe behaviour.

Insufficient level of knowledge of the worker reveals his/her incompetence on the issues of labour protection. In the process of work, the worker cannot precisely determine what is dangerous, and what is safe; where the consequences of the error are small, and where are the large ones. In addition, the worker cannot quickly navigate and find solutions in difficult and dangerous situations. Such worker understands that he/she can easily assume a dangerous mistake, realizes that he/she has little opportunity to deal with danger. All this gives rise to anxiety, insecurity, safety of one's work and leads to dangerous actions. These factors are defined as a manifestation of inexperience.

Teaching of safe work should be organically linked with the teaching of profession. The most suitable and purposeful way of labour training is to develop skills in which the way to achieve the goal of work is organically consistent with labour protection conditions. When teaching safe work, great attention should be paid to developing the ability to think, the ability to critically evaluate various work tasks, and willingness to act in new, spontaneously emerging hazardous situations.

Skills and awareness of occupational safety and health issues of the workers reduce the risk of injury or occupational disease. Therefore, one of the most prior ways for reducing injuries is to increase the level of knowledge of the workers on these issues, which should be provided by educational institutions and continuously by training workers in the process of their work.

All of the listed above methods of organizing the safe work (creating a psychological mood, stimulating, and training safety rules), in addition to their main purpose, fulfill the functions of education.

Education is a directed action on the human psyche in order to develop the qualities that contribute to person's safe work (positive attitude to safety rules, attentiveness, diligence, etc.).

Means of influence on the worker in the process of education are:

- normative editions (instructions, rules);
- posters on labour protection;
- audiovisual media (television, cinema, conversations); collective discussion with workers of the same professions, cases of violations of labour protection rules, ways of raising the level of safety and working conditions.

The key direction in the process of education is the formation of each worker, especially the management of enterprises, institutions and organizations, new labour-minded thinking (the priority importance of labour protection), the ideology of security and law-abidingness.

The most important aspects of the educational work on occupational safety are:

- training of qualified specialists in this field;
- increasing the authority of the labour protection service.

A significant place in the educating of safe behaviour in the work process is given to the propagation of safe working conditions. Propagation is a deliberate work on the dissemination of advanced ideas, provisions and knowledge that serves to consolidate, change and develop the attitude of workers to complying with labour protection regulations.

The main areas of propagation are to draw the attention of working people to the urgent issues of labour protection and the dangers that arise in the process of labour; to dispel the faith in the inevitability, accidental occurrence of dangerous situations in the process of labour, because such faith generates pessimism and apathy at work. This is achieved by the way of a fundamental, scientific approach to a true assessment of events and facts, disclosure of specific causes, conditions and perpetrators in the occurrence of false actions of the worker in the labour process.

The means of propagation of labour protection are the press, radio and television.

The effect of propagation becomes more effective when certain rules are followed:

1. It is forbidden to promote ideas on labour protection, which limit the material and spiritual needs of workers. For instance, propagation of the requirement not to work on an outdated model of PC without a protective screen is simply ignored by the workers, because they need to perform tasks and earn money. The issue of providing a PC with protective screen must be solved in advance.

2. It is necessary to take into account the interconnection of the general direction of propagation with the facts of reality. If propagation's influence

contradicts the facts, then it is doomed to failure. In addition, the intimidation of workers with an imaginary danger without facts, which would confirm the possibility of its implementation in specific conditions, also will not bring positive results.

Thus, propagation of occupational safety issues actively interferes with the consciousness of the workers, their thoughts, plans, and actions and aims to change the existing attitude of the worker to the danger in favor of labour protection.

An important role in creating safe working conditions is played by the labour collective and its leader.

Term «collective» is understood as a group of people who have achieved high efficiency in the process of joint activity, due to the efficiency, interoperability, and the nature of interpersonal relationships.

The determinants of the regulation of joint activities are factors such as the specificity and complexity of tasks, the duration of the joint activity, the quantitative composition of the group, the relationship between the members of the group, the functional structure of the group, the degree of isolation and autonomy of the group.

Psychological climate in the team is the result of interpersonal relationships and joint activities.

Psychological climate can be considered as the result of group compatibility, which is characterized by psychological indicators of the unity of a group of people, which ensures coherence and non-conflict communication.

Psychological climate is manifested in the formation of a common opinion, an assessment of people and events, actions and mood, attitude to labour protection.

Comfortable psychological climate promotes preservation of health of the members of the labour collective, provides a sense of responsibility and duty, communicative mutual assistance, self-criticism, demanding oneself and another in the interests of the collective. A person can understand his/her own value only when his/her affairs become meaningful, they have some value to others. Self-esteem increases on the basis of relationships with others and is one of the forms of manifestation of the psychological climate.

The psychological climate can be determined through satisfaction with interpersonal relationships vertically (leader – subordinates) and horizontally (performers).

Interpersonal relationships are influenced by the role tendencies of the participants in the management process. The most important of them is the leader. Confidence and optimism of the leader improves the atmosphere of relationships in the organization and collective, promotes productivity and safety of work. Experienced leaders have no doubt in accomplishing their tasks. They embody the confidence in the workers. Moral and ethical qualities of a leader are very important. The leader should have an individual approach to workers. The leader delegates appropriate powers to workers, supports and encourages them, increases their self-confidence.

Therefore, it should be noted that the great harm is caused by the unwarranted appointment of unprepared and incompetent people to lead a labour collective. When the leader has the authority and trust of the team, all his/her decisions are considered to be true, and the workers carry out them with full dedication of physical and mental efforts, avoiding dangerous situations.

One of the main tasks of the leader is the creation of conditions for strengthening of interpersonal connections, whose strength increases the level of development of the collective.

Each collective always has a person or a group of people whose interests do not coincide with others. They make up a number of opponents. Management theory states that in the presence of 30 % of dissatisfied or critically minded people in the collective begins disorganization, and in the presence of 50 % of such people begins a crisis that gives rise to conflict.

The most common type of conflict is interpersonal. Joint service activities unite people into groups with different traits of character, different intelligence and education. Sometimes they cannot cooperate at all because of psychological incompatibility.

Conflict between a person and a group is possible when the expectations of the person do not coincide with the adopted group settings. There are situations when a person finds his/her idea to be the most valuable, and the group does not perceive it. A conflict between a leader and performers arises if means of punishment or remuneration apply unfairly.

Conflicts in the collective reduce not only the efficiency of the labour process, but also lead to nervous-emotional stress, the development of stressful situations, neglect of safety rules and labour protection requirements and create dangerous and bad accidents.

Comfortable psychological climate in the collective also plays an important role in creating safe working conditions. It is necessary to ensure the highest integrity of duties, the establishment of benevolent interpersonal relations, and the development of a proper collective attitude to the requirements of labour protection in collectives.

Taking into account the foregoing, one can conclude that the problem of the labour protection, protection of the worker from the action of harmful and dangerous industrial factors must be solved not only by creating a safe technique, improving the technical means of protection and improving their use in the labour process, but also taking into account the ‘human factor’. In modern production, when the content and the nature of the work of many specialists have changed substantially, due to the introduction of advanced technologies in practice, solving the problems of labour protection without taking into account psycho-physiological factors is impossible.

2.7. Hygienic classification of labour. Attestation of workplaces under working conditions

During any type of work, each person is exposed to factors associated with the nature of the work and the environment in which it occurs. These factors may cause unwanted consequences (see Section 2.1). To reduce the influence of such factors and ensure the sustainability of the characteristics’ values of the vital activity of the organism, adaptive reactions are included. That is, the protective reflex of the body, which affects the work of the basic functional systems of the person, which naturally leads to a decrease in efficiency. At the same time, wishing to save it, a person, as a rule, forces his body to reduce the influence of the protective reflex. After some time, the worker adapts to the adverse effects of sanitary-hygienic factors (of course, if they do not exceed certain limits). This is achieved with the additional costs of muscular and neuropsychic energy. From the points of view of the main labour process, such use of internal body reserves is, of course, impractical.

Consequently, the adverse impact on human health and hygiene factors leads to the diversion of internal resources of the worker from the main labour process, it has adverse effects on the psychophysiological state of the person, its efficiency and, as a result, it is reflected in the technical and economic indicators of production. Study of changes in the human body in the process of various forms of labour activity is the subject of labour physiology. Assessment of work, according this point of view, involves the definition of the physiological content of labour (physical activity, nervous and emotional tension, rhythm, pace and monotony of work, the amount of information received and processed). Labour hygiene deals with practical use of these laws in order to develop appropriate standards and rational modes of work and rest, methods of professional selection and thus ensuring optimal human capacity for a long time. The branch of preventive medicine, which studies the conditions and nature of labour, their impact on health, the functional state of man, develops the scientific basis of hygienic regulation of factors of the production environment and labour process, practical measures aimed at preventing harmful and dangerous effects on workers is called labour hygiene.

Hygiene of labour studies the impact of the production environment itself on the functioning of the human body and its individual systems. The human body was formed in the conditions of the natural environment. The main factors of this environment are atmospheric conditions, air composition, its natural electromagnetic, radiation and acoustic background, light climate, etc. Depending on the conditions of implementation and peculiarities of technological processes, technogenic human activity may be accompanied by a significant deviation of the parameters of the production environment from their natural value, which is desirable for ensuring the normal functioning of the human body. Thus, during the labour process, specific harmful factors associated with it may occur and develop. Possible list and classification of harmful production factors is given in clause 2.1.

The consequent of the deviation of working environment factors from natural physiological norms for a person becomes violation of function as separate systems of the human body as well as whole organism. Depending on the degree of this deviation, they may be partial or complete, temporary or permanent.

It is impossible to completely avoid unwanted impact of manufactured activity on the state of the industrial environment and the environment as a whole. Therefore, the purpose of hygiene of labour is to establish such limit deviations from natural physiological norms for a person, such allowable loads on the human body by individual factors of the production environment, and such permissible loads on the human body with a complex action of these factors as that, which will not cause negative changes in human body functioning and will not lead to genetic changes in future generations.

With a purpose of the comprehensive assessment of working conditions, taking into account physiological and hygienic conditions, according to the Order of the Minister of Health of Ukraine No. 248 of April 8, 2014, approved by State Sanitary norms and rules "Hygienic classification of labour on the indicators of harmfulness and danger factors of the production environment, the severity and intensity of labour process" (hereinafter – the Hygienic Classification of Labour) [19]. Hygienic classification is based on the principle of differentiation of working conditions, depending on the ratio of actual levels of harmful factors and existing hygiene norms, as well as depending on the possible influence of these factors on the health of workers.

This classification of labour divides the working conditions into 4 classes:

Class 1 (optimal working conditions) are conditions under which not only the health of workers is preserved, but also the preconditions for maintaining a high level of labour ability are created.

The optimal hygiene norms of the production factors are set for the microclimate and indicators of the severity of the labour process. For other factors, optimal norms are accepted for such working conditions, in which the adverse factors of the production environment do not exceed the safe levels admitted for the personnel.

Class 2 (acceptable working conditions) are conditions characterized by such levels of factors of the production environment and the labour process that do not exceed the established hygienic standards (and possible changes in the functional state of the organism are restored during the time of regulated rest or before the beginning of the next shift) and should not make an unfavorable impact on the health of workers and their descendants in the near and distant periods.

Class 3 (harmful working conditions) are conditions that are characterized by such levels of harmful production factors that exceed the hygiene norms and can have an adverse effect on the worker's health and / or his descendants.

Class 3 (harmful working conditions) are conditions that by the level of exceeding hygienic standards and the severity of possible changes in the body of workers are divided into 4 degrees:

1 degree (3.1) – is working conditions characterized by such levels of harmful factors in the production environment and the work process that cause functional changes beyond the limits of physiological oscillations (the latter are recovered for longer time, than the beginning of the next shift, the interruption of contact with harmful factors), and increase the risk of deterioration of health, including the occurrence of occupational diseases;

2 degree (3.2) – is working conditions characterized by such levels of harmful factors in the production environment and labour process, which can cause persistent functional disorders, in most cases lead to an increase in production-related morbidity and the emergence of individual cases of occupational diseases that arise after prolonged exposures;

3 degree (3.3) – is working conditions characterized by such levels of harmful factors of the industrial environment and labour process, which, in addition to the growth of chronic morbidity (caused by production and morbidity with temporary disability), lead to the development of occupational diseases;

4 degree (3.4) – is working conditions characterized by such levels of harmful factors of the industrial environment and labour process, which can lead to a significant increase in chronic pathology and levels of morbidity with temporary disability, as well as the development of severe forms of occupational diseases;

Class 4 (dangerous working conditions) – conditions characterized by such levels of harmful factors in the production environment and labour process, the impact of which during the work shift (or its part) creates a threat for life, a high risk of acute occupational injuries, including severe forms .

Hygienic norms of working conditions – MPC, GDR, and other maximum permissible (safe for people) levels of harmful and dangerous production factors, are established based on the fact that for daily (except weekends) 8-hour work, but not more than 40 hours per week They should not, during the entire period of work experience, cause illness or health impairment, which are manifested by modern methods of research in the course of work or in distant periods of life of present and future generations. If more than 8 hours of change in each case are possible, the opportunity to work should be agreed with the institutions of the State Sanitary and Epidemiological Service.

The general hygienic assessment of working conditions is carried out as follows. If the actual values of the levels of harmful factors are at the workplace within the limits of the optimal or permissible levels, the working conditions at this workplace correspond to the hygienic requirements and are classified according to class 1 or 2.

If the level of at least one factor exceeds the permissible value, then the conditions of work at such a workplace (depending on the amount of excess and in accordance with the hygienic criteria of this Hygienic classification of labour) both as a separate factor and in their combined action, may be classified as 1–4 degrees of harmful degree 3 or 4 classes of hazardous working conditions.

The assignment of factors to a particular class is determined by the actual measured parameters of the production environment and labour process. To establish a class of working conditions, exceeding the MPC, the GDRs can be set within one day (shift), typical for a particular process. When atypical or occasional exposure occurs (during certain days, weeks, months), hygienic assessment of working conditions is performed with the help of equivalent exposure and/or a maximum level of factor depending on the purpose of research.

Hygienic assessment of working conditions, considering the combined action of connecting factors of production, is based on the results of the preliminary assessment of working conditions for individual factors, where it is taken into account the effects of summation and potentiation at the combined exposure to chemicals, biological agents, and different frequency ranges of electromagnetic radiation. The general hygienic assessment of working conditions by degree of harmfulness and danger is determined by the highest class and degree of harm.

With the reduction of contact time with harmful factors (protection time), effective use of personal protective level of occupational health hazard is reduced, so that conditions can be evaluated as less harmful (according to certificates on VPC), but not less than 3.1 degree class 3. In difficult cases the working conditions of workers are estimated on the basis of occupational disease' indicators and functional state of the disease, according to medical records of worker.

Hygienic labour classification is used for job evaluation of their compliance with sanitary requirements and priority in the implementation of health measures, development of recommendations for physical fitness, proficiency; creation of a data bank for working conditions at the enterprise level, district, city, region, country.

Attestation of workplaces under working conditions

Attestation of workplaces under working conditions (hereinafter – attestation) is conducted in enterprises and organizations regardless of ownership and management forms, where the manufacturing process, used equipment, raw materials are potential sources of harmful and dangerous industrial factors that may badly affect the health of workers, as well as their descendants, now and in the future.

The main purpose of attestation is the regulation of relations between the owner or an authorized body and workers in the field of realization of the rights to healthy and safe working conditions, preferential pension provision, benefits and compensation for work in unfavorable conditions.

Attestation of workplaces under the conditions of work is conducted in accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 442 dated August 1, 1992 [20], the attestation structure and powers of which are determined by order on the enterprise, organization in the terms provided by collective agreement. But not less than once in every five years. The authorized representative of the elective body of the primary trade union organization is included in the commission, and in the case of absence of a trade union organization, the authorized person by a hired worker is included.

Responsibility for well-timed and qualitative certification is imposed on the head of an enterprise or organization.

Extraordinary attestation is carried out in the event of a radical change in the conditions and nature of work on the initiative of the employer, trade union, committee, labour collective or its elected body, bodies of State Labour.

Certification may involve design and development scientific research organizations, technical inspections of labour unions, territorial offices of the State Labour Organization.

Attestation of workplaces under working conditions provides:

- identification of factors and causes of unfavorable working conditions occurrence;
- sanitary-hygienic study of the factors of the production environment, the severity and intensity of the labour process at the workplace;
- comprehensive assessment of the factors of the production environment and the nature of labour to match their characteristics with the standards of safety, construction and sanitary norms and rules;
- establishment of the degree of harmfulness and danger of labour and its nature by the Hygienic Classification of Labour;
- substantiation of the classification of the workplace as a category with harmful (especially harmful), heavy (especially severe) labour conditions;

- determination (confirmation) of workers' rights to privileged pension for work in unfavorable conditions;
- compiling a list of jobs, industries, professions and positions with preferential pension provision for workers;
- analysis of the implementation of technical and organizational measures aimed at optimizing the level of hygiene, the nature and safety of labour.

Hygienic studies of the factors of the production environment and labour process is carried out by laboratories, the certified State Labour Organization and the Ministry of Health in the manner prescribed by the Ministry of Health Policy together with the Ministry of Health.

Assessment of working conditions during the certification of workplaces is carried out in order to establish classes (degrees) of harmful working conditions in accordance with the State sanitary norms and rules “Hygienic classification of labour on the indicators of danger and unsafe factors of the production environment, severity and labour process tension”.

Information about the results of the certification of workplaces is recorded on the map of working conditions, the form of which was approved by the Ministry of Social Policy along with the Ministry of Health.

The list of jobs, productions, professions and posts with preferential pension provision of workers agrees with the trade union committee and is approved by orders of the enterprise, organization and stored for 50 years. Excerpts from the order are added to the work record book of workers, whose occupation and positions are included in the list.

The attestation results are used for development of measures for improving the working conditions and the health of workers and during determination of the right to a retirement pension on preferential terms, benefits and compensations at the expense of enterprises, institutions and organizations, justification of proposals for making changes to the lists of industries, jobs, professions, positions and indicators, employment in which gives you the right to a retirement pension on preferential terms.

Proposals for making changes to the lists of production, works, professions, positions and indicators, employment in which gives the right to old-age pension on preferential terms, are prepared by the State Labour Inspectorate on base of substantiated and agreed with MH petitions, interested ministries and other central bodies of executive power, coordinated with all-Ukrainian branch trade unions and employer associations, and are moved to the Cabinet of Ministers of Ukraine.

The control over the quality of the certification, the correctness of the use of lists No. 1 and No. 2 of production, works, professions, positions that give entitlement to preferential pension benefits, perks and compensation is relied on the State Labour Organization.

2.8. Sanitary and hygienic requirements for territories, production and auxiliary premises of business facility (BF)

2.8.1. Sanitary requirements for the location and planning of territories (BF). Classes of harmfulness of enterprises according to the sanitary norms.

According to the State Sanitary Rules of planning and development of settlements of the enterprise, their separate buildings and constructions with technological processes that are sources of environmental pollution by chemical, physical or biological factors, should be separated from residential buildings by sanitary protection zones (SPZ). It should be done because of impossibility to create non-waste technologies. The size of the sanitary protection zone is determined directly from sources of air pollution to the boundary of residential development.

There are such sources of air pollution:

- organized (concentrated) emissions through pipes and mines;
- dispersed emissions through the lanterns of industrial buildings;
- unorganized emission through open warehouses and cellars, places of loading, places for the preservation of industrial waste.

For enterprises that are sources of atmospheric pollution by industrial emissions (depending on capacity, conditions of implementation of the technological process, quantitative and qualitative composition of harmful emissions, etc.), are established the following sizes of sanitary protection zones according to the class of harmfulness of the enterprises:

Class I – 1000 m,

Class II – 500 m,

Class III – 300 m

Class IV – 100 m,

Class V – 50 m.

I, II and III classes mainly relate enterprises of the chemical and metallurgical industry, some ore mining enterprises, and the production of building materials.

To IV class along with the enterprises of the chemical and metallurgical industry, relate enterprises of the metal-working industry with cast iron (up to 10,000 tons / year) and coloured (up to 100 tons per year) casting, a number of enterprises for the production of building materials, wood processing, a lot of enterprises of textile, light industry, food industry.

To V class, in addition to some industries of the chemical and metallurgical industry, relate enterprises of the metalworking industry with heat-treated without foundry processes, large printing houses, furniture factories.

Sanitary protection zones should be greened, because at this particular time they can fully act as protective barriers to industrial dust, gases, and noise.

At the external boundary of the sanitary-protective zone facing residential development, the concentration and level of harmful factors should not exceed their hygienic standards (MPC). At the boundary of the resort recreational zone – 0,8 of the value of the norm. The great importance from the sanitary-hygienic point of view is the landscaping of the territory, which requires greening, equipment sidewalks, playgrounds, sports, etc. Landscaped areas should come to, at least 10...15 % of the total area of the enterprise. To collect and store industrial waste, you need to remove special areas with fencing and convenient access.

The territory of the production enterprise includes the following areas: public purpose, production area with open areas and auxiliary facilities of production and farms, guest parking, recreation area and gardening area, including a sports area, as well as a sanitary protection zone.

Public areas and recreation areas should be isolated as much as possible from the production area with open areas and auxiliary objects of productions and farms with protective plantings, carriers of sound-coloured information warning about danger, as well as permanent and temporary fencing of different kinds. All objects and premises of public areas and rest areas should be accessible to the less-mobile groups according to DBN B.2.2-17 [21].

Pre-planting area is a free space of a public area for holding public events of a production enterprise that is placed near the administrative, main industrial building or near the main passages within the boundaries of the territories of production facilities and in the territories adjacent to the settlement. The area ofpre-factory territory should be determined from 0.6 ha to 0.9 ha per 1,000 workers. It is necessary to allocate from 40 % to 50 % of pre-factory territory for gardening and placing the elements of improvement.

Planting is projected along pedestrian communications (on one or both sides) in the form of lawns and flowerbeds, ordinary plantings of trees and bushes.

Planting is formed in the form of pictorial compositions, where monotony and similarity are excluded.

Obligatory list of elements of complex improvement of pre-factory territory should include solid types of coatings, elements of combination of surfaces, planting of greenery, lava, urns, containers for household waste collection, lighting equipment, information storage media, bicycle-parking equipment.

It is recommended to provide types of cover in the form of tile paving, placement of elements of decorative and applied design, water devices, architectural and decorative lighting. Landscaping of the square is designed as parterre or molded in the form of a garden square, using colour design and mobile forms of landscaping.

Small architectural forms, means of outdoor advertising and information are on the pre-factory territory.

The minimum width of the main pedestrian communications must be 2.25 m, minor – 1.5 m, the estimated width - based on the capacity of pedestrian streams, but no more than 800 per s / hour per 1 m wide of the road.

The obligatory list of elements of improvement in the pedestrian communications area should include solid types of covering, a combination of surfaces, landscaping (including mobile), bins and containers for household waste, lighting equipment.

The dimensions of the recreation areas should be determined in the norm from 1 square meters to 1.2 square meters per seat (seats are from 10 % to 15 % of the workers in the most numerous shifts). The sum of the distances from the workplace to the dining room and from the dining room to the resting place should not be more than 300 m. In the case of a noisy nature of production, it is necessary to apply forms of quiet rest and calm colours and form elements of improvement, in the case of a monotonous nature of production – active forms of rest and various elements of the bright colouring.

The obligatory list of elements of improvement on recreation areas should include solid types of coatings, elements of combination of surfaces, planting of greenery, benches, tables for games, urns, and lighting equipment.

The obligatory list of elements of improvement on parking places for cars, bicycles, motorcycles should include solid types of coverage, elements of combination of surfaces, equipment for bicycle parking, marking, lighting equipment, urns. In addition, fences can be arranged.

Objects of recreation should be formed, as a rule, in the form of squares for short-term rest before or after the shift. The square should be placed on the territory protected from the adverse effects of industrial activity as much as possible.

The obligatory list of elements for the improvement of the sanitary protection zone of the production enterprise should include elements of the combination of the greenery with the adjoining territories (side stone, retaining walls, etc.), elements of plant protection and landscaping areas.

The territory of enterprises and platforms for parking vehicles should be equipped with devices for collecting and discharging wastewater that is formed because of precipitation and its treatment facilities.

2.8.2. Sanitary requirements for production facilities

During the planning of production facilities, it is necessary to take into account the sanitary characteristics of production processes, adhere to the norms of the useful area for the workers, as well as the norms of the areas for the location of the equipment and the required width of passage, which ensure safe work and convenient service of the equipment.

The volume of production premises per one worker, in accordance with sanitary norms, should be not less than 15 cubic meters, and the area of premises – not less than 4,5 square meters.

If in one structure it is necessary to place industrial premises, which from the point of view of industrial sanitation and fire prevention, different requirements are put forward, then it is essential to group them in such a way that they are isolated from each other. Workshops, offices and sections with significant harmful emissions, excess heat and fire hazard should be located near the outer walls of the building and, if it is permissible under the conditions of the technological process and production flow, on the upper floors of the multistory building. You cannot place harmless workshops and sections (such as machine tools, computers, etc.), as well as office premises over harmful ones, because when windows open, gas and steam can penetrate into these premises.

The premises, where are housed power supply, ventilation, compressor and other types of high-risk equipment should be located, must be permanently locked on the key in order to prevent third-party workers from getting into them. In order to prevent injuries in industrial premises, it is necessary to apply a warning paint of building structures and security signs (GOST 12.4.026-76) [22]. For example, in yellow (or black strips) are paint the structure lowly above the aisles, narrowing fares, imperceptible steps, protrusions and fluctuations in the floor plane.

The width of the main passages inside the shops and sections should be at least 1.5 m and the width of the passes is 2.5 m. Doors and gates leading directly to the yard must be equipped with vestibules or air curtains.

An important place for healthy and safe working conditions is the rational location of the main and auxiliary equipment, production furniture, and the correct organization of workplaces. The order of equipment and the distance between machines are determined by their size, technological requirements and safety requirements. However, in all cases, the equipment that has an electric appliance should have a free approach on all sides with a width of at least 1 m from the side of the working zone and 0.6 m from the side of the non-working zone. Production furniture (cabinets, shelves, tables, etc.) can be placed close to the structural elements of the building – walls, columns. For the treatment and interior surfaces protection of building constructions from the harmful action and aggressive substances (e.g. acids, alkalis, lead) and moisture, usually are used ceramic tile, acid-resistant plaster, oil paint, which prevent sorption of these substances and allow surfaces to be washed.

The height of the production premises should be not less than 3,2 m, and for the premises of the energy and storage facilities – 3 m. The distance from the floor to the structural elements of the ceiling is 2.6 m. Galleries, bridges, stairs and platforms should be at least 1 m wide and guarded with rails in height 1 m and below should have sideways in height of 0,2 m.

All platforms, which are located at an altitude of more than 260 mm from the floor, must have rails. Sanitary metal stairs for service equipment are installed at an angle not exceeding 45° from the distance between the steps of 230–260 mm and the width of the stairs 250–300 mm. For maintenance of equipment, which is used 1–2 times per shift and which is located on sites with a difference in markings of no more than 3 m allowed angle of inclination of stairs 60° and railings are painted in yellow (red) colour, but risers are painted in white. Stairs made of ribbed or striped steel. The width of exits from the premises must be not less than 1 m, height not less than 2,2 m. When driving through the door, their width should be more than 0,8 m on both sides of the transport dimension.

The floors of production premises should be wear-resistant, warm non-slippery, dense, easy to clean, and in some workshops and sections – moist-, acid- and fire-resistant. Water, lubricants, harmful substances, gases must not penetrate through the floor to other premises.

2.8.3. Sanitary requirements for sanitary facilities of BF

The sanitary facilities include walk-in closets, rooms for drying and disinfecting work clothes, showers, washers, detergents, food intake rooms, smoking rooms, rooms for women's hygiene, breastfeeding, and rest.

The composition of sanitary facilities depending on the nature of the production processes. According to this indicator, they are divided into 4 groups.

The first group includes production processes that occur under normal meteorological conditions and are not associated with the release of harmful gases and dust. In such processes, wardrobe and wash-in are provided, and in case of possible contamination of clothing, hands and body – also showers and baths for the feet.

The second group includes production processes that occur during adverse weather conditions related to the release of large amounts of dust and harmful chemicals or hard physical labour. In addition to wardrobe, they are provided with washroom and shower, extra room for work clothes drying, warming, and respiratory and inhalation rooms.

The third group includes production processes associated with discernable occupational hazards: contact with pesticides infected materials, with a strong dust liberation with ionizing radiation.

To the group of residential premises are included: delousing with dressing room, shower, wash and besides facilities for drying, rooms for disinfection of work clothes, appliances for washing and cleaning shoes, respiratory, inhalating and disinfecting chamber, dosimetry camera for storage radioactive contaminated work clothes and personal protective equipment.

The fourth group includes processes that require special sanitary regime to ensure quality of products, namely related to food processing and processes related to the preparation of sterile materials.

During performing such processes of the sanitary facilities dressing rooms, wash rooms, rooms for medical examination and manicure, issue room for sanitary and work clothing are included.

Dresser is designed for storing street, home and work clothes. It is equipped with open hangers or enclosed individual wardrobes.

The place for drying working clothes is determined from the calculation of 0.2 m^2 for each user in the most numerous shift. Clothes drying is allowed in closed cabinets with the supply of warmed air in them.

The rooms for decontamination should be separated from the dressing rooms and have an area of at least 12 square meter.

Depending on the production, shower rooms are expected to be at a rate of 3–15 people per shower grid. Estimated working time of shower 45 minutes after each shift. They need to be placed in rooms adjacent to changing rooms, as a rule, between lockers for work and home clothes. The shower must be equipped with open cubicles with dimensions 0,9 x 0,9 m. The width of the passage between the rows of shower cabins in the plan is taken at least 2.0 m, and between the shower cabins and wall or partition – not less than 1.2 m.

Washrooms are placed in separate rooms, adjacent to or in the locker rooms.

Washstands arrange according to the rules depending on the group of production processes – 7...20 people per crane. The distance between the cranes of the washers should be not less than 0,65 m. The width of the passage between the rows of washstands is 2.0 m, and between the extreme rows and walls or partitions – 1.5 m.

Cleaning rooms should be located at a distance of not more than 75 m from the most remote working place in buildings and 150 m from the workplace in the premises . In multistory buildings, cleaning rooms should be provided on each floor for men and women. They are counted on the basis of the number: 15 women on one toilet and 30 men on 1 toilet and 1 urinal.

When number of employed people is less than 10, in the most numerous shifts, cleaning equipment is assumed with one cabin for men and women.

Workers must be provided with drinking water at a rate of 2–5 liters per person in one shift. In hot workshops, spaces should be provided with an area of 2–3 square meters for installations with cooled, salt, soda water (5 g of salt per liter of water).

Premises for smoking are assumed to be with an area of 0.03 square meters per worker and 0.01 square meters for women, but no more than 9 square meters. Usually they are arranged at a distance of no more than 75 m from the workplaces located in the building and 150 m – on the territory of the premises.

Women's personal hygiene rooms should be provided in case when there are more than15 women in one shift. These premises should be isolated from other premises. The number of personal cabins is determined from the calculation: one cabin per 100 women working in the most numerous shift. The sizes of personal cubes for procedures should be taken 1.8 x 1.2 m.

Premises for breastfeeding are envisaged if the number of women working in the most numerous shift is at least 100. The room area for feeding children is determined at a rate of 1.5 square meter per nursing mother. The number of nursing mothers is assumed to be equal to 2.5 % of women working in the most numerous changes.

The rooms for rest in working time are projected in accordance with the technological part of the project. The area of these premises should be taken at a rate of 0.2 m^2 per one worker of the most numerous shift. But not less than 18 m^2. The distance from the work places to the rooms for recreation should be no more than 75 m. These rooms are equipped with washbasins with a supply of cold and hot water.

Premises for the heating of workers are provided when working process is on the open air or in rooms with air temperature at the workplace below 5 ^oC. The area of these premises is determined from the calculation of 0.1 m^2 per 1 working man of the most numerous shift, but should be not less than 12 m^2. The temperature there should be 22–24 ^oC.

Baths for hands are assumed in the production processes associated with vibration, which is transferred to the hands. For bath equipment, use semi-circular washbasins measuring 0,6 x 0,5 m. The water temperature for procedures should be 37–38 ^oC. The number of baths is determined on the basis of their use of 35 % of the workers of most numerous shift. The area of the premises should be at least 1 m^2 per bath.

2.9. Partial and general safety requirements for the process of production

The safety of the process of production includes three main components:

- the safety of industrial equipment;
- the safety of the production process;
- the safety of work performance.

The safety of industrial equipment isregulated by the GOST 12.2.003-91 [23] and other reference documents, that accompany requirements of the GOST 12.2.003-91 about certain industrial equipment, including:

- DSTU National Standard 12.2.061:2009 [24];
- DSTU EN 60204-1:2004 [25];
- DSTU ISO 14159:2005 [26];
- DSTU ISO 14122-1:2004 [27];
- DSTU ISO 14122-3:2004 [28];
- DSTU EN 457-2001 [29];
- DSTU 3680-98 [30];
- DSTU ISO 60825-1:2004 [31];
- NPAOP 0.00-1.08-94 [32];
- NPAOP 0.00-1.73-14 [33];
- NPAOP 0.00-6.18-04 [34];
- Technical Regulations ***ofthe safety of low-voltage electrical equipment /*** The Resolution of the Cabinet of Ministers of Ukraine № 632datedAugust 28, 2013 [35] and other reference documents.

Technical Regulations of safety of the industrial equipment and products, amended by the Decree of the Cabinet of Ministers, hold a unique position among the dignified regulatory acts in this sphere. They derive from the relevant Policy Statements of the EU and current statements in the EU and define terms of safety considering the New Approach Directives in the sphere of safety of the industrial equipment and products.

Safety conditions for particular industrial equipment were determined with regard to the assignation, operation circumstances and their implementation under the terms of GOST 12.2.003-91 [23] and other reference documents.

Safety of industrial equipment can be provided under condition of following the next steps:

- selecting the operating principles and featuring the work processes;
- minimizing the amount of energy, which is used or contained;
- using built in safety equipment in the construction and information on likely alarm conditions;
- using the automated equipment, remote control and sampling;
- adherence the ergonomic requirements, limiting physical and neuro-physiological activities of the workers.

Manufacturing facilities during the work process, unassisted or consisting of technological complexes, should be kept in accordance with safety conditions during the complete operating period.

The materials of the industrial equipment construction should not cause hazards or harmful factors that can influence worker’s health. The load in individual elements of equipment should not reach the dangerous limit. If that limit was exceeded, the special feature of the security facilities in the equipment design should be activated (protection enclosure, blocking devices and others).

The danger areas of industrial equipment (actuated parts, high-temperature elements, current-carrying elements of the electrical facilities) should be protected, insulated or housed within inaccessible places or enclosed, as potential sources of injury risk.

Exclusively the industrial equipment characterized by fire and explosion protection in prescribed operation conditions should be used. The industrial equipment should not stack the static charge in dangerous amount as that would endanger the lives of workers.

The operation of the industrial equipment leading to the pollutant emission and containing organisms, flammable or explosive materials should include fixed equipment for isolation of extraction. In default of such equipment the spot for the accessing off-line units for isolation of extraction should be available in the construction.

If the industrial equipment leads to increased noise, ultra- or infrasound, vibration, industrial radiating (electromagnetic, laser etc.), it should be constructed thereby taking into consideration the outlined harmful factors which should be within the limits that are identified by the relevant existing standards.

The industrial equipment should be equipped with the option of accent lighting, identified by the relevant existing standards, if its deficiency can cause an overload of visual organs or other hazards associated with the maintenance of such equipment.

If the appliance of lifting facilities is envisaged during the assembly, repair works, carriage and manufacturing processes, appropriate construction elements or indicated spots for attaching the hauling devices with information of the mass of the equipment should be provided in the construction of such equipment according to the standards. If the relocation of equipment will be carried out manually, appropriate elements or forms for a handgrip should be available.

Operation and usage of lifting tacking and load-carrying devices should be identified by the relevant existing standards. Clamps, hauling and hoisting devices should exclude the possibility of hazard outbreaks during the forced outage and unauthorized state modification of these devices after reapplication of power supply.

Management and maintenance of the vessels working under the pressure and connected with the manufacturing facilities with higher hazard level shall be provided with all safety requirements identified by the relevant existing standards and existing "Standard of Care of facilities that work under pressure" and "Standard of Care of high pressure vessels". The pressured, condensed and rarefied gases and reservoirs, which pursuant to the normative base are only detailed on groups of vessels, which can work under the pressure, also belong to that kind of equipment.

Safety conditions during the installation, exploitation, repair works and performance of the scheduled operations of the boiling equipment, which belongs to the equipment with higher hazard level (I group – plenum steam boilers with pressure higher than 0,07 MPa /0,7 kgs/sm^2/, hot-water boilers with water heating temperature not higher than 115 °C; II group – plenum steam boilers with pressure not higher than 0,07 MPa /0,7 kgs/sm^2, hot-water boilers with water heating temperature not higher than 115 °C).

One of the principal constituents of the safety of any industrial equipment is work area design, its aspect ratio, workers controlling the level of safety, display medium, supporting machinery etc. The aspect ratio of the work area and its elements should provide the performance of operations in a convenient working manner and should not impede the performance of workers. The sitting position operations should prevail (according to DSTU 8604:2015 [36]) or siting-standing positions should take place, if the human performance do not demand the continual redeployment of the worker. The construction of chair and footrest should comply with the ergonomic requirements.

The control system of the fabrication facilities should provide its effective and safe functioning in all operational conditions including the cases of exposures and comply with TRS.

In the work area there should be the captioning data, schemes and other information for the sequence of regulating actions. Construction and facility charts of hazard warnings should provide for correct, authentic and fast information perception.

Central control board of technological complex should have installed alarm system, mnemonic scheme or other display devices with information about the malfunction of each resource, complex tripping device or individual units of such kind, unless that would impede the workers' reaction and actions during the emergency situation.

The acceleration of the industrial equipment and its restart, for any cause, should be selectable only by the responsible worker. The elements of the emergency shuting out after the tripping should be kept at the stop position to its homing action by the operating staff. Homing action after the emergency shutout should not lead to the extension of the equipment.

Security facilities included into the construction of the industrial equipment should perform the following actions:

- provide the possibility of the control over their functioning;
- continuously accomplish their function during the work process;

- work until the full normalization of the accordant dangerous or pernicious factor, which caused the tripping;
- keep functioning in case of the breakdown of the protection elements;
- the control circuit should have the relevant block system if there is a need for security facilities insertion before the start of the work process.

The main guiding materials of the robotized technological complex safety is DSTU 3738-98 [37], outlining the safety requirements for the construction of the industrial robotic systems.

According the up-to-date safety requirements, any industrial equipment and work process associated with the production and functioning of such equipment or process should get a certificate proving their safety conformance and the corresponding technical documents. It concerns any type of industrial equipment or production process.

The safety of the work process is determined by the GOST 12.3.002-75 [38].

Primarily, the safety of the work process is determined by the incorporation of safety requirements for the certain equipment at the project design and release phases, as well as during the trial of the sample and its assignation to the full-scale production.

The main safety requirements for the technical process are:

- elimination of the direct contact of the workers with the basic materials, work pieces, half-blanks, finished products and production residual that can be potentially dangerous;
- the replacement of the technological processes and operations, which are connected with appearance of dangerous or pernicious factors, processes and operations, whereby those factors become absent or less intensive;
- Integrated mechanization, industrial automatization, and the appliance of technological processes and operations with remote control if case of dangerous or pernicious factors;
- equipment pressurization;
- application of collective work protection;

- time-and-motion engineering purposely for prophylaxis of routine work, physical inactivation and limitation of job complexity;
- timely obtaining of the information about the appearance of dangerous or pernicious factors during certain processing steps (the system of obtaining such information should be based on the principle of the automatic action devices with the output on the safety alarm systems);
- obtaining of the control systems and industrial process control providing the safety of workers and emergency outage of industrial equipment;
- well-timed waste management of the equipment considered to be the source of dangerous or pernicious factors;
- securing the fire and explosion protection.

The protection equipment should meet the requirements of the relevant standards of OSSS following the types of work processes and taking into consideration the groups of industrial equipment used in these processes. The listing grid of valid standards is given in the references of State Committee for Standardization and Metrology extended annually.

The safety requirements to the conduction of the technological process should be covered in the fabrication documentation. The common measures for providing the fire-safety of the manufacturing processes are determined by the GOST 12.1.004-91 [39].

Industrial buildings and constructions, depending on the elected architecturally construction and space planning decision, can influence the working conditions: light, noise, microclimate, gaseousness and cleanliness of the air environment of the manufacturing emission. Besides, the wrong color or architectural interior arrangement can have the negative psychological impact on workers.

The working conditions in the shop floor depend on such factors as arrangement of the fabrication facilities, work place arrangement, raw material, blank parts and finished products. The safety requirements for shop floors and grounds tend to form the demands of the relevant code of practice.

The levels of dangerous or pernicious factors on the work areas should not exceed the levels stated in the normative documents of the hazard safety requirements. The work areas should have the levels and illumination factors pointed out in DBN B.2.5-28:2018 [18].

The placement of industrial equipment, feed stocks, blank parts, half blanks, end products and production residuals in shop floors and workplaces should be safe for workers. The distance between the production units, equipment and walls of the shop floors and buildings should satisfy the preproduction planning standards of the building code.

The equipment containing feedstocks, blank parts, half blanks, and finishing products should have corresponding documents including the information about the increase of dangerous and harmful factors, usage of secure storage devices, mechanization and automatization of loading-unloading operations etc.

Secure transportation services and cargo transportation eliminating the possibility of appearance of dangerous and harmful factors should be used for transportation of feed stocks, blank parts, half blanks and finishing products; mechanization and automatization of transportation should comply with the GOST 12.2.022-80 [40] and GOST 12.3.020-80 [41].

The safety of job execution includes the appliance of rational methods of technology and industrial engineering. Particularly, type of work, workflow, level of worker's specialty, work and relaxation mode-selection, workplace discipline, collective psychological climate, organization of health education and welfare support play an important role.

During the creation of the safety work conditions the accounting of medical alerts of the worker in certain technological processes, education and training programs in safety work procedures are of paramount importance.

Certain demands are imposed on the individuals involved in the working process concerning their physical and psychophysical characteristics, and in certain cases, anthropometric data of job characteristics. The workers' health check-ups should be carried out before the issue of the permission to work. It can also occasionally take place during the work process according to the current standards. The health inspection period depends on dangerous and harmful factors of the work process and is prescribed by the Ministry of Health.

As for conduction of gas dangerous works (GDW), they should take place only if they can be performed without human intervention. Enterprises should provide systematic measures to reduce the quantity of such works. The types of works connected with inspection, clearance, reparation, procession of equipment seal failures and communication lines are classified as gas dangerous works. Works inside the containers (machinery, boiler drums, heat exchangers, furnaces, reactors, cisterns, collectors, tunnels, shafts, etc.) also belong to gas dangerous works, if there is a possibility of the explosion, conflagration, negative effects on human organism or oxygen deficient environment in the work zone (less than 20 % volumetric). The organization control over GDW should be provided by gas safety service and work safety service agreeably to their functions.

Individuals, who can take part in the process of production, should have ratable technical trainings (also workplace safety), that correspond their job category. Workers' workplace safety training sessions held on each enterprise and organization independently of the nature and danger level of the manufactory should be arranged with regard to the typical instruction about knowledge of the inspection procedure on the issue of work safety.

The main directions of work security upgrade should be complex mechanization and automatization of the manufacture, which are the prerequisite for the substantial improvement of employment terms. Due to this, the labour efficiency and product quality will be increased, which, in return, will help to dissolve the distinctions between mental and physical work. At the same time, during work process of manufacturing psychological and physiological factors should be accounted. In other words, to coordinate the automatic devices functions manually and automatically, anthropometric data and the ability to process the information should be accounted.

Automated manufacturing also requires strict adherence to the safety requirements during the repairs and setups of automatic computers and systems.

One of the upcoming trends of complex automatization of manufacturing processes is the usage of industry robots. In this case, the industry robot holds a position between a worker and the machine (machinery). The structure of the system looks like that: worker – industrial robot – machine. In this case, the worker does not have the constant direct contact with manufacturing facilities. Engineering usability and quality estimation of the control center and automatization-equipped working place shall be provided in accordance with DSTU ISO 11064-6:2013 [42].

2.10. Safety exploitation of electricity-generating equipment

The main reference documents, which standardize the security issues of the exploitation of electrical installations in Ukraine, are:

- DNAOP 0.00-1.32-01 [43]. This document confirmed by the Ministry of Labour of Ukraine covers the questions concerning electrical lightning and special furnishment facilities, as well as supplements in accordance with normative acts applied in Ukraine and in other countries.
- DNAOP 0.00-1.21-98 [44]. It is an inter-industry normative act laying out the requirements for the EI safe operation that applies to the electric installations with voltage not higher than 220 kW.
- ***Rules of technical operation of electric installations of consumers*** contain the main organizational and technical requirements for the EI exploitated by the consumers and are applied to the operating EI with voltage not higher than 150 kW.
- DNAOP 1.1.10-1.07-01 [45]. Include the normative act containing the requirements for necessary electrical safety devices checklist with regard to the particular conditions of storage, examination, status checkup and usage of electrical safety devices.
- DNAOP 0.00-8.19-99 [46].
- DNAOP 0.00-8.20-99 [47].
- Standard of care of ***low-voltage electric installations*** (Resolution of the Cabinet of Ministers of Ukraine № 1149 dated October 29, 2009) [48].

2.11. Electrical safety

2.11.1. Actuality of the problem of electrical safety

Electrical safety – a system of organizational and technical measures and facilities that protect people from harmful and dangerous effects of electric current, electric arc, electric field and static electricity. This definition includes 4 factors. Two of them (electric current and electric arc) are directly dangerous and are the subject of consideration of this section. Safety issues related to electromagnetic fields and static electricity are discussed in the relevant sections of the textbook.

Electrical traumatism is characterized by a combination of electrical injuries for a certain period of time, their absolute and relative indicators, distribution by severity, branches of production, etc. Electric shock is found in 1–2.5 % of all types of injuries, but in terms of mortal and severe consequences occupy one of the first places.

According to international statistics, electrical injuries accounts for 0.2 % of all accidents at work, and fatal injuries – almost 3 %. According to various sources, electric shock is fatal in 9–10 % of cases.

Electrical installations – a complex of interconnected machines, apparatus, lines and auxiliary equipment (together with the buildings and premises in which they are installed), intended for the production, transformation, transformation, transmission, distribution of electric energy and transformation into other types of energy (PUE) .

As direct causes of getting people under stress stand out:

- touching uninsulated live parts of electrical installations under voltage, or insulated with practically damaged insulation – 55 %;
- touching non-conductive parts of electrical installations or electrically connected to them metal structures, which were under stress as a result of insulation damage – 23 %;
- step voltage action – 2.5 %;
- losses through the electric arc – 1,2 %;
- other reasons – less than 20 %.

Electro-traumatic symptoms are characterized by the following features:

- a person is unable to detect the presence of voltage remotely, without special devices, and therefore the effect of the current is, as a rule, sudden, and the protective reaction of the organism is manifested only after falling under tension;
- the current flowing through the human body acts on tissues and organs not only in places of contact with current-carrying parts and in the path of flow, but also reflexively, as an extremely strong stimulus, affects the entire organism, which can lead to disruption of the functioning of vital body systems – nervous, cardiovascular systems, breathing, etc.;
- electric trauma is impossible without touching a person to live parts – as a result of the formation of an electric arc in the breakdown of the wind between the conductive parts or between the conductive parts of a person or land.

A special feature of electrotraumatism is that electric installations with a voltage of up to 1 kV account for up to 70–80 % of electro-traumas with a fatal outcome, and for electrical installations with a voltage of over 1 kV, up to 20–30 %. The resulted distribution of electric traumas by the voltage of electrical installations is determined not only by the greater prevalence of electrical installations with a voltage of up to 1 kV, but more so by the fact that such facilities are available to a large number of workers who do not have a clear idea of the danger of electric current and handle them recklessly.

Causes of electro-injury:

- Technical – the imperfection of the design of the electrical installation and the means of protection, the admitted shortcomings in the manufacture, installation and repair of the electrical installation.
- Organizational and technical – non-compliance with the requirements of current standards for controlling parameters and examination of the technical condition of electrical installations; errors in the removal of voltage from electrical installations when performing work in them without checking the absence of voltage on the electrical installation on which people work; absence of fences or inconsistency of the design and placement requirements of existing regulations and the lack of necessary posters and warning and

prohibitory inscriptions; errors in the establishment and removal of portable grounding, or their absence.

- Organizational – the absence (not the appointment of an order) at the enterprise of the person responsible for the electric economy or the non-compliance of this person's qualifications with the current requirements; Inadequate staffing of the electrotechnical service by employees of the relevant qualifications;
- Organizational and social – forced execution not in the specialty of electrical hazardous works; negative attitude to the work performed due to social factors; involvement of employees in overtime work; violation of industrial discipline; recruitment of persons under 18 years of age.

2.11.2. The effect of electric current on the human body. Types of electric injury

The thermal action of the current is to heat the tissues and evaporate the moisture, which causes burns, carbon stomachs and their breakage by steam.

The electrolytic action of the current manifested in the expansion of the organic matter (its electrolysis), including the blood, which causes the change in its physical, chemical and biochemical properties.

The biological action of the current manifests itself in the disturbance of biological processes occurring in the body, and is accompanied by distraction and excitation of tissues and muscle contraction.

At the same time, the disturbing effect of the current on the tissue may not be direct, but reflex – through the central nervous system. The mechanism of this action is that perturbations of the receptors (peripheral organs of the central nervous system) under the action of electric current are transmitted to the central nervous system, processes this information and issues commands for the normalization of vital processes in the relevant tissues and organs.

When information is overloaded (cell and receptor perturbation), the central nervous system may produce inappropriate, inadequate information to the executive team. The latter can lead to serious disruptions in the activity of vital organs, including the heart and lungs, even if these organs do not lie in the path of current.

Mechanical – is manifested by damage (ruptures, bundles, etc.) of various tissues of an organism as a result of electrodynamic effect. There are three types of electric trauma: local, general and mixed. Local electric trauma accounts for about 20 % of electric trauma, general – 25 % and mixed – 55 %.

Local electrical trauma:

- Electrical burns – the most common electrical injuries. Depending on the conditions of burn, they are divided into contact and arc.
- Electrical signs (current signs or electrical labels) are observed in the form of sharply defined spots of gray or pale yellow on the surface of the human body at the point of contact with current-conducting elements. Typically, the signs have a round or oval shape, or the shape of the current element, to which a person has touched, up to 10 mm in size, with a deepening in the center.Sometimes electrical signs can take the form of microfibers, which is contrasted on the surface of the body. Electrical signs can occur both at the moment of passing current through the human body, and after some time after contact with the current-conducting elements of the electrical installation. Electrical signs do not cause a special pain sensation and eventually disappear without a trace.
- Metallization of the skin is the penetration into the upper layers of the skin of small particles of metal, which melted under the action of an electric arc. Extra metal particles have a high temperature, but a small supply of heat. Therefore, they are not able to penetrate through clothing and dangerous to open areas of the body. At the affected area of the body at the same time there is pain from burn due to the heat introduced into the skin of the metal and the stress of the skin from the presence of a foreign solid substance – particles of metal. Over time, the affected area of the skin becomes normal, and feelings of pain disappear. Especially dangerous electrometallization, associated with the emergence of an electric arc, for the organs of vision. In the case of electrometallization, the treatment can be quite lengthy, and in some cases, it is unrecognizable. Therefore, when performing work under conditions of probable occurrence of an electric arc, it is necessary to use

protective glasses. In most cases, simultaneously with the metallization of the skin there are arched burns.

- Electroophthalmia – inflammation of the outer shells of the eye, caused by excessive exposure to ultraviolet radiation from the electric arc. Electroophthalmia, as a rule, develops 2–6 hours after irradiation (depending on the intensity of irradiation) and manifests itself in the form of reddening and inflammation of the skin and mucous membranes of the eyelids, purulent discharge, whistle bolts and photophobia. Duration of the disease 3...5 days.

- Mechanical damage associated with the action of electric current on the human body is caused by an unpredictable convulsive contraction of the muscles as a result of the irritating action of the current. Due to such convulsive muscle contractions, tendons, skin, blood vessels, nerve tissues, dislocation of joints, fractures of bones, etc. can be broken. Mechanical damage caused by the action of an electric current does not include damages caused by falling from a height, and other similar cases, even when the fall was caused by the action of electric current.

General electrical injuries and electric shocks – this is a violation of the vital organs or the entire human body as a result of the disturbance of living tissues of the body by electric current, accompanied by involuntary convulsive muscle contraction. The result of the negative effect on the body of this phenomenon can be different: from convulsive contraction of individual muscles to the complete cessation of breathing and circulation. In this case, external local damage may be absent.

Depending on the consequences of the impact, electric shocks are divided into four groups:

- I – convulsive muscle contractions without losing consciousness;

- II – convulsive muscle contractions with loss of consciousness without disturbances of breathing and circulation

- III – loss of consciousness with violation of cardiac activity or breathing, or cardiac activity and breathing together;

- IV – clinical death, i.e. lack of breathing and circulation.

Clinical or “apparent” death is a transitional state from life to death. In the state of clinical death, blood circulation and respiration are absent, oxygen is not supplied to the human body. Signs of clinical death: lack of pulse and respiration, skin bluish-pale, pupils of the eyes are sharply enlarged and do not respond to light.

Depending on the oxygen supply in the body at the time of circulatory arrest, the period of clinical death can be from several to 10...12 minutes, and the oxygen resources of the body, in turn, are determined by the severity of the work performed – decrease with increasing work severity. If the victim is in a state of clinical death in a timely manner to provide qualified assistance (artificial respiration and closed heart massage), then breathing and blood circulation may resume, or the period of clinical death will continue until the arrival of medical care. Closed heart massage does not contribute to the virtually restoration of his work in the presence of cardiac fibrillation – disordered contractions of the heart muscles, which do not lead to blood circulation. At fibrillation of restoration of work of heart it is possible at application of medical preparations and defibrillators (Special electrodevices). Thus, with fibrillation of the heart, closed massage contributes mainly to lengthening the period of clinical death.

In addition to electric shocks, one of the types of common electrical injuries is electric shock – a severe neuro-reflex reaction of the body to electrical stimulation. In shock, there are significant disorders of the nervous system and, as a consequence, disorders of the respiratory, circulatory, metabolic systems, the functioning of the body as a whole, and the vital functions of the body gradually fade. This state of the body can last from tens of minutes to days and end with either recovery from active treatment, or death of the victim.

2.11.3. Factors affecting the severity of electric shock

Factors affecting the severity of human injury by electric current can be divided into three groups: electrical, non-electrical nature and factors of the production environment.

The main factors of an electrical nature are the amount of current passing through the person, the voltage under which it hits, and the resistance of its body, the genus and frequency of the current (Fig. 2.1).

The amount of current passing through a person directly and most directly affects the severity of electric shock. By the nature of the effect on the body, there are:

- a perceptible current – causes tangible irritations when passing through the body;
- non-dormant current – causes, when passing through the body, irresistible convulsive contractions of the muscles of the hand in which the conductor is clamped;
- fibrillation current – causes fibrillation of the heart when passing through the body.

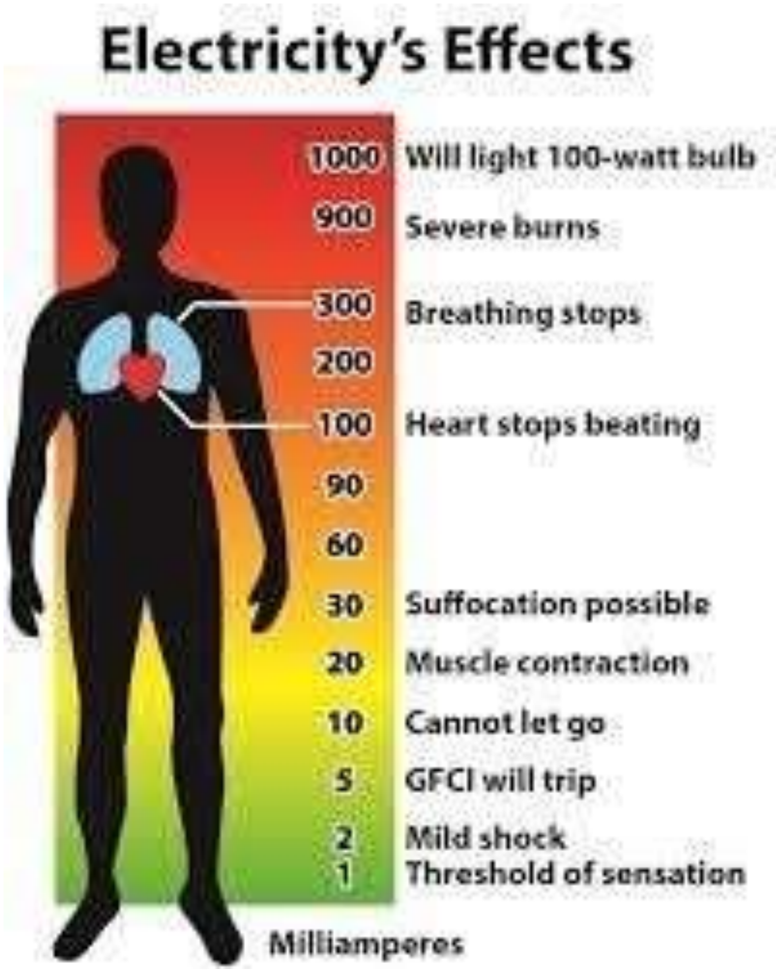


Fig. 2.1. Electricity's effects

In accordance with the above:

- threshold sensible current (the lowest value of perceptible current) for alternating current at a frequency of 50 Hz varies between 0.6–1.5 mA and 5–7 mA for a constant current;
- the threshold of nontransferring strings (the least important of the invisible goiter) is pricked in the intervals of 10–15 mA for a sexual stream in 50–80 mA – for the peristoneal;
- the threshold fibrillation current is the minimum current that causes cardiac fibrillation. Its value for alternating current is 100 mA, for direct current it is 300 mA.

The boundary-permissible layers that pass through people with normal (non-automatic) mode and robotic electrical installations are not guilty of overhauling 0.3 mA for the clamping circuit and 1 mA for the post.

The magnitude of the voltage, the person falls under the yak, affects the severity of the electric shock insofar as the resistance of the human body decreases with increasing body weight. The latter is produced before the increase of the current in the network of a closure through the human body and, as a consequence, to an increase in the severity of the defeat.

Electrical Resistance of the human body. The human body is a folding complex of tissues. These are the skin, bones, adipose tissue, tendon, cartilage, muscle tissue, blood, lymph, spinal cord and brain, and so forth. The electrical resistance of these tissues is significantly different. Skin is the main factor that determines the Resistance of the human body as a whole. Skin resistance sharply decreases with damage to its stratum corneum, the presence of moisture on its surface, increased sweating, and contamination. In addition to these factors, the skin's resistance is affected by the density and area of the contacts, the magnitude of the applied voltage, the magnitude of the current and the time of its action. With increasing value of voltage, current and time of its action, the resistance of the skin, as well as of the human body as a whole, decreases. So, if at a voltage of several volts the resistance of the human body exceeds 10,000 Ω, then at a voltage of 100 V it drops to 1500 Ω, and at a voltage of more than 1000 V – up to 300 Ω.

Resistance of the human body depends on its sex and age: it is less in women than in men, in children less than in adults, in young people is less than in the elderly. This dependence is caused by the thickness and degree of coarsening of the upper layer of the skin.

Frequency and type of current. Due to the presence of a capacitive component in the human support, an increase in the frequency of the applied voltage is accompanied by a decrease in the total resistance of the human body and, as a consequence, an increase in current through the person. The latter gives reason to believe that the severity of electric shock should increase with increasing frequency. But such a pattern is observed only within the frequency range of 0...50 Hz. Further increase of frequency, in spite of the increase in current passing through a person, is not accompanied by an increase in the risk of injury. At frequencies of 450–500 kHz, the probability of common electrical injuries almost disappears, but the risk of arc burns remains due to the passage of current through the human body. In this case, current burns are observed on the skin and adjacent tissues – due to the surface effect of alternating current.

As an irritating factor, direct current (DC) causes irritation in the tissues of the body when the current passing through the person is closed and opened. In the time interval between closing and opening the network, the action of the DC is reduced, mainly, to the thermal current. Alternating current (AC) causes longer intense irritations due to voltage ripple. From this point of view, AC is more dangerous. In fact, this pattern is maintained up to a voltage of 400–600 V, and at a higher DC voltage, it is more dangerous for a person.

The main factors of the non-electric nature are the current path through the person, the individual characteristics and the state of the human body, the time, the suddenness and unpredictability of the action of the current.

Current time. With increasing time of current exposure, the resistance of the human body decreases due to skin hydration from perspiration and electrolytic processes in the tissues, the breakdown of the skin extends, the defenses of the body are weakened, the likelihood of coincidence of the maximum current pulse through the heart with the T cardiocycle phase (the phase of cardiac muscle relaxation) that, in general, leads to more severe lesions (Fig. 2.2).

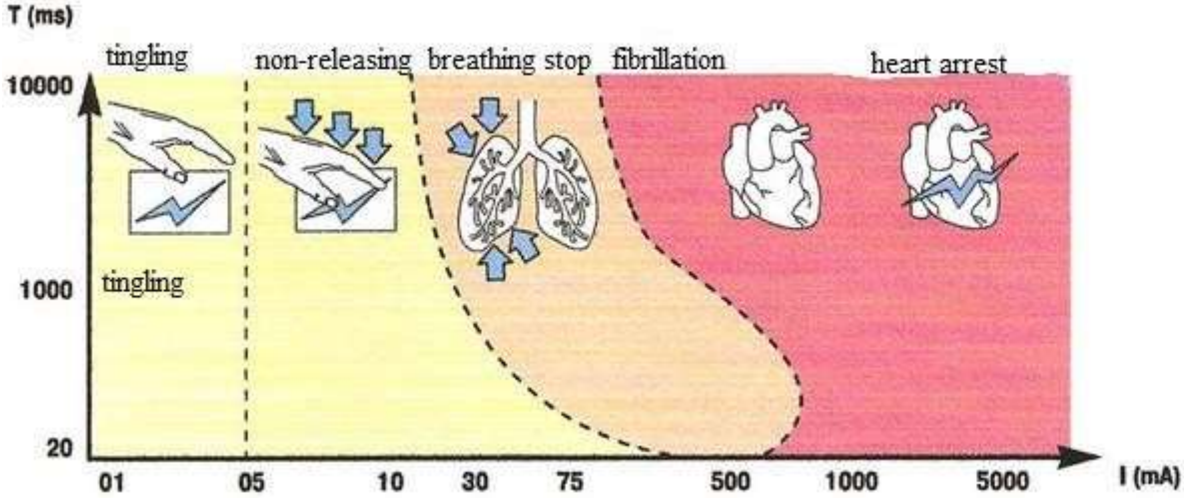


Fig. 2.2. Consequences of increasing the time of exposure to current on the human body

The path of current through the human body significantly affects the severity of the lesion. Especially dangerous when the current passes through vital organs and directly affects them.

If the current does not pass through vital organs, then it can affect them only reflexively – through the central nervous system, and the probability of destruction of these organs is less.

Possible current paths through the human body are called current loops: hand-arm, head-leg, arm-leg, etc. Among the cases with severe and fatal consequences, the hand-arm loop (40 %), the right hand-foot (20 %), the left hand-foot (17 %) are more common. Especially dangerous are the "head-hand" and "head-to-foot" loops, but they happen rarely.

Individual characteristics and body condition. The individual features of the body that affect the severity of electric shock, other things being equal, include: the sensitivity of the body to the action of the current, mental characteristics and personality traits (choleric, sanguine, melancholic). Analysis of electro-injury statistics shows that choleric and melancholic are more sensitive to the effect of electrical current. They suffer more from the effect of current, and physically healthy and strong people – less.

In addition to the individual characteristics of the body, the severity of electric shock is largely dependent on the state of the body. To more severe lesions by electric current result: a state of perturbation of the nervous system; depression; skin diseases; cardiovascular system, internal secretion organs, lungs; various nature of inflammation, accompanied by an increase in body temperature sweating, etc. The more severe consequences of the action of the current are clearly observed in a state of alcoholic or narcotic intoxication, and therefore the admission to work of workers in this state is prohibited.

Surprisingly, the effect of current. The effect of this factor on the severity of the lesion is due to the fact that when an unexpected person falls under tension, the protective functions of the body are not set for danger. It has been experimentally established that if a person is clearly aware of the threat of being able to get under tension, then in realizing this threat the threshold current values are 30–50 % higher. Conversely, if such a threat is not realized, and the effect of the current appears unexpectedly, then the threshold current values will be lower.

Factors of the production environmentthat affect the risk of electric shock to an individual are the environmental conditions and the scheme of the person's inclusion in the electrical network.

According to the factors of the production environment of the PUE, these types of premises are distinguished:

- hot, the temperature in which during the day exceeds 35 °C;
- dry, relative humidity in which does not exceed 60 %, that is, it is within the limits of the optimal hygienic standards;
- wet, relative humidity in which does not exceed 75 %, that is, it is within the permissible limits for hygienic standards;
- raw, relative humidity in which more than 75 %, but less than the saturation humidity;
- especially raw, relative humidity in which is close to saturation, condensation of steam on building structures, equipment is observed;
- pollination, in which dust penetrates into electrical apparatus and other

consumers of electricity and settles on live parts, while such premises are divided into premises with conductive and non-current dust;

- a room with a chemical-aggressive environment, leads to a violation of insulation, or biological environment, in the form of mold formed on electrical equipment.

According to the PUE [49], the premises for the danger of electric trauma are divided into three categories:

- without increased danger;
- with increased danger;
- are especially dangerous.

The category of the room is determined by the presence in the room of the factors of increased or special danger of electric trauma.

The factors of increased danger include:

- the temperature in the room during the day exceeds 35 °C;
- relative humidity of more than 75 %, but less than full saturation (100 %);
- conductive floor – metal, concrete, brick, earth and the like;
- conductive dust;
- the possibility of a simultaneous touch of a person to non-conductive parts of the electrical installation and to metal structures that have contact with the ground.

To the factors of special danger of electric trauma are:

- relative humidity is close to saturation (up to 100 %);
- an aggressive environment that damages the insulation.

If there are no factors of increased and special danger in the room, then it refers to rooms without increased danger of electric trauma.

In the presence of one of the factors of increased danger, the room belongs to the premises of increased danger of electric trauma.

If there are simultaneously two factors of increased danger or one factor of particular danger, the premises are considered particularly dangerous.

From the foregoing it can be seen that the classification of premises on the risk of electric trauma takes into account only the features of these rooms, the state of their environment and does not take into account the electrical parameters of electrical installations.

The category of premises is one of the main factors that determine the requirements for the implementation of electrical installations, their safe operation, the magnitude of voltage, grounding (zeroing) of electrical installations. Conditions outside the premises are equated with especially dangerous ones.

In the operation of single-phase electrical networks, there are three possible schemes for incorporating a person into an electrical network (Fig. 2.3–2.5):

1. Touching the neutral wire

The current through the person will not pass

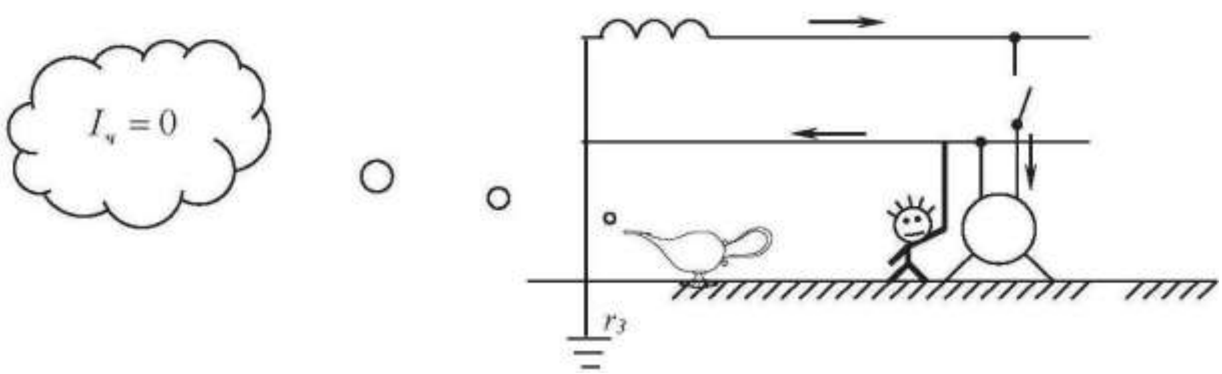


Fig. 2.3. The current through the person will not pass

2. Touching the phase wire

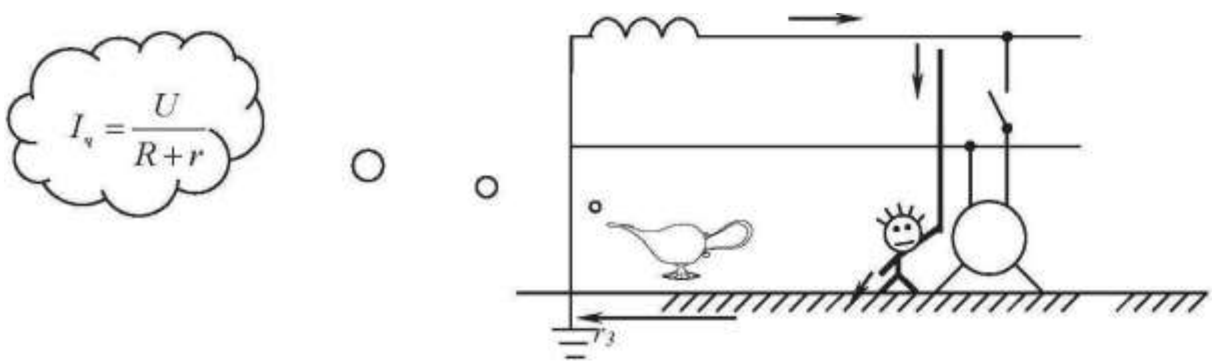


Fig. 2.4. Touching the phase wire

The current flowing through the person will depend on its resistance *R*, and the resistance *r*, which is determined by the environmental conditions.

The safer these conditions are, the higher r and thus the lower the current flowing through the person.

3. Simultaneous contact with the phase and neutral wires

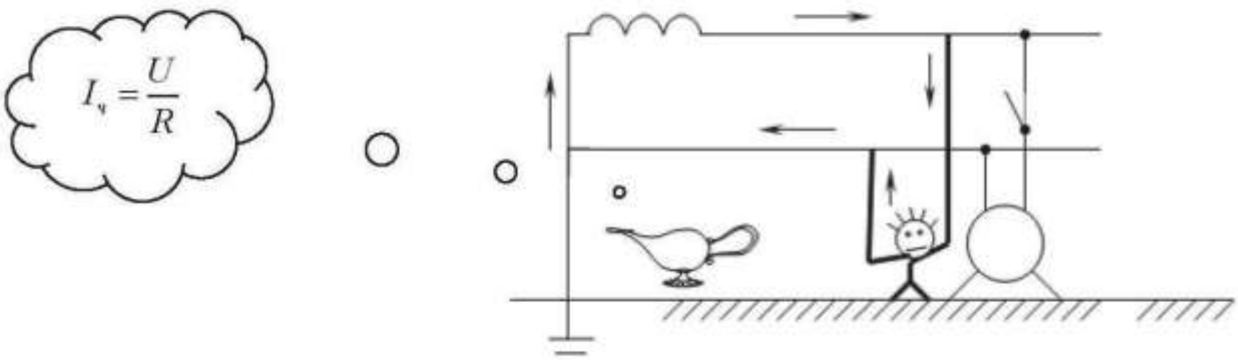


Fig. 2.5. Simultaneous contact with the phase and neutral wires

With a simultaneous touch, all the voltage will be applied directly to the person and the maximum possible current passes through it, will be determined only by its individual properties. That is, this scheme is the most dangerous.

2.11.4. General characteristics of electrical installations

Electrical installation (EI) is an installation in which electrical energy is produced, converted, transmitted, distributed and consumed (converted into other types).

By types of current, the power supplies are divided into AC and DC installations. The most common are AC power. The most common, incl. and in Ukraine, an AC of alternating current with a frequency of 50 Hz. Therefore, in this section, when it comes to AC power, it is necessary to take information about the EI with a frequency of 50 Hz.

The AC of an alternating current is divided into single-phase and three-phase. Single-phase electrical networks are networks that are powered from a separate winding of a power supply (generator or transformer, PS) that does not have electrical connections to other windings. Such electrical networks are used very rarely. In the vast majority of cases, three-phase electrical networks and three-phase consumers are used. Three-phase electrical networks are powered by three windings and have certain electrical connections to each other (Fig. 2.6).

Three-phase electrical networks with a voltage of more than 1 kV have three phase conductors (denoted by L1, L2, L3), and with a voltage of up to 1 kV, five or four conductors, incl. three phase ones, one neutral (to obtain phase voltage – N) and one protective (to ensure the safety of operation of the EI – PE) or one combined conductor (combines the functions of neutral and protective – PEN).

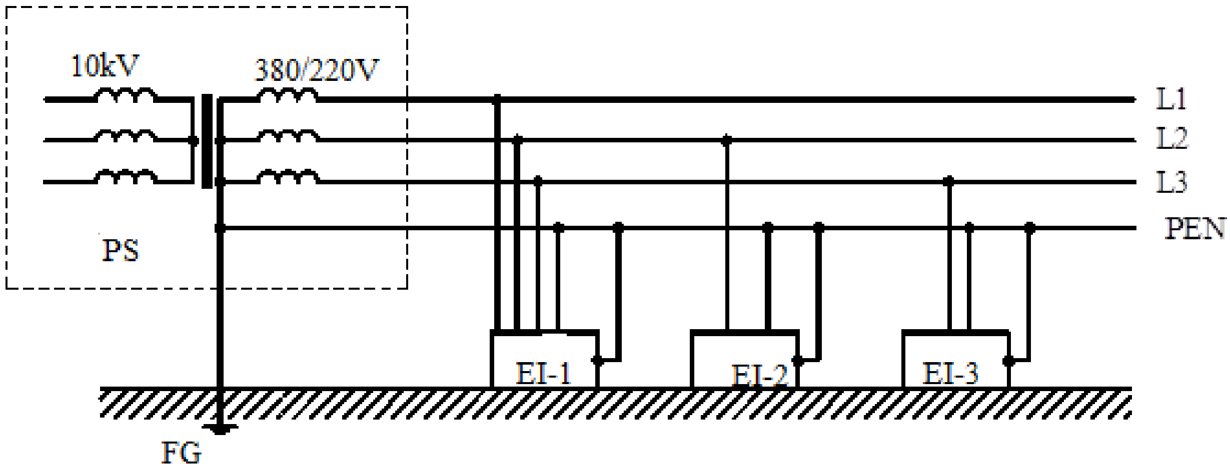


Fig. 2.6. Scheme of power supply from three-phase electrical networks with grounded neutral: PS – power supply; FG – functional grounding; EI-1 – three-phase consumer (for example, engine) EI-2, EI-3 – single-phase consumers

Consumers of electrical energy can be three-phase, which are powered by all three phases, most often – electric motors. Less frequently in the production conditions, there are single-phase consumers that are powered by a single phase and neutral (N) wires. In terms of production, this is mainly lighting installations or EI of low power, incl. and a PC.

Single-phase power plants are most often used in everyday life. Although these EIs are single-phase, they do not feed on single-phase networks, but on three-phase networks. Therefore, in the case of resolving safety issues, it should be considered that they receive power from the three-phase electrical networks, being a part of it, and they are subject to all provisions on three-phase electrical networks.

Three-phase networks have two voltages: a phase (U_f) between phase and neutral conductors and a linear (U_l) between two phase conductors. Linear voltage in more phase. Most often U_f = 220 V, and U_l = 380 V. Three-phase consumers have both voltages, and single-phase – only 220 V.

In terms of the voltage, the power supplies are divided into installations with a voltage of up to 1 kV (inclusive of the effective value) and more than 1 kV. For voltages up to 1 kV, it is common to indicate both voltages – linear and phase, and more than 1 kV – only line voltage. Standard voltages up to 1 kV are: 220/127, 380/220 and 660/380 V. The most common are power supplies with a voltage of 380/220 V (three-phase consumers) or 220 V (single-phase consumers). Standard voltages over 1 kV are: 6, 10, 35, 110, 150, 220, 400, 500 and 750 kV.

About electrical safety measures, electrical installations are divided into:

- electrical installations with a voltage of up to 1 kV in networks with a deadly grounded neutral;
- electrical installations with voltage up to 1 kV in networks with isolated neutral;
- electrical installations with voltages above 1 kV in networks with isolated, compensated or (and) earthed through a resistor neutral;
- electrical installations with voltages above 1 kV in networks with a grounded or effectively earthed neutral.

Requirements for electrical installations with voltages up to 1 kV concern also electrical installations with voltages up to 1.5 kV of constant and rectified current, the variable component of which does not exceed 10 % of the current value.

At the location of the power plant are divided into:

- closed or internal – this is the EI, protected by the building from atmospheric influences;
- open or external – this is an EI, not protected by the building from atmospheric influences.

EIs are protected only by canopies, mesh fences, etc. are considered as external.

Electric rooms – this is a room or fenced, for example, with grids, parts of premises, available exclusively for qualified servicers, in which EIs are located.

The EIs have the following basic structural elements:

- **the leading part** – any part that has the property of conducting an electric current;
- **conductor** – the leading part, designed to conduct an electrical current of a certain value;
- **linear (phase) conductor (L)** – conductor, which under normal operation of the EA is under voltage and is used for transmission and distribution of electrical energy, but is not a medium conductor or a neutral conductor;
- **neutral conductor (N-conductor)** – conductor in the power supply unit up to 1 kV, electrically connected to the neutral point of the PI, used for the distribution of electrical energy;
- **neutral point** – the common point of a multiphase system connected to a star or a grounded point of a single-phase system;
- **conductor of the middle point (M-conductor)** – conductor in the power supply unit up to 1 kV, which is electrically connected to the middle point of the PID and is used for the distribution of electrical energy;
- **protective conductor** – conductor designed to ensure electrical safety;
- **PE-conductor** – protective conductor in the power supply with voltage up to 1 kV, designed to protect against electric shock;
- **PEN-conductor** – conductor in the power supply with voltage up to 1 kV, combining the functions of neutral (N-) and protective (PE) conductors;
- **live parts** – conductor or conductive part, is in the process of normal operation of the power supply under voltage, including neutral (N-) conductor, but not (PE) conductor;
- **the open conductive part** – the conductive part of the EC available for contact, which during operation is not under operating voltage, but can be

energized in the event of damage to the insulation of current-carrying parts (for example, the power housing);

- **the outer leading part** – the leading part, which is not part of the ES, is capable of carrying electrical potential, as a rule, the electrical potential of the local earth (for example, railways of access roads, building metal constructions, metal pipes and shells of communications, etc.).

According to the method of protecting a person from electric shock, electrical equipment is divided into the following classes: 0, 0I, I, II, III. Class 0 refers to products that have working insulation and where there are no elements for grounding. Class 0I includes products that have working insulation, an element for grounding, and a wire without a ground conductor for connection to a power source.

Class I includes products that have working insulation, a wire for connection to a power supply with a grounding conductor and a plug with a grounding contact, and also an external element for earthing, if necessary. The class of II includes products that have double or reinforced insulation and do not have elements for grounding. Class III includes products that do not have internal and external electrical circuits with voltages above 42 V.

2.11.5. Danger of operation of electrical installations

General provisions. The danger of the operation of the power plant is the possibility of switching on the person under touch voltage and step voltage:

- **touch voltage** is the voltage that occurs on the body of a person or an animal in the case of simultaneous contact with two conductive parts;

- **the step voltage** is the voltage between two points on the surface of the local earth, located at a distance of 1 m from each other, which corresponds to the length of the person's big step.

According to PUE-2017 [49], there are two schemes of touching a person:

- **direct touch** is the electrical contact of people or animals withconductive parts that are energized, or approaching them to a dangerous distance;

- **indirect touch** is the electrical contact of people or animals with an open conductive part (most often – the body of the power unit), which turned out to be energized as a result of damage to the insulation.

Danger of direct contact with current-carrying parts of single-phase networks and direct current networks. In single-phase AC networks and DC networks there can be two types of direct contact:

- **single-pole direct touch** is the touch of a person standing on the leading ground (ground), to one pole of the network;
- **two-pole direct touch** is a touch of a person to the two poles of the network.

The most dangerous is the case of a bipolar direct contact, because in this case the force will be the greatest value, since the resistance of the human circuit will be minimal, and the current will flow through the most dangerous path.

Danger of direct contact with current-carrying parts of three-phase EM. In three-phase EM there can be three types of direct contact:

- **single-phase direct touch** is the touch of a person standing on the leading basis, to a single phase conductor;
- **two-phase direct touch** is the simultaneous touch of a person to two different phase conductors;
- **simultaneous contact with phase and N-, PE or zero conductors in networks up to 1 kV with dead-ground neutral.**

Danger of earth fault in the EC. Stress indirect contact with the body of the power unit and the step. Earth faults in the EC occur in the following cases:

- breakage and dropping to the ground of the wires of the overhead line (VL) under tension;
- breakdowns of CL isolation and phase closure to ground;
- damage to the insulation and closure of the grounded body of the power unit.

The danger of earth faults in the EA is due to the property of the current to return to its source (in this case because of the ground) and because the soil resists the current flowing through it. Therefore, potentials appear on the surface of the soil.

The law of the distribution of potentials on the earth's surface in the event of earth faults. Let's consider a classical case - short circuit on a hemispherical earthing switch at a surface of the earth. A ground fault current flows through the earth (Fig. 2.7).

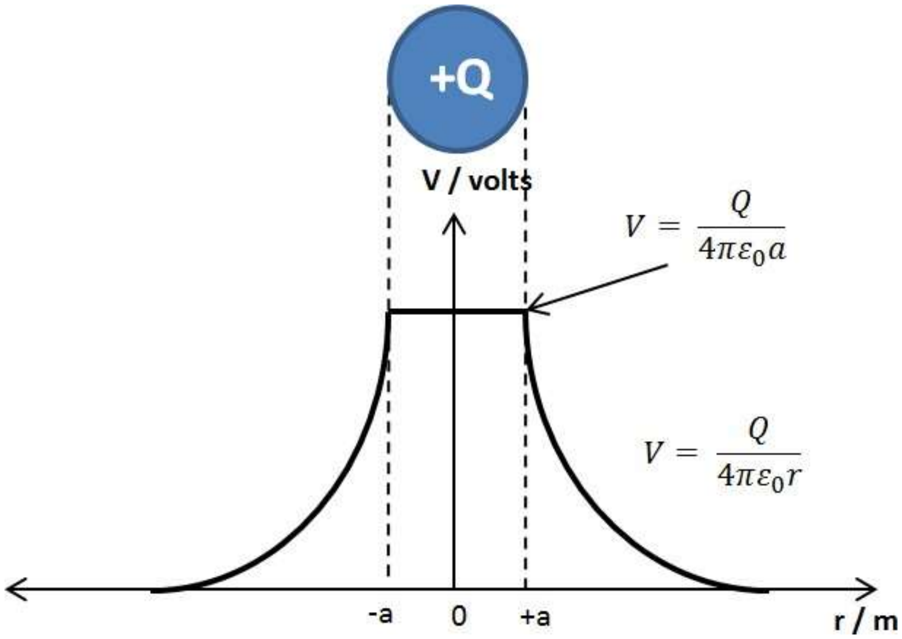


Fig. 2.7. Circuit diagrams and the laws of potential distribution on the earth's surface

Thus, the potential on the surface of the earth, due to the closure of the hemispherical earthing switch, is distributed according to the law of the hyperbola, decreasing x away from the ground-fault location. It is characteristic that for grounding devices of any shape this law is valid only with some error.

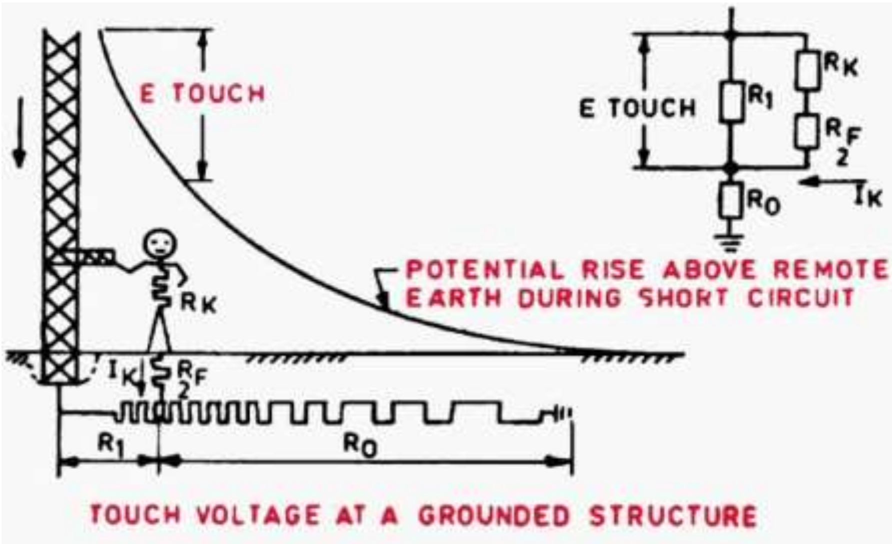
For the characterization of ground faults, two concepts are introduced in the EI:

- **the spreading zone (local earth)** is a part of the earth that is in electrical contact with the earth electrode and whose electrical potential is not necessarily zero (the radius of this zone depends on and from, for any possible now it does not exceed 20 m, and for the power supply voltage 10 kV on average soils R ≈ 6...8 m);
- **the zone of zero potential (relative ground)** is the leading part of the earth that lies outside the zone of influence of any grounding device whose electrical potential can be conditionally taken as zero.

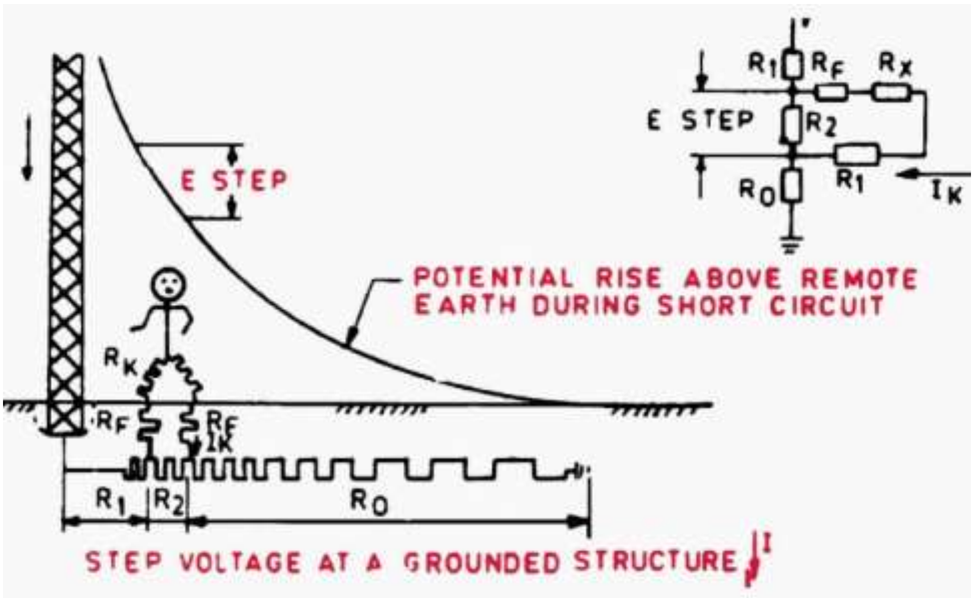
In connection with this distribution of potentials, there are two dangerous for a person voltages: an indirect touch to the body of the EI (V_t) and the step (V_s).

Voltage indirect touchwith the body of the power. Under the voltage of indirect touch to the body, a person standing on the soil (current-carrying basis) is hit and touches the body of the damaged EI (Fig. 2.8, *a*).

The touch voltage is equal to the potential difference between the EI body and the point where the human legs are located:



a



b

Fig. 2.8. Touch and step voltage: *a* – an indirect touch to the body of the EI; *b* – step voltage

The contact voltage is directly proportional to u and x and inversely proportional to the resistivity of the soil.

Step voltage. Under the voltage step is a person, moving on the surface of the earth in the zone of spreading of the earth fault current (local earth). The voltage of the step is equal to the potential difference of the points of the soil surface in which the human legs are located (Fig. 2.8, *b*).

The step voltage is:

$$U_s = \frac{I_K \cdot \rho \cdot a}{2\pi \cdot x \cdot (x + a)}. \qquad (2.53)$$

The step voltage Vs is directly proportional to ground fault current (IK), soil resistivity (ρ), step size (*a*) and inversely proportional – from the distance of a earth short circuit (*x*); outside the spreading zone $Vs = 0$.

2.11.6. Classification of methods of safe operation of electrical installations.

Safe operation of the power plant is provided by the following three methods:

- the use of structural and circuit protection measures;
- use of protective equipment, including in electrical installations;
- compliance with appropriate protective measures during the execution of work in the EI.

Constructive and circuit protection measures are an integral part of the EI and protect its operation all the time while the power plant is under voltage. According to PUE-2017, they are divided into two groups:

- protection measures against direct contact in the normal operation mode of the EI;
- protection measures with indirect touch in case of single damage.

A remedy is a means designed to prevent or reduce leakage to an employee of hazardous and/or harmful production factors.

Electro-protective means is a means designed to ensure electrical safety (these are tools and devices for safe work in power plants: insulating rods, tongs, voltage indicators, etc.), as well as dielectric clothing and footwear (gloves, boots, galoshes, etc.).

Protective measures in the performance of work in the EI – a set of requirements for employees and the order of work to ensure the safety of operation of the power plant.

2.11.7. Accidental release measures in normal operation of electrical installations

General Provisions

1. The current-carrying parts of the power plant must not be accessible for accidental direct contact with them, and open and third-party conductive parts accessible to touch must not be under tension, present a danger of electric shock both in normal operation and in case of insulation damage.

2. To prevent electric shock in normal operation, the following protection against direct contact should be used separately or in combination:

- basic insulation of current-carrying parts;
- fences and shells in the power plant;
- barriers in energy management;
- placement of current-carrying parts out of reach;
- placement of current-carrying parts at an unattainable height or inaccessible place;
- safety interlocks in the EC.

3. Protection from direct contact is not required if the rated voltage of the power plant does not exceed:

- 25 V AC or 60 V DC with the application of the SELV system (safety extra-low voltage system), if the electrical equipment is operated in dry rooms;
- 25 V AC and 60 VDC in the case of PELV system (protective extra-low voltage system) if the equipment is in the zone of equalization of potentials and is operated only in dry premises;
- 6 V alternating or 15 V DC in all other cases.

Electrical insulation in EI

Insulation is a layer of dielectric or a construction made of dielectric, through which the conductive parts are separated from each other or from other structural elements of the equipment. EI has, in the first place, a working insulation – insulation, which ensures the flow of current in the right way and safe operation of the equipment, that is isolating the current-conducting parts from the cases.

Requirements for basic insulation:

- has a full covering of current-carrying parts;
- must withstand mechanical, electrical, chemical, thermal and other impacts during operation;
- the elimination of insulation should be possible only by destroying it;
- protection against direct contact or approaching live parts at a hazardous distance, including in a power plant with voltages above 1 kV, must be provided by other measures (shells, enclosures, bar, interiors or placement outside the reach zone).

The protective action of insulation is to limit the amount of current flowing through the insulation and, accordingly, through the person who touches the insulation. This is due to the large electrical insulation resistance.

Insulation monitoring is divided into periodic (performed at certain intervals); constant (performed throughout the period of the operation of the EI) and pre-start (performed before the start of the EI).

In addition to the main one, the following types of electrical insulation are used:

- additional insulation is an independent insulation provided as an additional insulation to the main insulation in the power plant up to 1 kV and designed to provide protection from electric shock in the event of damage to the main insulation;
- double insulation - insulation in the power supply with voltage up to 1 kV, consisting of basic and additional insulation;
- reinforced insulation – a single system of insulation of current-carrying parts in the power supply with voltage up to 1kV, which provides the same degree of protection from electric shock, as well as double insulation.

Fences and shells in electrical installations.

The fence is a part that provides protection from direct contact from the side of possible access.

The shell is the fence of the internal parts of the equipment, which prevents access to live parts from any direction, that is, the shell completely protects the power plant.

Requirements for enclosures and enclosures:

- fences and shells should provide the protection degree IP2X (namely protection against penetration of fingers or objects with a length of more than 80 mm or solid bodies larger than 12 mm);
- in the case when larger gaps are necessary for normal operation of the equipment, other measures should be taken to prevent unintentional contact with live parts;
- the entrance to the fence or the opening of the shell must be possible only with a special key or tool.

Protections are carried out:

- continuous (in the power plant up to 1 kV);
- mesh (in the power plant up to and above 1 kV).

Fences and shells are placed at certain distances from current-carrying parts, depending on the voltage (according to the PUE).

Barriers in the ec. The barrier is the part that prevents unintentional direct touch, but does not prevent deliberate direct touch. This is a constructive part that blocks a free approach to energy management.

Requirements for barriers:

- barriers must be protected from accidental contact with live parts in the power plant with voltage up to 1 kV or approaching a dangerous distance in the power plant above 1 kV;
- to remove barriers, you do not need to use a key or tool, but they need to be fixed so that it is impossible to eliminate the unintentional;
- barriers should be made of insulating material.

Placement of current-carrying parts to an unattainable height orin hard-to-reach places refers to the wires of overhead lines or buses and equipment in substations. The height of the placement of wires depends on the line voltage and the terrain on which it occurs. For example, the height of placing the wires of overhead lines up to 110 kV inclusive in the populated area should be at least 7 m above ground (ground).

Placement of live parts in an inaccessible place refers to the cable line or wires in the room. cable line is laid in the ground in trenches or structures at a depth of more than 0.6 m. The wiring in the room is laid under a layer of plaster or under the floor.

Placement out of reach to protect against unintentional direct contact with live parts in electrical installations with voltages up to 1 kV or approaching them to dangerous distances in electrical installations with voltages above 1 kV may be applied if precautionary measures can not be implemented or if they are insufficient.

Within the reach zone, there should be no parts with different potentials and available for simultaneous contact. In electrical installations with voltages up to 1 kV two parts are considered accessible for simultaneous contact if they are not more than 2.5 m apart. In the vertical direction, the reach zone is 2.5 m from the surface on which people are located

E-vehicle blockes are devices that prevent electric shock to people in case of false positives. By principle, they are divided into: mechanical electromagnetic and electrical.

Orientation methods allow workers to navigate during work and warn them against wrong actions. Orientation methods are:

- Marking of parts of electrical equipment – is intended to recognize the accessories and equipment. It is carried out with the help of conventional symbols: alphanumeric and digital (for example, switch – B and number). These designations are applied to the EI enclosures and must correspond to the notations on the connection diagrams.

All elements of a single connection must have one numeric designation, and the apparatuses of the two combinations must have a double number.

- Safety sign "Caution! Electrical voltage" (Fig. 2.9) – background – yellow or interior colors, sides and arrow – red (black) It is applied or attached to the EI cases, on the doors to the entrance to electrical rooms and overhead towers.

Fig. 2.9. Safety Signal "Caution Electrical Voltage"

- Corresponding arrangement and painting of live parts:

− for alternating current: phase L1 – upper, left, most remote, color yellow; phase L2 – medium, color green; phase L3 – lower, right, color red; neutral N – isolated – blue; grounded – longitudinal stripes of yellow and green;

− for direct current: positive pole L +, lower, near, right, color red; negative pole L – medium, color blue; neutral M – upper, left, far, blue.

- Light signaling – indicates the switched on state of the EI with the help of warning lights.

2.11.8. Protection measures against indirect contact in electrical installations

General information

Protection with indirect touch – protection that prevents human injury by electric shock in the event of a single damage.

To prevent electric shock, in case of insulation damage, separate protection measures should be used separately or in combination with indirect contact:

- protective earthing;
- automatic power off;
- protective equalization (equalization) of potentials;
- protective (electrical) compartment (electrical separation of circuits) insulating (non-conductive) premises, zones, platforms;
- systems of ultra-low (small) voltage;
- class II equipment with electrical protection or equivalent insulation.

Protection for indirect contact should be carried out in all cases, if the rated voltage of the power supply exceeds 50 V AC and 120 V DC.

In rooms with increased danger, especially dangerous and outdoor installations, this protection may be required at lower voltages, for example 25 V AC and 60 V DC or 12 V AC and 30 V DC – if there are requirements of the relevant PUE chapters and other regulatory documents .

Protective earthing, as the main protection measure for indirect contact in the power plant, are discussed in the relevant section (2.11.9).

Protective automatic power off (curtains) is the automatic opening of one or more line conductors and, if necessary, a neutral conductor, performed for the purpose of electrical safety.

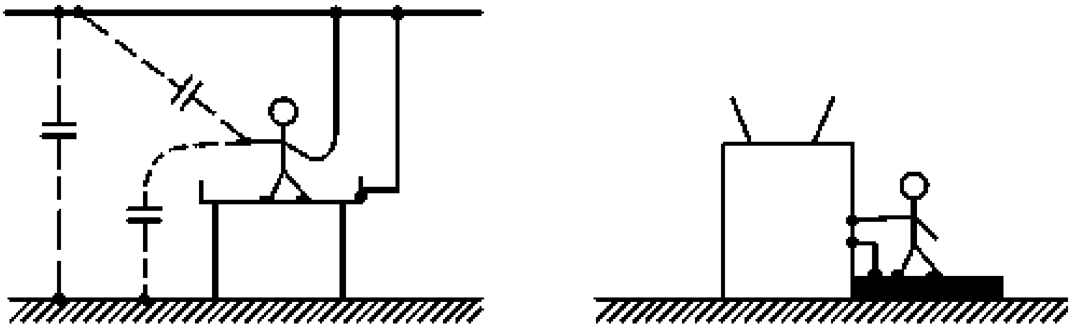
Existing wiring diagrams can monitor the voltage on the EI relative to the earth, the earth fault current or the residual current.

The principle of operation is based on measuring the balance of the currents of current-carrying conductors in it using a differential current transformer. If the current balance is violated, the RCD immediately opens all the contacts entering into it, thus disabling the faulty load.

Protective equalization (equalization) of potentials. Protective equipotential bonding is the achievement of the equality of the potentials of conducting parts by electrically connecting them together.

These measures are most often applied by combining the supporting surface of a person's feet with a current-carrying or conductive part of the equipment to which a person touches when performing work in the power plant (Fig. 2.10), as well as in contour protective earthing designs.

If protective potential equalization is performed on current-carrying parts (Fig. 2.10, *a*), a chair isolated from the ground is located at the work site. On the top of this support is a working platform with metal floors and fences. The worker rises to this site, and then, using an insulating rod, puts a jumper between the metal stairs of the site and the wire. This “carries” the potential of the wire to the metalwork of the site, that is, it performs “equalization” of its potentials. Then you can touch the hand or the instrument to the wire. The current through the person will not pass, because there is no difference in the potentials of the voltage under the voltage and the platform.



a *b*

Fig. 2.10. Schemes of protective equalization (*a*) and equalization (*b*) of potentials: *a* – in the case of work on live parts (wires); *b* – in the case of work on current-carrying parts (EC cases)

The protective (electrical) separation (electrical separation of circuits) is the separation of one electrical circuit from the others in a power plant with a voltage of up to 1 kV by means of double insulation or basic insulation and a protective screen or reinforced insulation.

Practically it is the distribution of an extended or branched electrical network with an isolated neutral to separate electrically unconnected sections with a separating transformer.

From the point of view of danger, the electrical separation of the circuits “allows” to reduce the current, flow through the person in the case of single-phase direct contact and the earth fault current.

Really, this is a power circuit of one consumer from a separate insulation transformer. In this case, the neutral of the network from the primary side can be isolated or grounded, and on the secondary side necessarily isolated.

Insulating (non-conductive) premises, zones,platforms, are premises, zones, platforms in which protection against indirect contact is provided by high resistance of the floor and walls and in which there are no grounded conductive parts.

The protective effect of these structures is a large resistance to their ground, limits the current that can flow through the person who touched a part of the power plant under voltage.

These designs, as a measure of protection against indirect contact, are allowed to be used in power plants with voltages up to 1 kV, are available only for qualified workers who service these EC.

The resistance of the isolated floor and walls of such premises, zones or areas at any point relative to the local zone should not be lower:

- 50 kΩ – for EE with rated voltage up to 500 V inclusive;
- 100 kΩ – for EE with rated voltage more than 500 V.

Ultra-low voltage systems can be used to protect against electric shock with indirect contact and in the case of direct contact in a power plant up to 1 kV, especially in rooms with increased danger and especially dangerous.

Ultra-low (low) voltage is the voltage between any conductors or any conductor and earth, does not exceed 50 V AC and 120 VDC.

Ultra-low voltage protects workers from electric shock the following two provisions:

- in the case of ultralow voltage through any resistance (including the human body), the current of the "ultra low force" will flow accordingly: $I_н = U_н / R$;
- the resistance of the human body back depends on the stress on the human body; that is, if if the voltage is extremely low, then the resistance of the human body will be a little over 1 kΩ.

Ultra-low voltage is of three systems:

1. The SELV system is a system of ultra-low voltage safety, in which the current carrying parts of the SELV system are electrically separated from other high voltage circuits by means of protective electrical separation of the circuits.

2. PELV system is a system of protective ultra-low voltage, which is a SELV system in case of grounding of its circuit.

3. The FELV system is a system of functional ultra-low voltage, in which, under the operating conditions, an ultra-low voltage is used to power the electric receivers, but in this case conditions can be met, according to SELV and PELV or in their application there is no need, and to protect

against electric shock in Extra protection measures (fencing or insulation, which corresponds to the insulation of the primary circuit, and automatic power off) are used for the extra-low voltage circuit.

To obtain an ultra-low voltage, various sources can be used: braking elements, batteries, converters, but more often safe transformers are used.

General requirements for ultra low voltage systems:

- the fork for the circuits of the systems SELV, PELV and FELV should not enter the high voltage power sockets, and the sockets of the systems must not allow the plugs of another voltage to be turned on;
- the socket receptacles of the circuits of the SELV system shall not have a protective contact, and the FELV systems must have a contact for connection of the protective conductor.

Equipment class II with electrical protection. This class includes electrical products having double or reinforced insulation.

2.11.9. Protective earthing in electrical installations.

Definitions

National and international standards (IEC 60364) clearly define the various elements of earthing connections. The following terms are commonly used in industry and in the literature. Bracketed numbers refer to Fig. 2.11.

Earth electrode (1): A conductor or group of conductors in intimate contact with,and providing an electrical connection with Earth.

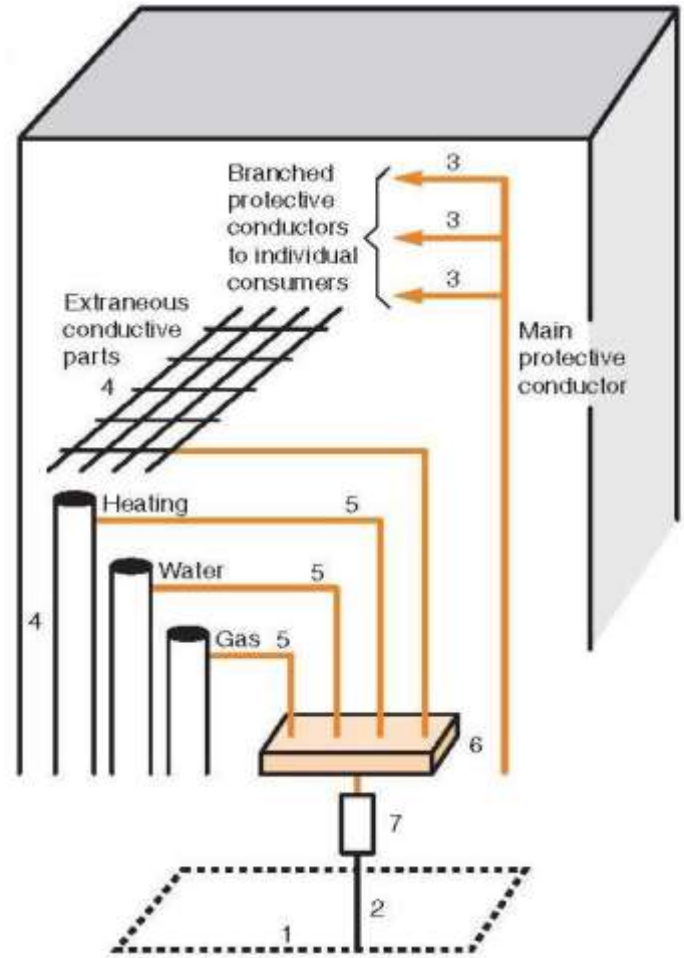
Earth: The conductive mass of the Earth, whose electric potential at any point isconventionally taken as zero.

Electrically independent earth electrodes: Earth electrodes located at such adistance from one another that the maximum current likely to flow through one of them does not significantly affect the potential of the other (s).

Earth electrode resistance: The contact resistance of an earth electrode with the Earth.

Earthing conductor (2): A protective conductor connecting the main earthingterminal (6) of an installation to an earth electrode (1) or to other means of earthing (e.g. TN systems).

Exposed-conductive-part: A conductive part of equipment which can be touchedand which is not a live part, but which may become live under fault conditions.



In a building, the connection of all metal parts of the building and all exposed conductive parts of electrical equipment to an earth electrode prevents the appearance of dangerously high voltages between any two simultaneously accessible metal parts

Fig. 2.11. An example of a block of flats in which the main earthing terminal (6) provides the main equipotential connection; the removable link (7) allows an earth-electrode-resistance check

Protective conductor (3): A conductor used for some measures of protection against electric shock and intended for connecting together any of the following parts:

- exposed-conductive-parts;
- extraneous-conductive-parts;
- the main earthing terminal;
- earth electrode (s);
- the earthed point of the source or an artificial neutral.

Extraneous-conductive-part: A conductive part liable to introduce a potential, generally earth potential, and not forming part of the electrical installation (4). For example:

- non-insulated floors or walls, metal framework of buildings.
- metal conduits and pipework (not part of the electrical installation) for water, gas, heating, compressed-air, etc. and metal materials associated with them.

Bonding conductor (5): A protective conductor providing equipotential bonding.

Main earthing terminal (6): The terminal or bar provided for the connection ofprotective conductors, including equipotential bonding conductors, and conductors for functional earthing, if any, to the means of earthing.

Connections

The main equipotential bonding system

The bonding is carried out by protective conductors and the aim is to ensure that, in the event of an incoming extraneous conductor (such as a gas pipe, etc.) being raised to some potential due to a fault external to the building, no difference of potential can occur between extraneous-conductive-parts within the installation.

The bonding must be effected as close as possible to the point (s) of entry into the building, and be connected to the main earthing terminal (6).

However, connections to earth of metallic sheaths of communications cables require the authorisation of the owners of the cables.

Supplementary equipotential connections

These connections are intended to connect all exposed-conductive-parts and all extraneous-conductive-parts simultaneously accessible, when correct conditions for protection have not been met, i.e. the original bonding conductors present an unacceptably high resistance.

Connection of exposed-conductive-parts to the earth electrode (s)

The connection is made by protective conductors with the object of providing a low- resistance path for fault currents flowing to earth.

Definition of standardised earthing schemes

The different earthing schemes (often referred to as the type of power system or system earthing arrangements) described characterise the method of earthing the installation downstream of the secondary winding of a HV/LV transformer and the means used for earthing the exposed conductive-parts of the LV installation supplied from it.

The choice of these methods governs the measures necessary for protection against indirect-contact hazards.

The earthing system qualifies three originally independent choices made by the designer of an electrical distribution system or installation:

- the type of connection of the electrical system (that is generally of the neutral conductor) and of the exposed parts to earth electrode (s);
- a separate protective conductor or protective conductor and neutral conductor being a single conductor;
- the use of earth fault protection of overcurrent protective switchgear which clear only relatively high fault currents or the use of additional relays able to detect and clear small insulation fault currents to earth.

In practice, these choices have been grouped and standardised as explained below. Each of these choices provides standardised earthing systems with three advantages and drawbacks:

- connection of the exposed conductive parts of the equipment and of the neutral conductor to the PE conductor results in equipotentiality and lower overvoltages but increases earth fault currents;
- a separate protective conductor is costly even if it has a small cross-sectional area but it is much more unlikely to be polluted by voltage drops and harmonics, etc. than a neutral conductor is. Leakage currents are also avoided in extraneous conductive parts;
- installation of residual current protective relays or insulation monitoring devices are much more sensitive and permits in many circumstances to clear faults before heavy damage occurs (motors, fires, electrocution). The protection offered is in addition independent with respect to changes in an existing installation.

TT system (earthed neutral) (see Fig. 2.12)

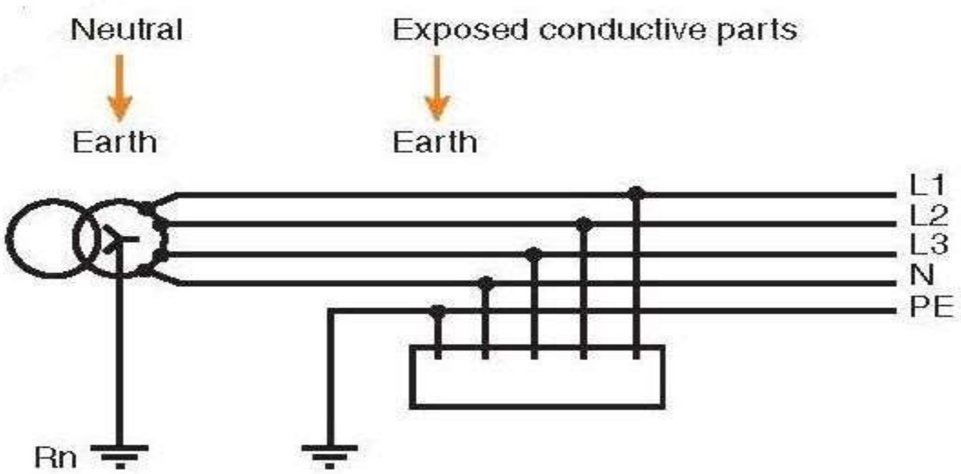


Fig. 2.12. TT system

One point at the supply source is connected directly to earth. All exposed- and extraneous-conductive-parts are connected to a separate earth electrode at the installation. This electrode may or may not be electrically independent of the source electrode. The two zones of influence may overlap without affecting the operation of protective devices.

TN systems (exposed conductive parts connected to the neutral)

The source is earthed as for the TT system (above). In the installation, all exposed- and extraneous-conductive-parts are connected to the neutral conductor. The several versions of TN systems are shown below.

TN-C system (see Fig. 2.13)

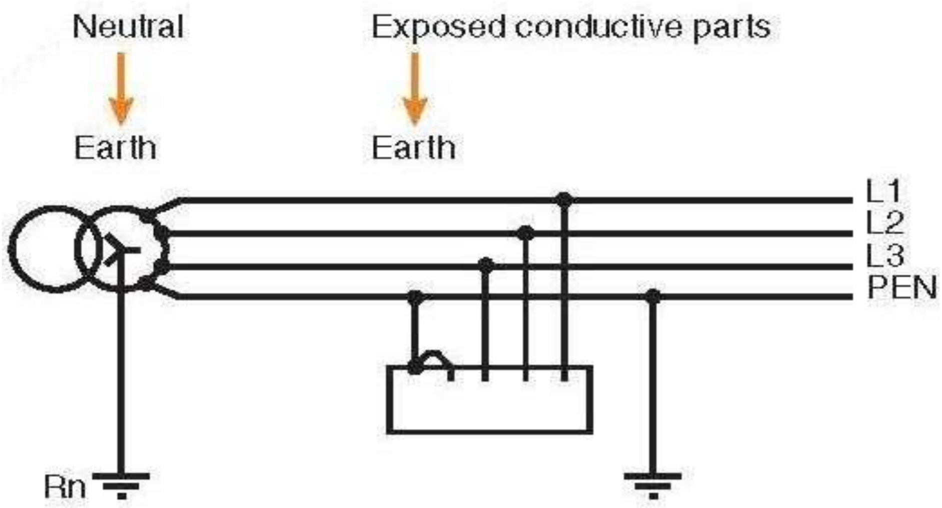


Fig. 2.13. TN-C system

The neutral conductor is also used as a protective conductor and is referred to as a PEN (Protective Earth and Neutral) conductor. This system is not permitted for conductors of less than 10 mm^2 or for portable equipment.

The TN-C system requires an effective equipotential environment within the installation with dispersed earth electrodes spaced as regularly as possible since the PEN conductor is both the neutral conductor and at the same time carries phase unbalance currents as well as 3rd order harmonic currents (and their multiples).

The PEN conductor must therefore be connected to a number of earth electrodes in the installation.

Since the neutral conductor is also the protective conductor, any break in the conductor represents a danger to life and property.

For this reason, electrical utilities impose the installation of residual current devices (RCDs) at the service connection points of private subscribers.

If an RCD is not installed, a low earthing resistance (no more than 2 ohms) is required to limit the touch voltage to 50 V in the event of a fault.

TN-S system (see Fig. 2.14)

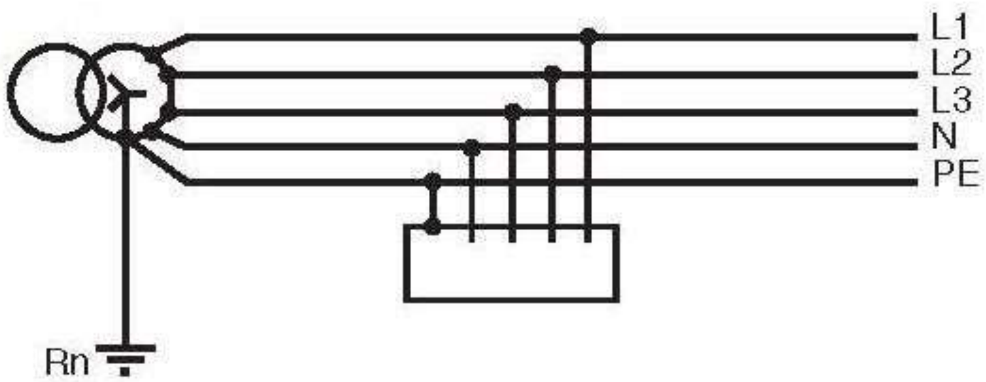


Fig. 2.14. TN-S system

The TN-S system (5 wires) is obligatory for circuits with cross-sectional areas less than 10 mm^2 for portable equipment.

The protective conductor and the neutral conductor are separate. On underground cable systems where lead-sheathed cables exist, the protective conductor is generally the lead sheath. The use of separate PE and N conductors (5 wires) is obligatory for circuits with cross-sectional areas less than 10 mm^2 for portable equipment.

TN-C-S system (see Fig. 2.15 below and Fig. 2.16 next page)

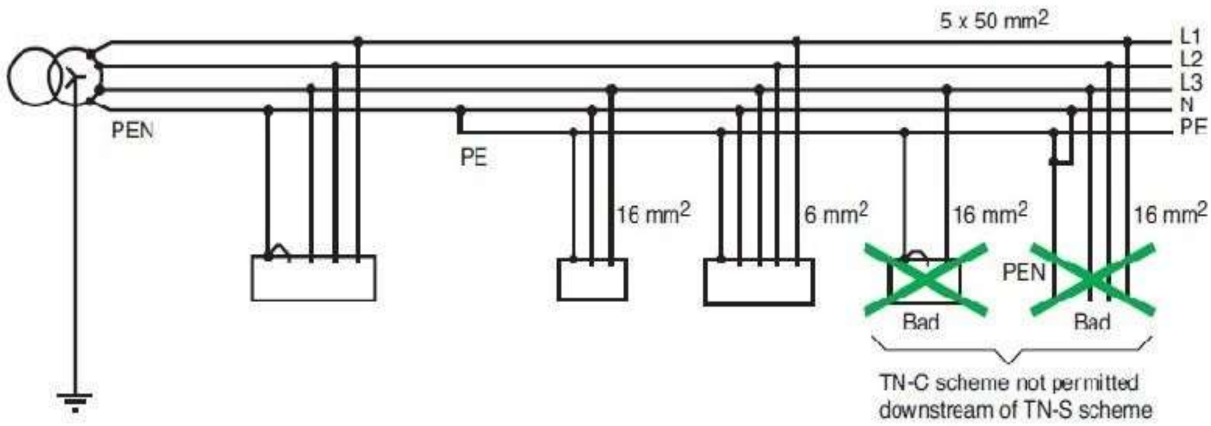


Fig. 2.15. TN-C-S system

Caution: In the TN-C system, the “protective conductor” function has priority over the “neutral function”. In particular, a PEN conductor must always be connected to the earthing terminal of a load and a jumper is used to connect this terminal to the neutral terminal.

The TN-C and TN-S systems can be used in the same installation. In the TN-C-S system, the TN-C (4 wires) system must never be used downstream of the TN-S (5 wires) system, since any accidental interruption in the neutral on the upstreampart would lead to an interruption in the protective conductor in the downstream part and therefore a danger.

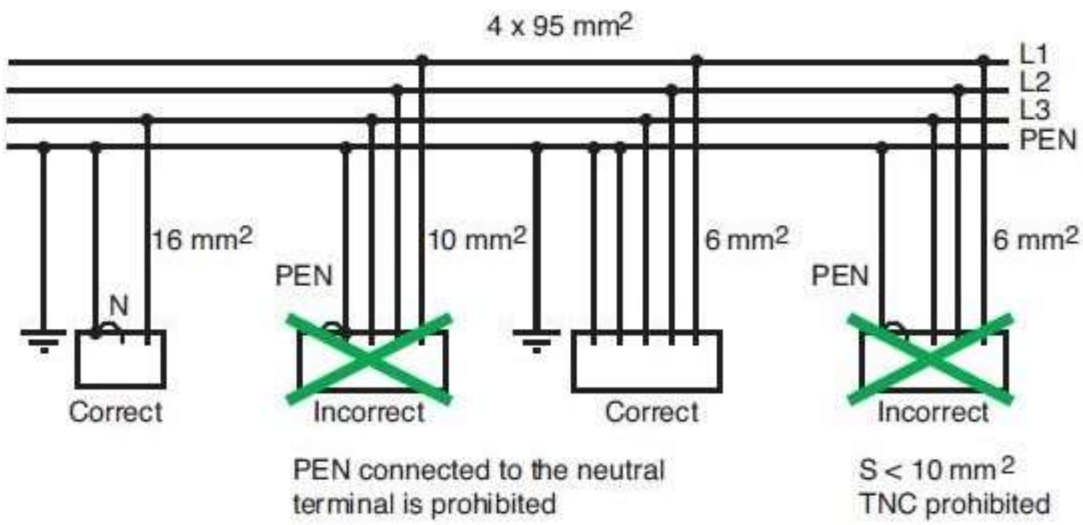


Fig. 2.16. Connection of the PEN conductor in the TN-C system

IT system (isolated or impedance-earthed neutral)

IT system (isolated neutral)

No intentional connection is made between the neutral point of the supply sourceand earth (see Fig. 2.17)

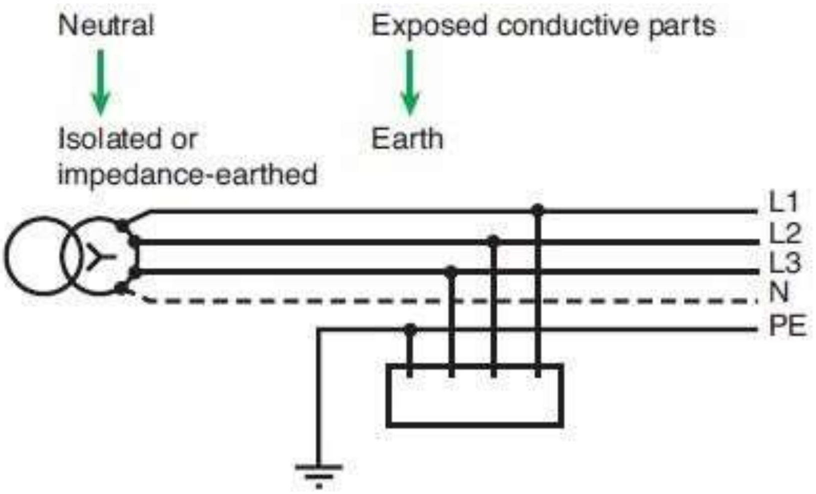


Fig. 2.17. IT system (isolated neutral)

Exposed- and extraneous-conductive-parts of the installation are connected to anearth electrode.

In practice all circuits have a leakage impedance to earth, since no insulation is perfect. In parallel with this (distributed) resistive leakage path, there is the distributed capacitive current path, the two paths together constituting the normalleakage impedance to earth (see Fig. 2.18)

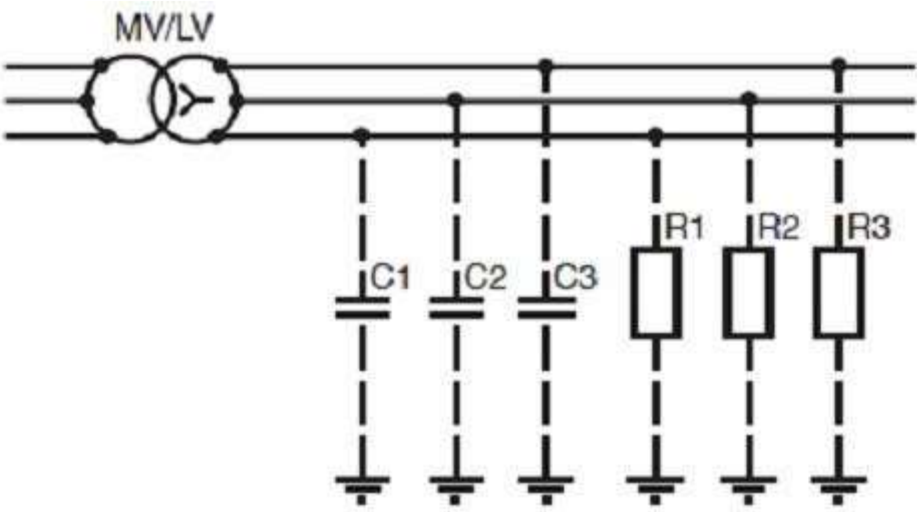


Fig. 2.18. IT system (isolated neutral)

Example (see Fig. 2.19)

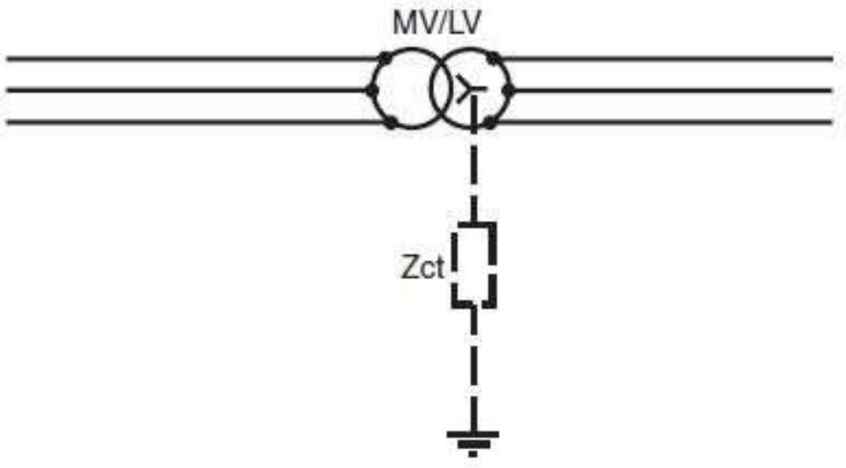


Fig. 2.19. Impedance equivalent to leakage impedances in an IT system

In a LV 3-phase 3-wire system, 1 km of cable will have a leakage impedance due to C1, C2, C3 and R1, R2 and R3 equivalent to a neutral earth impedance Zct of 3,000 to 4,000 **Ω**, without counting the filtering capacitances of electronic devices.

IT system (impedance-earthed neutral)

An impedance Zs (in the order of 1,000 to 2,000 **Ω**) is connected permanently between the neutral point of the transformer LV winding and earth (see Fig. 2.20).

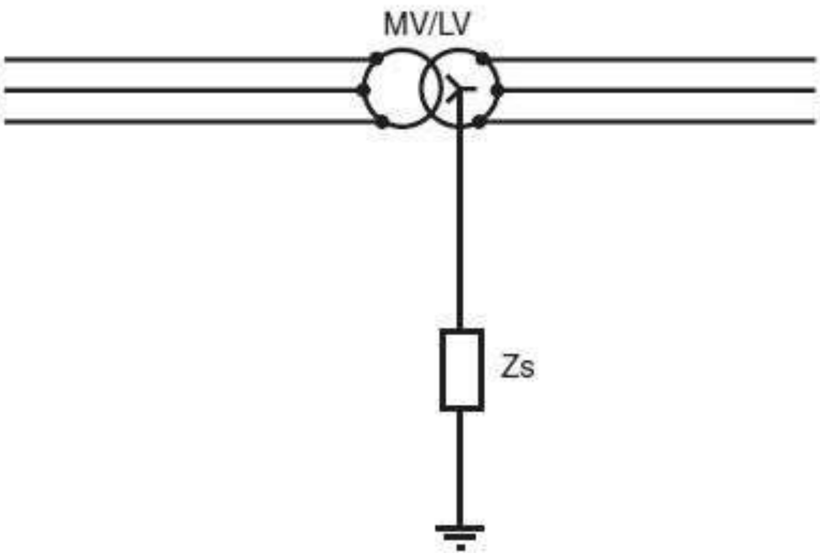


Fig. 2.20. T system (impedance-earthed neutral)

All exposed- and extraneous-conductive-parts are connected to an earth electrode.The reasons for this form of power-source earthing are to fix the potential of a small network with respect to earth (Zs is small compared to the leakage impedance) and to reduce the level of overvoltages, such as transmitted surges from the HV windings, static charges, etc. with respect to earth. It has, however, the effect of slightly increasing the first-fault current level.

Characteristics of TT, TN and IT systems

TT system (see Fig. 2.21)

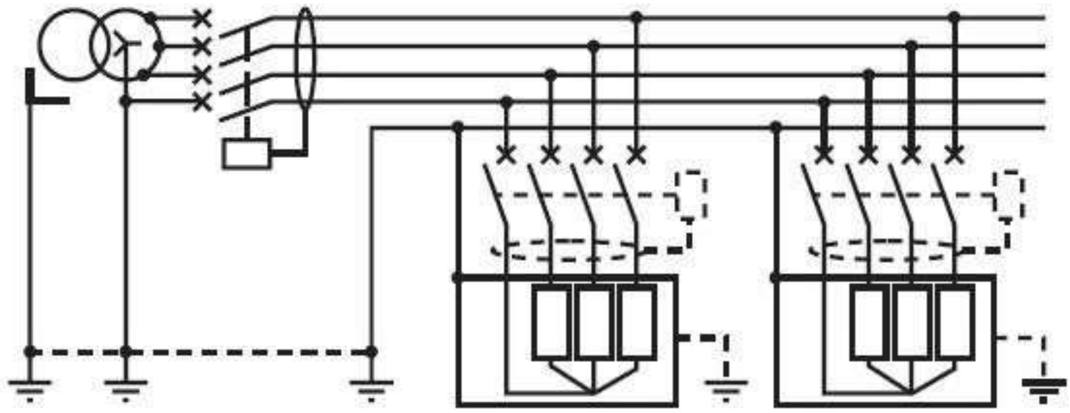


Fig. 2.21. TT system

The TT system:

- Technique for the protection of persons: the exposed conductive parts are earthed and residual current devices (RCDs) are used.
- Operating technique: interruption for the first insulation fault.

Note: If the exposed conductive parts are earthed at a number of points, an RCD must be installed for each set of circuits connected to a given earth electrode.

Main characteristics

- Simplest solution to design and install. Used in installations supplied directly by the public LV distribution network.
- Does not require continuous monitoring during operation (a periodic check on the RCDs may be necessary).
- Protection is ensured by special devices, the residual current devices (RCD), which also prevent the risk of fire when they are set to y 500 mA.

• Each insulation fault results in an interruption in the supply of power, however the outage is limited to the faulty circuit by installing the RCDs in series (selective RCDs) or in parallel (circuit selection).

• Loads or parts of the installation which, during normal operation, cause high leakage currents, require special measures to avoid nuisance tripping, i.e. supply the loads with a separation transformer or use specific RCDs

TT system (see Fig. 2.22)

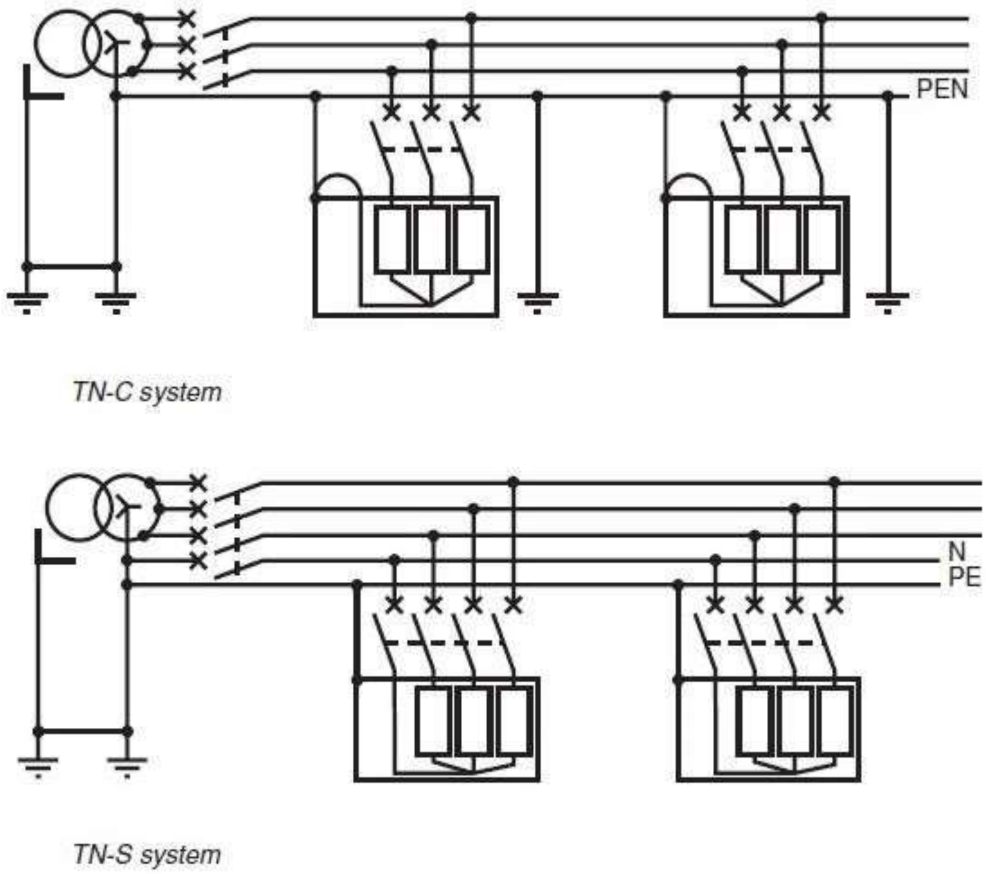


Fig. 2.22. TN-C and TN-S systems

The TN system:

• Technique for the protection of persons:

– interconnection and earthing of exposed conductive parts and the neutral are mandatory;

– interruption for the first fault using overcurrent protection (circuit-breakers or fuses).

• Operating technique: interruption for the first insulation fault

Main characteristics

Generally speaking, the TN system:

- Requires the installation of earth electrodes at regular intervals throughout theinstallation.
- Requires that the initial check on effective tripping for the first insulation faultbe carried out by calculations during the design stage, followed by mandatorymeasurements to confirm tripping during commissioning.
- Requires that any modification or extension be designed and carried out by aqualified electrician.
- May result, in the case of insulation faults, in greater damage to the windings ofrotating machines.
- May, on premises with a risk of fire, represent a greater danger due to the higherfault currents.

In addition, the TN-C system:

- At first glance, would appear to be less expensive (elimination of a device pole andof a conductor).
- Requires the use of fixed and rigid conductors.
- Is forbidden in certain cases:

– premises with a risk of fire;

– for computer equipment (presence of harmonic currents in the neutral).

In addition, the TN-S system:

- May be used even with flexible conductors and small conduits.
- Due to the separation of the neutral and the protection conductor, provides a clean.

IT system (see Fig. 2.23)

IT system:

- Protection technique:

– interconnection and earthing of exposed conductive parts;

– indication of the first fault by an insulation monitoring device (IMD);

– interruption for the second fault using overcurrent protection (circuit-breakers or fuses).

• Operating technique:

– monitoring of the first insulation fault;

– mandatory location and clearing of the fault v Interruption for two simultaneous insulation faults.

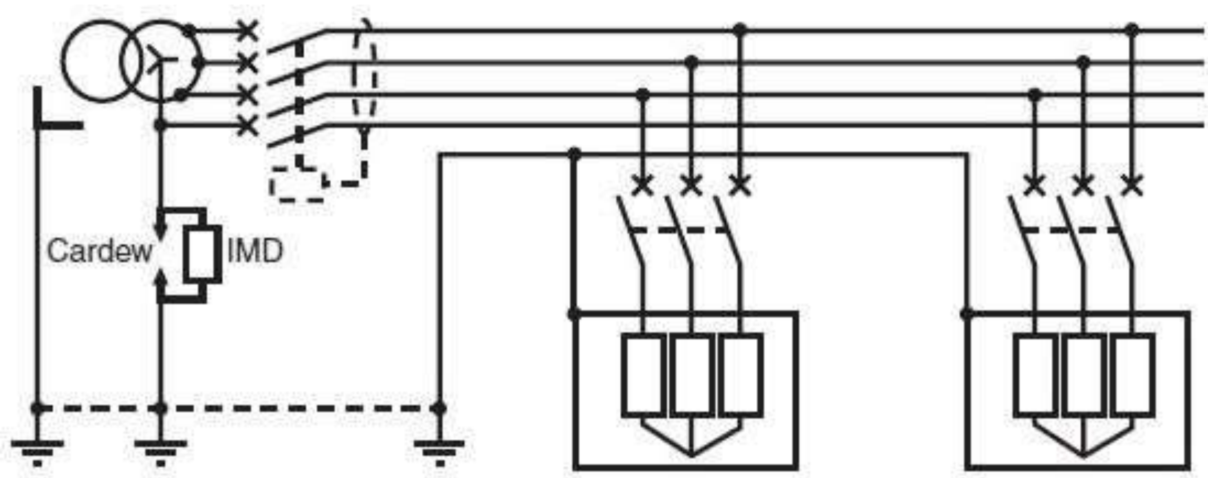


Fig. 2.23. IT system

Main characteristics

• Solution offering the best continuity of service during operation.

• Indication of the first insulation fault, followed by mandatory location and clearing, ensures systematic prevention of supply outages.

• Generally used in installations supplied by a private MV/LV or LV/LV transformer.

• Requires maintenance personnel for monitoring and operation.

• Requires a high level of insulation in the network (implies breaking up the network if it is very large and the use of circuit-separation transformers to supply loads with high leakage currents).

• The check on effective tripping for two simultaneous faults must be carried out by calculations during the design stage, followed by mandatory measurements during commissioning on each group of interconnected exposed conductive parts.

• Protection of the neutral conductor must be ensured.

2.11.10. Means of protection in electrical installations

General requirements for the nomenclature of types of protection are regulated by DSTU 7237:2011 [50].

Classification and conditions for the use of protective equipment. When servicing the power plant, the means of electrical protection (ESD), means of protection from the electric field of industrial frequency (EFIF) and means of individual protection (PPE) are used.

ESD is a tool designed to provide electrical safety. ESD are divided into insulations and special for carrying out work under voltage. Isolating ESD are divided into basic and additional.

The main ESD is an electrically insulating means, the insulation of which for a long time withstands the working voltage of the power plant and which allows working on current-carrying live parts (Table 2.8).

Table 2.8. Basic electrical protective equipment

Up to 1 kV	More than 1 kV
Isolating rods Insulating pincers Electrical mites Voltage indicators Dielectric gloves The tool with an insulating coating	Isolating rods Insulating pincers Electrical mites Voltage indicators Devices for creating safe working conditions during tests and measurements in EI (voltage indicators for phasing, indicators of damage to cables, etc.)

Additional ESD – electrically insulated means, which in itself can not in this voltage provide protection from electric shock; it complements the main ESD, and can also protect against indirect contact and step voltage (Table 2.9).

Means of protection in the performance of work under voltage: dielectric caps, lining, plate-plates, tips, boxes; a set of fitter's mounting tools; rod-manipulators; Insulating ladders, rods and rods, ropes, inserts, hinged and supporting structures: polymer insulators, flexible insulators and insulating ladders.

The requirements for protective conductive clothing are regulated by DSTU IEC 60895:2008 [51].

Table 2.9. Additional electric protective devices

Up to 1 kV	More than 1 kV
Dielectric shoes Dielectric rugs Insulating stands Insulating lining Isolating caps Voltage sensors Protective enclosures (shields, screens) Portable earthing Security posters Other means of protection	Dielectric gloves Dielectric shoes Dielectric rugs Insulating stands Insulating lining Isolating caps Rods for carrying and measuring the potential Voltage sensors Protective enclosures(shields, screens) Portable earthing Security posters Other means of protection

In addition, the following PPE are used in EI:

- protective helmets - to protect the head;
- safety glasses and shields – for the protection of eyes and face;
- gas masks and respirators – to protect the respiratory system;
- gloves and gloves – for the hands protection;
- safety belts and safety ropes (during the execution of work at an altitude of 1.3–5 m and high-flying);
- other special PPE.

In the case of the use of basic isolating ESD it is enough to use one additional remedy, except for individual cases. In case of need to protect the worker from voltage stress only, dielectric shoes may be used without the use of basic protective equipment.

2.11.11. Organization of safe operation of existing electrical installations

The organization of safe operation of the EI includes:

- selection and training of employees for the operation of the EI;
- observance of organizational security measures;
- implementation of technical security measures;
- tests of existing EI;
- providing first aid to victims of accidents.

Requirements for employees serving EI

Employees who serve EI are divided into two groups: electrical workers and electrotechnical workers.

Electrotechnical workers – are those whose position or profession is related to the maintenance of the EI that passed the safety test during the operation of the EI and have a group on electrical safety.

Electrotechnical employees – employees whose position or profession is associated with the operation of the electrical part of production equipment, but whose duties do not include maintenance of its electric drive.

Electrotechnical workers are divided into:

- administrative-technical – are managers of enterprises, heads of shops, services, departments, sections, laboratories, their deputies, other ITP, which are assigned administrative functions;
- operational – workers who are on duty alternate and admitted to operational;
- production – are employees who provide the production process, the work of which is associated with the production process;
- operative-production – production workers, prepared for the operational maintenance of the equipment attached to them.

Age requirements. Workers under the age of 18 can be awarded a qualification group for electrical safety not higher II.

Health requirements. Before taking a job and periodically, after 2 years, the worker serving the EI is undergoing medical examination. Before work in the EI, workers with a fatal injury, visual acuity and hearing loss below a certain level, as well as diseases of the heart, respiratory tract, nervous system, blood, skin and other organs are not allowed.

Training requirements. Before hiring and during work, employees receive appropriate briefings (introductory, primary, recurrent, unscheduled and targeted). In addition, before appointment for independent work, in case of transfer to another job and a break in work for more than 6 months, and periodically a year later, employees serving the operating EI are trained and make examinations of the qualification commission. Because of the exam result, they are awarded a qualification group on electrical safety and a nominal certificate is issued.

In total there are five qualifying groups – I–V. Group I is assigned without an examination after the appropriate instruction. To assign the next group of electrical safety, it is necessary to have a minimum work experience in EI with the previous group. For work in EI with voltage up to 1 kV the worker must have Group II or III, and up to and above 1 kV – IV or V group.

To receive groups II–III, employees must:

- to clearly understand the dangers associated with work in the EI;
- to know and be able to apply in practice safety rules to the extent necessary for performance of work;
- to know the structure of electrical installations;
- to be able to provide first aid to victims in case of accidents, including an appliance of resuscitation methods.

In order to receive groups IV–V, it is necessary to know the layout of the EI, as well as be able to organize the safe conduct of work and train other group workers about the safety rules and first aid help.

In order to obtain a group V, it is necessary to understand what the requirements of the rules of safety regulations are called.

It is prohibited to admit to work in the EI workers who have not passed training and verification of knowledge of the Safety Rules, who do not have a certificate of knowledge verification, as well as with an expired period of knowledge testing.

Organizational measures that protect workers during work, determine a certain procedure for the execution of work in the EI. EI's work on their organization are divided into the following:

- on a work permission;
- by order;
- in the order of the current operation.

The organizational security measures are:

- conclusion and approval of the list of works performed on work permission; orders and in the order of current operation;
- appointment of workers responsible for the safe conduct of work;
- execution of work by order-admission or order;
- preparation of workplaces;
- admission to work;
- supervision during work execution;
- transfer to another workplace;
- registration of breaks in work and its completion.

Responsible for the safety of works in the EI is:

- an employee who issues a work permission or order;
- an employee who gives permission to prepare a workplace;
- an employee who prepares a workplace;
- an employee who admits to work (gives an admission);
- the head of the works;
- an employee who oversees the safe execution of work (supervisor);
- members of the working brigade.

Each of the listed persons is responsible for safety at their site.

Execution of work permission. Work permission (***outfit***) – a special form for safely conducting work that defines its contents, the time of beginning and end, the necessary security measures, the composition of the team and the workers responsible for the safe execution of work.

By the work permission the most responsible works are ordered, which require special preparation of the workplace:

- with the voltage removal;
- without the removal of stress on current-conducting parts and near them;
- without the removal of voltage from the distance from current-carrying parts, when the installation of temporary protections is required;
- with lifting more than 3 m from the ground level to the worker's feet (work at a height);
- with disassembly of the support structure;
- with the removal of support racks to a depth of more than 0.5 m;
- with the use of load-lifting machines and mechanisms in the distribution substation (DSS) or the protective zone of the aerial line (AL), etc.

The head of works must supervise the members of the brigade and remove the members of the brigade who violate the Existing Rules. He should have a group of electrical safety IV during the execution of works in the EI with voltage of more than 1 kV and III – up to 1 kV.

Execution of work on an order. An order – is a task for the safe execution of works registered in the journal and defines its content, place, time, security measures (if required) and the workers entrusted with its execution. It is one-time and its duration is limited to the duration of the working day.

By order, less complex work is performed that does not require the preparation of the workplace, namely:

- work without the removal of voltage from current-conducting parts, which are under voltage;
- emergency repair works (up to 1 hour);
- work with the removal of voltage in EI with voltage up to 1 kV;
- inspection of the AL in an easily accessible area in favorable weather conditions;
- with a lift up to 3 m from the ground level to the worker's feet;
- with the removal of support racks to a depth of up to 0.5 m, etc.

The work on the order is executed with the preliminary registration in the journal of the account of work on the work permission and orders.

Execution of works in the order of the current operation. The current operation – is a long-term task for the operational or operational-production workers to independently work in the assigned section during the change of work in a pre-approved and approved list.

In the order of the current operation, the following works can be carried out:

- without the removal of voltage away from current-conducting parts that are under voltage (cleaning corridors and office space, cleaning the territory, repair of lighting equipment and replacement of lamps);
- with the removal of voltage in EI up to 1 kV;
- servicing of indoor and outdoor lighting installations;
- service of workshops and other EI.

Organizational measures that ensure the execution of works in the order of the current operation are:

- determination of the necessity and the possibility of safe work performance;
- conclusion and approval of the list of works performed in the order of the current operation;
- appointment of the performers (executor) of works with the corresponding group of electrical safety;
- familiarization of the performers with the list and nature of the work, as well as security requirements during their execution.

Technical measures that create safe conditions for the execution of works. To prepare a workplace for work requiring a voltage drop, the following technical steps should be taken in the order indicated:

- Perform the necessary disconnections of current-carrying parts, on which the work will be performed, as well as uncovered current-carrying parts, to which the approach of workers or their tools and devices at a distance is less than permissible. Take measures that prevent the false or spontaneous activation of the switching equipment, namely: the actuators of the switching devices to lock the mechanical lock or lock, install the insulation lining, remove the fuses, disconnect the ends of the cable, execute the expansion, etc. The voltage should be switched off on all sides.
- Insert prohibitive posters on the drives of switching devices (disconnectors, separators, switches): "Do not turn on! People work", "Do not

turn on! Work on the line" or on the latches closing the access of compressed air to the pneumatic actuators of the switching equipment – "Do not open! People work".

- Fasten non-disconnected current-conducting parts available for accidental touch, shields, screens, screens made of insulating materials. At the time fences, attach the caution posters "Stop! Voltage", inversed by the inscription outside. It is allowed to use isolation strips placed between the switched off and those under voltage, current-carrying parts up to 10 kV. In the VRU during work carried out on the ground, the workplace should be fenced (with the abandonment of the passage) rope from vegetable or synthetic fibers and hang on the rope warning posters "Warning! Voltage", inversely inscribed inside the enclosed space. On constructs adjacent to the one on which it is allowed to climb to the workplace, there should be posted warning posters "Warning!"
- Check the absence of voltage on the switched off current conductors by checking the circuit and the voltage indicator (voltage up to 220 kV inclusive, in external EI (AL, DSS) check the absence of voltage indicator is allowed only in dry weather).
- Ground disconnected circular parts by turning off the grounding knives of the disconnectors or imposing portable earthing. The portable grounding must be connected to the grounding device, and then, after checking the absence of voltage, install on the current-carrying part. Grounding the current conductive parts should be on all sides, from where the voltage can be applied to the workplace. It is necessary to remove the portable ground in reverse order: first remove it from current-carrying parts, and then – from the grounding device. After the grounding of disconnected current-conducting parts on the drives of switching devices, the inclusion of which will lead to the voltage supply to these parts, hanging signposts – "Earthed" should be hung.
- After performing these operations on the preparation of the workplace in the work place, install posters – "Work here", and on stationary ladders and constructions that are allowed to rise – "Get in here".

SELF-CONTROL QUESTIONS TO SECTION 2. LABOUR PROTECTION

1. To analyse the place and features of labour protection in the system of ensuring the safety of human life.

2. List and describe the main sources of negative impact on the human body during work.

3. Analyse the factors and characteristics of the labour process and the working environment in relation to labour protection.

4. Define and describe the purpose, structure, subjects and objects of protection and labour.

5. Describe the modern concept and main tasks of labour protection.

6. Give and describe the hygienic parameters of the air of the working area and the principles of their evaluation.

7. Describe the efficiency and scope of the main methods of normalization of air parameters of the working area.

8. Analyse the possibilities and effectiveness of methods to prevent air pollution in the work area.

9. Using the classification characteristics to give the principles of choosing a ventilation system.

10. Comment on the basic requirements for ventilation systems.

11. Give a comparative description and scope of effective use of natural and mechanical ventilation.

12. Basic types and principles of use of means of individual protection against influence of harmful substances and parameters of a microclimate.

13. Causes and classification of noise sources.

14. Give a comparative description and justify the use of methods of hygienic assessment of noise in the workplace.

15. Analyse the effectiveness and practical possibilities of using methods of collective and individual protection against noise.

16. Sources and features of human impact of ultrasound and infrasound.

17. Features of identification and hygienic assessment of ultrasound and infrasound.

18. Specifics of methods and features of means of protection against ultrasound and infrasound.

19. Nature and classification of types and sources of vibration.

20. Explain the features of the impact and consequences of human vibrations.

21. Hygienic assessment of vibration.

22. Analyse the methods and justify the principles of choice of collective and individual protection against vibration.

23. Explain the features of exposure and hygienic assessment of human exposure to radiation in the optical range.

24. To substantiate the principles and algorithm of choice of methods of collective and means of individual protection against radiation of optical range.

25. Danger of exposure and assessment of possible effects of ionizing radiation on humans.

26. Sources, features of identification and hygienic assessment of ionizing radiation.

27. Analyse the conditions and possibilities of using methods of collective and individual protection of workers from ionizing radiation.

28. Classification, features of human exposure and hygienic evaluation of laser radiation.

29. Measures and means of protection against laser radiation.

30. Analyse the role and importance of lighting in creating healthy and safe working conditions.

31. Using the classification of types and lighting systems, analyse the scope and effectiveness of their use.

32. Basic requirements for lighting of workplaces and premises.

33. Advantages, disadvantages and features of the assessment of natural light.

34. Advantages, disadvantages and features of artificial lighting.

35. Critical analysis of modern artificial light sources.

36. Analyse options for lighting workplaces and premises.

37. A typical list, possible causes and sources of psychophysiological harmful factors of the labour process.

38. Analyse the effects of physical exertion on the health and efficiency of the worker.

39. The main types of neuropsychological and psychoemotional stress, their sources and consequences of the impact on the professional activities of the person.

40. Fatigue, as a consequence of the impact on the body of the worker workload and working environment.

41. Causes and consequences of stress and mobbing in the workplace.

42. The content and practical significance of the hygienic classification of labour for the organization and provision of labour activity in industrial enterprises.

43. Purpose, tasks and procedure for attestation of jobs under working conditions.

44. Directions of industrial safety.

45. Assess the practical possibilities of using methods and means to ensure the safety of production equipment.

46. Assess the practical possibilities of using methods and tools to ensure the safety of technological processes.

47. Describe the effectiveness and algorithm for selecting methods and means of ensuring the safety of work.

48. Signal colours, safety signs and signal markings – as components of increasing the level of industrial safety.

49. Analyse the impact of automation and robotization of production processes on the overall level of labour protection.

50. The nature and effects of electric current on humans.

51. Classification and analysis of factors influencing the consequences of electric shock.

52. Analyse the causes and consequences of step voltage.

53. Analyse the causes and possible consequences of indirect contact with live parts of electrical installations.

54. Organizational measures to ensure safe operation of electrical installations.

55. Determine the conditions of occurrence and course of the combustion process and analyse their significance for fire prevention.

56. Describe and analyse the legal framework for labour protection in Ukraine.

57. Describe and evaluate the functions, duties and responsibilities of the employer in the field of labour protection.

58. The procedure for appointment, functions and rights of the person authorized by employees for labour protection.

59. Analyse the general structure and typical principles of functioning of the labour protection management system at the enterprise.

60. Describe the responsibilities and functions of the employer in organizing and coordinating work on occupational safety management.

Section 3. CIVIL DEFENSE OF THE POPULATION AND TERRITORIES

3.1. Fundamentals of Civil defense

3.1.1. Basics of state policy in the field of civil defense

The legal basis for civil defense (CD) is the Constitution of Ukraine [52], the Civil defense Code [53], the Law of Ukraine "On the Fundamentals of National Security of Ukraine" [54], other laws of Ukraine, as well as presidential decrees and regulatory documents of the Ukrainian Cabinet of Ministers.

During emergencies, potential dangers to human life and health are manifested to a greater extent and with greater probability of negative consequences.

Every citizen in accordance with the Constitution of Ukraine has the right to protect his life and health from the consequences of accidents, disasters, natural disasters, the use of weapons, and also on demand to ensure the realization of this right from executive authorities, heads of enterprises, organizations, institutions, regardless of form property and submission.

Civil defense is a system of measures (organizational, engineering, sanitary, hygienic, anti-epidemic, etc.), take central and local executive authorities and their subordinate forces, enterprises, institutions and organizations to protect the population, territories, natural environment environment and property from emergency situations by preventing such situations, eliminating their consequences and providing assistance to victims in peacetime and in a special period.

The solution of problems of natural and industrial safety of Ukraine ensures the following measures at the state level:

- managing technological risks;
- creation of an integrated interdepartmental monitoring and debugging system for the public service for forecasting and preventing natural and man-made emergencies;

- creation of a national register of potentially dangerous objects and territories and mechanisms for their monitoring;
- increase of efficiency of work of bodies of state supervision over a condition and functioning of potentially dangerous manufactures.

The means of solving the problem of protection from man-caused and natural emergencies is the creation in Ukraine of the Unified State System of the CD of the population and territories whose main task is to prevent and respond to emergencies.

Preventing emergencies involves the preparation and implementation of measures aimed at regulating man-made and natural safety, conducting risk assessment, responding in advance to events posing a threat of emergencies, to prevent a disaster or mitigate possible consequences.

Responses to emergencies are the coordinated actions of units of the Unified State Civil defense System in the implementation of plans for the localization and elimination of accidents (catastrophes) to eliminate the threat to life and health of people, providing emergency assistance to the victims.

Civil defense is carried out according to the following principles:

- ensuring and ensuring the state's constitutional rights of citizens to protect life, health and property;
- an integrated approach to solving civil defense tasks;
- the priority of tasks aimed at saving lives and preserving the health of citizens;
- the maximum possible, economically feasible reduction in the risk of emergencies;
- centralization of management, one-man management, subordination, the statutory discipline of the Operational and Rescue Civil defense Service, emergency services;
- publicity, transparency, free receipt and dissemination of public information on the status of civil defense, except for the restrictions established by law;
- voluntarism – in case of involving citizens in the implementation of civil defense measures related to the risk to their life and health;

- responsibility of officials of public authorities and local governments to comply with the requirements of legislation on civil defense issues;
- the justified risk and responsibility of the heads of civil defense forces to ensure safety during emergency rescue and other urgent work.

3.1.2. Unified state civil defense system

The unified state system of civil defense (USS CD) of the population and territories was created to implement the state policy aimed at ensuring the safety and protection of the population and territories, material and cultural values, the environment from the negative consequences of emergencies in peacetime and a special period, overcoming the consequences of emergencies.

The main tasks of USS CD:

- ensuring the implementation of measures to prevent emergencies;
- training the population in the rules of conduct and actions in the event of an emergency;
- prevention of emergency situations, ensuring the sustainable operation of enterprises, institutions and organizations, reducing the potential for material losses;
- processing of information on emergencies, publication of information materials on the protection of the population and territories from the effects of emergency situations;
- forecasting and assessment of socio-economic consequences of emergencies, determination based on the forecast of the need for forces, funds, material and financial resources;
- creation, rational storage and use of the reserve of material and financial resources necessary for prevention and response to emergencies;
- notification of the population about the threat and emergence of emergency situations, timely and reliable information about the actual situation and the measures taken;
- protection of the population in case of emergencies;

- carrying out rescue and other urgent works to eliminate the consequences of emergency situations, organizing the life support of the affected population;
- mitigation of possible consequences of emergencies in case of their occurrence;
- implementation of social protection measures for the affected population;
- realization of the rights defined by law in the field of protecting the population from the consequences of emergency situations;
- international cooperation in the field of civil defense.

USS CD structure

The single state civil defense system includes territorial and functional subsystems (Table 3.1).

Territorial subsystems are created in the regions and Kyiv, functional subsystems in ministries and departments. Each subsystem has four levels: national, regional, local and object.

The subsystem includes:

- governing bodies;
- forces and means;
- reserves of material and financial resources;
- communication, alert and information systems.

Civil defense governing and their functions

The general management of the USS CD is carried out by the Cabinet of Ministers of Ukraine. The head of the CD of Ukraine is the Prime Minister of Ukraine.

The direct governing of the USS CD activity is entrusted to the specially authorized central executive body on issues of the Central Committee – The State Emergency Service of Ukraine (SESU). The head of this body is the deputy head of the CD of Ukraine.

The administration of the territorial subsystems of the USS CD is carried out by the executive authorities in the regions and Kyiv. Heads of territorial subsystems of the USS CD are heads of state administrations, and their deputies are heads of territorial bodies of the SESU.

Table 3.1. Structure of EDS

USS CD

territorial subsystems	**levels:** **state** **regional** **local** **object**	**Functional subsystems**

GOVERNING		
Coordinative	**Constant**	**Daily**
Council of National Security and Defense of Ukraine **CMU** **Commission for TEQ and CD** **(State, region, district)** **Commission for emergency situations (object)**	CMU SESU Territorial bodies The executive bodies, their authorized units with the CD Department (department) for Emergency Situations and Central Administration of State Administrations Subdivisions (individuals) for emergency situations at sites	Emergency management centers Operational-duty services of departments (departments) for emergency situations and CD dispatching services

Powers and facilities	**Reservations**	**systems**
ARF readiness formation of APC Emergency Medicine freelance formations union of citizens	financial material	communications Notification Informational support of the population

The SESU exercises its powers through territorial bodies in accordance with the administrative-territorial division into the regions inclusive.

Permanent governing bodies are: CMU, SESU, territorial employment agencies, executive bodies at the appropriate level and authorized units of these bodies (departments, departments) for emergency and public health issues, and at the object level – division (department, sector) or specially appointed persons on emergency situations.

Organs of day-to-day management are emergency management centers, emergency duty services of authorized bodies for emergency situations and protection of the population at all levels; dispatching services of central and local executive authorities, state enterprises, organizations, institutions.

The formation of civil defense is formed to carry out large amounts of work to eliminate the consequences of emergencies or terrorist acts, as well as to carry out restoration work that requires the involvement of a large number of specialists and equipment.

The formation of civil defense is divided into object and territorial.

Object – at the objects of economic activity, which have special equipment and property, and workers are prepared for action in emergency situations as a CD.

Territorial (by combining object formations of civil defense in the corresponding territory):

- in the region, the Kyiv, the district;
- in a city of regional importance.

Specialized services of civil defense (energy, protection of agricultural animals and plants, engineering, utilities, material support, medical, communications and alerts, fire fighting, trade and food, technical, transportation, public order) are formed for special works and events on civil defense and their provision, which require the involvement of specialists of a certain specialty, technology and special-purpose property.

Voluntary civil defense formations are formed during a threat or emergence of emergency situations for conducting auxiliary works to prevent or eliminate the consequences of such situations at the decision of the central executive authority, local state administration, local government.

Citizens on voluntary basis are involved in voluntary civil defense formations.

Citizens who perform tasks to prevent or eliminate the consequences of emergencies as part of the voluntary formation of civil defense are entitled to:

- ensuring and using personal protective equipment;
- compensation for harm caused to their lives;
- medical care and medical and psychological rehabilitation in the event of physical and psychological trauma during the implementation of tasks to prevent and eliminate the consequences of an emergency.

Involvement of the Armed Forces of Ukraine, other military formations and law enforcement agencies of special purpose, formed in accordance with the laws of Ukraine, for the liquidation of the consequences of emergency situations.

To eliminate the consequences of emergencies in accordance with the law, the Armed Forces of Ukraine, other military formations and special law enforcement agencies may be involved.

Public organizations

In order to fulfill certain functions in the sphere of civil defense, public organizations can be formed. Public organizations are involved on a voluntary or contractual basis to work on the prevention and elimination of the consequences of emergencies if the participants have the appropriate level of training.

3.1.3. Modes of functioning of the unified state civil defensesystem

In order to organize the activity of the USS CD, the Cabinet of Ministers of Ukraine is developing a plan of the main measures of civil defense of Ukraine for the corresponding hour. Depending on the scale and peculiarities of the Emergency situation, one of the following modes of functioning of the unified state civil system is predicted or has arisen, in Ukraine or within its specific territory protection: day-to-day functioning, high alertness, emergency, emergency.

The mode of daily functioning – with the industrial-industrial, radiation, chemical situation. In this mode, the following activities are carried out:

- monitoring and control of the state of the environment, the situation on potentially dangerous objects and the adjacent territories;

- round-the-clock duty of fire-rescue units;
- development and implementation of targeted and scientific and technical programs to prevent emergencies and reduce possible losses; organization and conduct of monitoring of emergencies, identification of the risks of their occurrence;
- ensuring the implementation of civil defense planning; ensuring the readiness of the management bodies and the forces of the Central Organ to act according to their intended purpose; organization of training of specialists of the Central Committee, training of managers and specialists, training of the population for actions in case of emergencies;
- creation and updating of material reserves for prevention of occurrence of extreme situations, liquidation of their consequences; maintenance in readiness of automated systems of centralized warning of a threat or occurrence of emergency situations.

High alert mode – in the event of a significant deterioration of the industrial and industrial, radiation, chemical and other situations, forecasting the occurrence of natural disasters, this mode is followed by measures of the daily operation regime, and in addition:

- to notify the management bodies and forces of the Central Organ, as well as the public about the threat of an emergency and inform him about actions in a possible emergency zone;
- the formation of operational groups to identify the causes of the deterioration of the situation and the preparation of proposals for its normalization;
- strengthening monitoring and control over the situation and carrying out constant forecasting of the possibility of occurrence of emergencies and their scales;
- clarification of response plans, implementation of measures to prevent emergencies, protection of the population and territories;
- alerting the available forces and resources of the Central Committee, attracting additional forces and means if necessary.

The stste of emergency mode – in case of occurrence and during elimination of consequences of emergency situations. In this mode:

- to notify the management bodies and civil defense forces, as well as the public about the emergence of an emergency situation and inform him of the actions in the current situation;
- appointment of the head of work on liquidation of consequences of an emergency situation and formation in case of need of the special commission on liquidation of consequences of an emergency situation;
- definition of the emergency zone; implementation of constant forecasting of a zone of possible distribution of an emergency situation and the scale of possible consequences;
- organization of works on localization and elimination of consequences of emergency, attraction for this purpose of necessary forces and means;
- organization and implementation of measures to protect the population and territories from the consequences of emergencies (life support for the affected population, the organization and implementation, if necessary, of evacuation measures, the organization and implementation of radiation, chemical, biological, engineering and medical protection of the population and territories);
- implementation of continuous monitoring of the development of the emergency situation and the situation at the emergency facilities and the adjacent territories;
- informing the civil defense authorities and the public about the development of the emergency situation and the measures being taken.

The state of emergency is established in accordance with the requirements of the Law of Ukraine "On the Legal Regime of the State of Emergency" [55].

A state of emergency is a special legal regime that can be temporarily introduced in Ukraine or in some of its localities in the event of emergencies of anthropogenic or natural nature not lower than the national level that have led or can lead to human and material losses, threaten the life and health of citizens or attempt to seize state power or change the constitutional order of Ukraine through violence.

The introduction of the state of emergency provides for the appropriate authorities of the state power, military command and local self-government bodies to have the powers necessary to prevent threats and ensure the safety and health of citizens, the normal functioning of the national economy, state authorities and local self-government bodies, protect the constitutional order, caused by the threat, restrictions in the exercise of constitutional rights and freedoms of people and civil rights and legitimate interests of legal persons indicating the period of validity of these restrictions.

The purpose of introducing a state of emergency is to eliminate the threat and early elimination of particularly grave consequences, the restoration of constitutional rights and freedoms of citizens, as well as the rights and legitimate interests of legal entities, the creation of conditions for the normal functioning of public authorities and local self-government bodies and other institutions of civil society.

3.1.4. Organization of CD at the object of economic activity

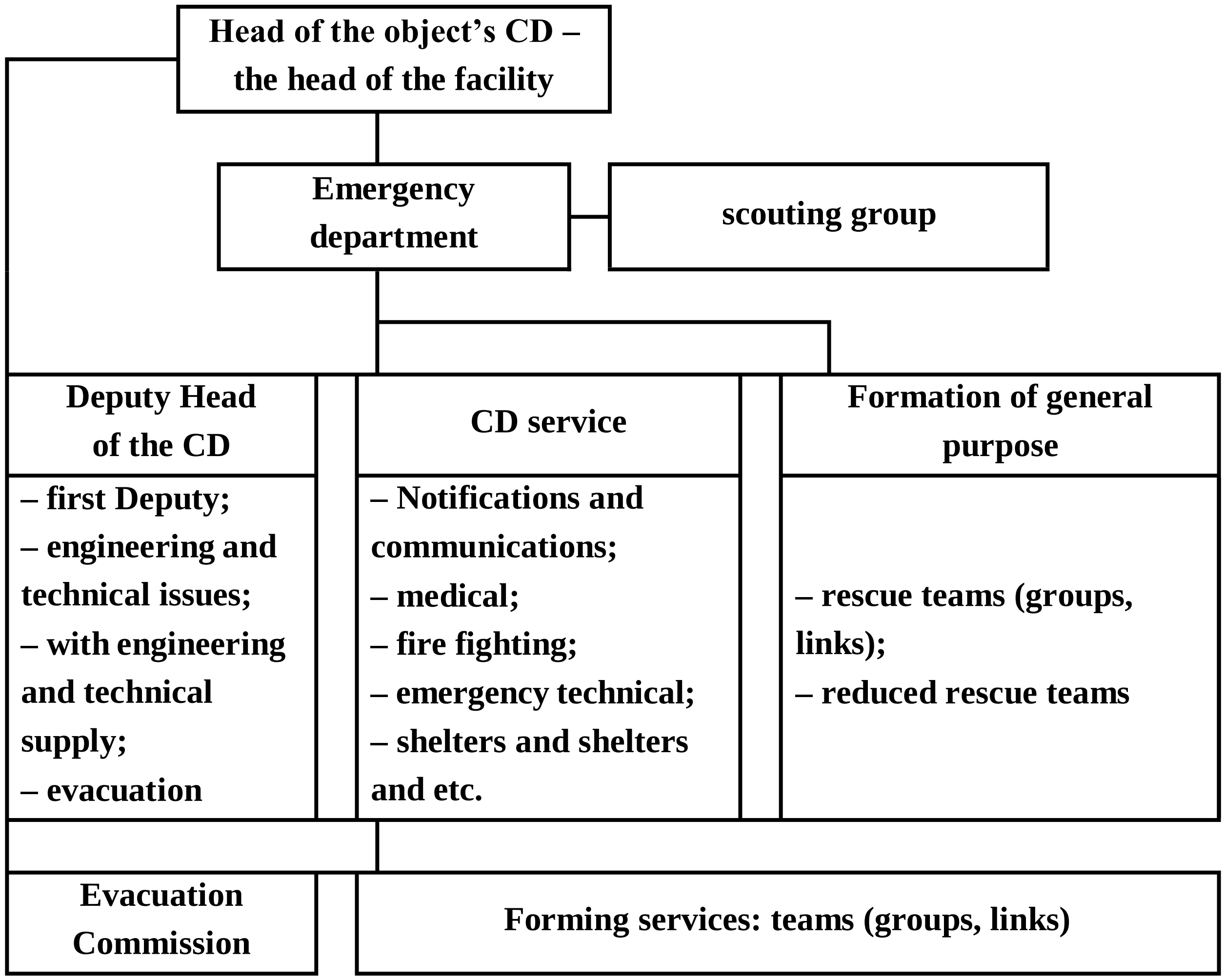
The object of economic activity (enterprise, institution, organization) is the main link in the system of the state's central government. On an object where human and material resources are concentrated, economic and protective measures are implemented.

In accordance with the legislation, the management of enterprises, institutions and organizations, regardless of the form of ownership and subordination, provides its employees with individual and collective protection facilities, places in protective structures, organizes evacuation, creates forces for eliminating the consequences of emergency situations and ensures their readiness, et “associated with this material and financial costs”. Owners of potentially hazardous facilities are also responsible for alerting and protecting the population living in areas of possible damage from the consequences of accidents at these facilities.

Structure of CD as the object of *economic activity*

The head of the CD object is the main person at object (Table 3.2). He is responsible for the organization and condition of the object’s CD, directs the actions of the bodies and forces of the Central Organ during rescue operations on it. The deputy head of the object's CD help him in matters of evacuation, material and technical supply, engineering and technical support, and the like.

Table 3.2. Structure of the object of CD



The day-to-day management of the Central Committee is a department (sector) for emergency situations, which organizes and provides day-to-day management of the implementation of the tasks of the CD at the facility.

For the preparation and implementation of activities in separate areas, communication and alert services, shelters and shelters, fire protection, public order, medical assistance, anti-radiation and chemical protection, emergency technical and logistical support, and the like are established. Chiefs of services are appointed chiefs of institutions, departments, laboratories, on the basis of which they are formed.

The service of notification and communication is created on the basis of the object's communication site. The main task of the service is to ensure timely notification of the management and employees about the threat of an accident, a catastrophe, a natural disaster, an enemy attack; organize communication and keep it in a state of constant readiness.

Fire-fighting service is created on the basis of subdivisions of departmental fire protection. The Service develops fire prevention measures and monitors their implementation; organizes localization and extinguishing the fire.

Medical service is formed on the basis of a medical center, a polyclinic facility. It is entrusted with organizing the organization of sanitary and hygienic and preventive measures, rendering medical assistance to the victims and evacuating them to medical institutions, and medical care for workers, employees and members of their families in places of dispersal.

The guard service of public order is created on the basis of subdivisions of departmental protection. Its task is to organize and provide reliable protection of the facility, public order in emergency situations, during the liquidation of the consequences of the accident, natural disaster, and also in wartime.

The anti-radiation and anti-chemical protection service is organized on the basis of a chemical laboratory or workshop. It is assigned to the development and implementation of measures to protect workers and employees, sources of water supply, radiation and chemical monitoring, to carry out measures for the elimination of radiation and chemical contamination and the implementation of radiation monitoring.

The service of storages and shelters is organized on the basis of the department of capital construction, housing and communal department. She develops a plan for protecting workers, employees and their families using storage facilities and shelters, ensuring their readiness and proper operation.

The emergency technical service is created on the basis of the production and technical department or the department of the chief mechanic. The Service develops and implements preventive measures that increase the stability of the main facilities, engineering networks and communications in the emergency situation, organizes the liquidation and localization of the accident on utility networks.

The material and technical support service is created on the basis of the material and technical supply department of the facility. It organizes the timely provision of formations with all means of equipment, food and basic necessities of workers and employees at the site and in places of dispersal, repair of machinery and property.

The transport service is organized on the basis of the transport department, the garage of the facility. It develops and implements measures to ensure transportation related to the dispersal of workers and their delivery to the workplace, rescue operations.

Each service creates, provides, prepares service formations (groups, links) and manages them during the execution of works.

The formation of general purpose – rescue teams (teams, groups, links), built rescue teams (commands), are subordinated directly to the head of the object's CD. Each of them has its own structure and capabilities. For example, an erected rescue team (SAM) has units for various purposes, such as a communications and intelligence unit, two rescue teams, a mechanization group, a sanitary wife and the like. The SAM can independently perform basic rescue and other urgent work in the lesion site.

Activities in the object of economic activity in the sphere of CD

At the enterprises, institutions and organizations, irrespective of the forms of ownership and subordination in the sphere of CD, the following activities are carried out:

- planning and implementation of measures for the safety and protection of workers against emergencies, reducing the risks of accidents, ensuring the sustainable operation of the facility in the emergency situation;
- development of plans for localization and elimination of accidents;
- maintenance in readiness for the use of forces and means for the prevention and elimination of consequences of emergencies;
- creation of material reserves in the event of emergencies;
- ensuring timely notification of workers about the threat or occurrence of emergencies.

On the site of planning of work on prevention and response to emergencies is carried out on the basis of expert assessment, the forecast of the consequences of possible emergencies.

The “Action Plan” is developed at the site – a motivated decision of the head (the head of the object’s CD) to organize and implement the civil defense of the facility. The main objective of the “Action Plan” is to preserve people’s lives and health, minimize material losses. The “Action Plan” consists of five sections.

In the first section, assess (analyse) the natural (topographic), technogenic and ecological state of the terrain (territory) where the facility is located, the presence of potentially dangerous objects and the possible nature of emergency situations.

The second section is devoted to assessing (analysing) the object of the CD, taking into account its location on the ground, assessing the factors that will facilitate or impede the organization and management of the object’s CB, searching for ways to prevent or reduce the impact of negative factors.

In the third chapter, apart from the decisions of the manager on the organization and management of the object’s CD during the period of prevention or response to emergencies, they separately note how to react to possible emergencies related to potentially hazardous objects, organize surveillance, radiation, chemical, medical protection and evacuation.

The fourth section is devoted to the material and technical support of the CD (anti-radiation, anti-chemical, medical, fire-fighting, transport, material, etc.).

The fifth section contains activities for the organization of management, communication, notification and interaction.

The Action Plan is added:

- management, communication, alert and interaction scheme;
- plan for the evacuation of workers and employees of the facility in the suburban area;
- plan-calendar of actions in the modes of activity (daily, high alert, NA);
- a map (scheme) of the region with the designated location of the facility, the zone of possible danger with the necessary calculations;

- personal plans of actions of the management of the facility, commanders of formations and the like.

The civil defense plan for the facility is a “plan of action” for the response plan (if it is developed separately) and applications that ensure an organized and clear implementation of the activities of the TOR for prevention and response to emergencies.

3.1.5. International cooperation in the field of civil defense

International cooperation in the field of civil defense consists of the following components:

- assistance to foreign states for the elimination of the consequences of emergencies, which is carried out on the basis of a request for assistance to deal with the consequences of the emergency situation from an authorized body of a foreign state, suffers; the decision to provide assistance and the direction of rescue units outside the territory of Ukraine, is taken by the Cabinet of Ministers of Ukraine;
- if the request for assistance in eliminating the consequences of the disaster comes from the administrative territorial unit of the neighboring foreign state, the right to take decisions on sending units of the rescue service and special equipment to provide assistance is provided to the head of the central executive authority that ensures the formation and implementation of public policy in the sphere of CD;
- the receipt of assistance by Ukraine for the liquidation of emergencies is carried out on the basis of a request, the decision on which direction is taken by the Cabinet of Ministers of Ukraine, on the receipt of such assistance or assistance offered by foreign states and international organizations;
- in the event of an emergency on the territory of the border area of Ukraine, in the liquidation of the consequences of which it is advisable to involve the rescue and rescue forces of the adjacent administrative territorial unit of the foreign state, the right to request the authorized body of the administrative territorial unit of the neighboring foreign state to receive assistance to eliminate the consequences of such The NA is given to the head

of the central executive authority, which ensures the formation and implementation the state policy in the sphere of civil defense;

- the representation of Ukraine in international organizations on the issues of the Central Organ is carried out by the central executive authority that ensures the formation and implementation of the state employment policy, other central executive bodies that exercise state supervision in the field of technogenic and fire safety, the implementation of state policy in the areas of industrial safety, labour protection and state mining supervision, the management of the exclusion zone and the mandatory exclusion zone.

3.2. Emergency situations and their consequences

3.2.1. Criteria for the transition of a dangerous event in an emergency situation

Emergency situation (ES) – situation in a separate territory or business entity on it or a water body that is characterized by a violation of normal living conditions caused by a disaster, accident, fire, natural disaster, epidemic, epizootic, use of weapons or other dangerous event , which led (may lead) to the emergence of a threat to the life or health of the population, a large number of deaths and injuries, the significant material damage, as well as to impossibility of living of the population in such territory or object, conducting economic activities on it.

The main causes of emergencies in Ukraine:

- emergency technogenic load of the territory;
- significant moral and physical depreciation of fixed assetsthe majority of Ukrainian enterprises;
- deterioration of material and technical support, reduction of productionand technological discipline;
- unsatisfactory state of preservation, disposal and burialhighly toxic, radioactive and domestic waste;
- ignoring economic factors, requirements, standards;
- inadequate attention of heads of relevant government bodiesto the

implementation of a set of measures aimed at preventingsituations of natural and technogenic nature and reduction of their consequences;

- the lack of modern control systems for hazardous processes;
- low vocational training of personnel and population for actions inextreme conditions;
- shortage of qualified personnel;
- low level of application of progressive resource-saving andecologically safe technologies.

A dangerous event is an event, including a catastrophe, an accident, a fire, a natural disaster, an epidemic, an epizootic, which in its consequences poses a threat to the life or health of the population or leads to material damage.

The classification symptom of ES is a technical or other characteristic of a dangerous event, which causes the emergence of an environment that is defined as an emergency situation;

The threshold value of the classification feature of the ES is defined in the established manner as the value of a technical or other characteristic of a specific emergency situation, the excess of which places the situation in the rank of emergency and requires an appropriate level of response.

An emergency zone is a separate area, the water area where an emergency situation occurred.

The accident is a dangerous event of a technogenic nature, resulting in injuries, traumas of the population or creates a threat to the life or health of the population in a particular territory or territory of the enterprise and leads to the destruction of buildings, structures, equipment and vehicles, the disruption of the production or transport process or entails excessive, accidental releases of polluting substances and other harmful effects on the environment.

A catastrophe is a large-scale accident or other event that leads to severe consequences.

The classification of emergencies has been introduced in Ukraine with the aim of ensuring the organizational interaction of central and local executive authorities, enterprises, institutions and organizations in the process of resolving issues related to emergencies, the elimination of their consequences and the conduct of state statistics.

Classification is carried out on the basis of the "Procedure for the classification of emergencies of anthropogenic and natural character according to their levels" [56], the State Classifier of Emergencies DK 019-2010 [57] and The Order of the Ministry of Emergencies of Ukraine dated 6, August 2018, No. 658 "On Approval of Classification Characteristics emergency situations" [58].

Depending on the reasons for the origin of the events that have caused or can cause the emergence of emergencies on the territory of Ukraine, distinguish between emergency situations of anthropogenic, natural, social and military nature, and depending on the volume of the consequences, technical and material resources, emergency situations necessary for their elimination are classified as state, regional, local and object level.

Figure 3.1 shows schematically the algorithm for classifying an emergency.

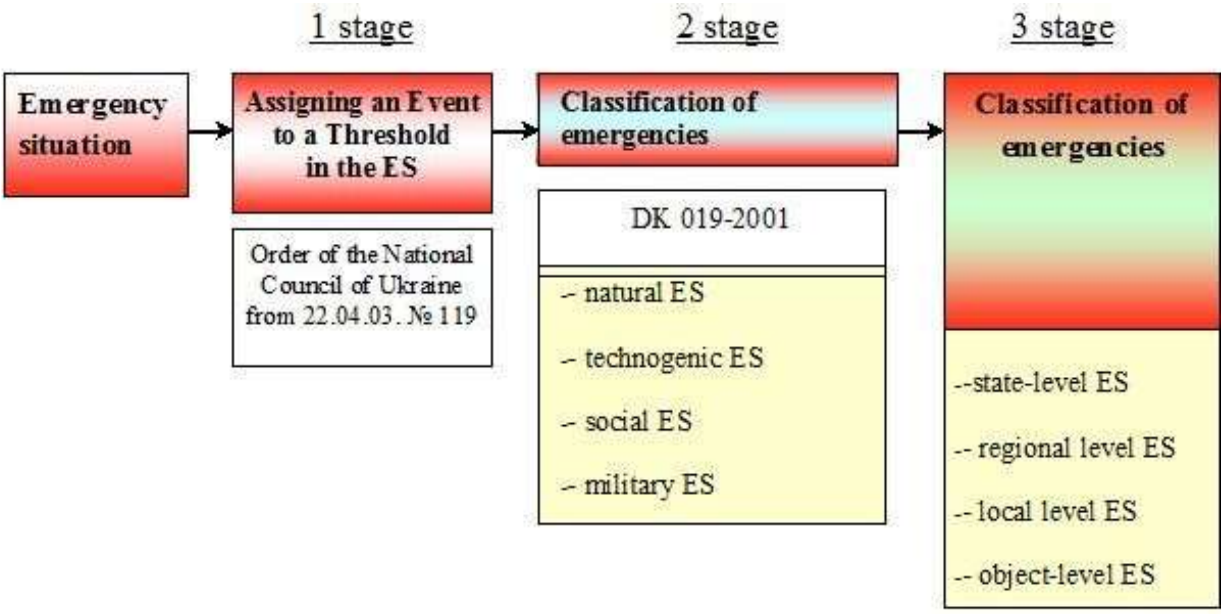


Fig. 3.1. Algorithm for the classification of emergencies

It consists of three stages:

- assignment of an event with a threshold value in the ES;
- classification of emergencies by origin;
- classification of emergencies by level.

This takes into account the nature of the origin of the emergency situation, the degree of spread of its dangerous factors and the amount of human losses and material damage.

1st stage. Recognition of an emergency in an emergency.

To assign an emergency in an emergency situation, it is necessary to compare the number of dead people, the extent of pollution of the environment and other consequences with the threshold values of the indicators of emergency signs. If the actual threshold is exceeded, an emergency is considered an emergency.

If to schematically consider the totality of all emergency events in the form of a triangle, then emergency situations will occupy the upper part, as shown in Fig. 3.2. The threshold for the transition of an dangerous event in an emergency situation will be the threshold value of the indicator signs of ES.

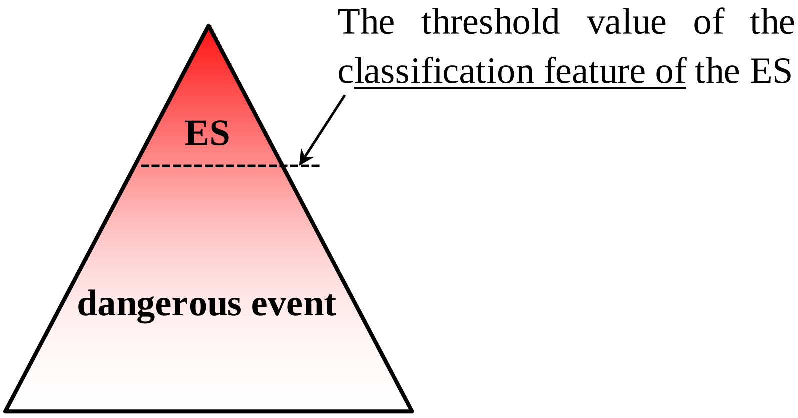


Fig. 3.2. Scheme transition to an dangerous event of an emergency.

It should be emphasized that the objects of classification can only be emergency situations. By definition, in an emergency situation, a violation of the normal living conditions and activities of people at the site or territory caused by an accident, a catastrophe, a natural disaster, an epidemic, an epizooty, epiphytoty, a large fire, the use of a means of destruction or other dangerous event that led (may lead) to loss of life and significant material losses.

2 nd stage. Classification of emergencies by origin.

If incidents in the first stage are attributed to an emergency situation, then depending on the cause of origin, it is classified using the State Classifier of Emergencies DK 019-2010. It should be noted that the objects of classification can only be emergency situations, which are divided into emergency situations of anthropogenic, natural, social and military nature.

The third stage. Classification of emergencies by levels.

Criteria – people were killed, people were harmed and conditions of vital activity of the population violated for a period exceeding 3 days are necessarily considered taking into account losses.

Emergencies, based on the classification of emergencies of anthropogenic and natural character according to their levels, approved by the Cabinet of Ministers of Ukraine of March 24, 2004, No. 368 [56], are classified as state, regional, local or facility emergency situations. Criteria for determining the level of emergency are territorial distribution, the amount of technical and material resources that are necessary to eliminate its consequences, the number of people affected or the violation of their living conditions and the amount of losses caused (expected) (Table 3.3).

It should be noted that an emergency situation refers to a certain level, provided that it meets at least one of the values of the given criteria.

In addition, it must be taken into account that when, as a result of an emergency, the volume of losses does not reach the established thresholds for the corresponding thresholds for the levels of human losses or the number of people affected or the violation of normal living conditions, the level of the emergency is taken to a lesser degree, transport incidents – two steps less.

The assignment of an emergency situation that has arisen on the territory of several administrative-territorial units to the state (regional) level for territorial distribution or the summary indicators of its consequences can not be grounds for assigning an emergency situation to the state (regional) level separately for each of these administrative territorial units.

Table. 3.3. Criteria for determining the level of emergency

CD level		Died	Victims	Violated the living conditions of the population more 3 days, person	Losses, fixed-income
	1	2	3	4	5
A	**state**	> 10	> 300	> 50 th.	> 150 th.
B	With losses	> 5	> 100	> 10 th.	> 25 th.
C	Territory	ES spread or may spread to the territory of other states			
D		ES spread to the territory of 2 regions, and for its liquidation, resources are needed in amounts exceeding the capabilities of these regions, but not less than 1 % of the expenditures of their budgets			
E	Regional	> 5	> 100	> 10 th.	> 15 th.
F	With losses	3 – 5	50 – 100	1 th. – 10 th.	> 5 th.
G	Territory	The ES has spread to the territory of 2 districts, and for its liquidation, resources are needed in amounts exceeding the capabilities of these regions, but not less than 1 % of the expenditures of their budgets			
H	Local	> 2	> 50	> 1 th.	> 2 th.
I	With losses	1 – 2	20 – 50	100 – 1 th.	> 0,5 th.
J	Territory	ES spread beyond the PHF territory, threatens the environment, populated areas, facilities, and for its liquidation, resources in quantities exceeding the capabilities of this facility			
K	Object	Criteria for an emergency situation do not reach these indicators			

3.2.2. Categories of economic activityobject on the level of emergency threat

By the degree of potential danger, which leads to accidents from the global to the object scale, it is possible to single out objects of the nuclear, chemical, metallurgical and mining industry, unique engineering structures (dams, overpasses, oil and gas storages), vehicles carrying dangerous goods and a significant number of people, main gas, oil and product pipelines. This includes dangerous facilities of the defense complex.

All economic entities whose activities are in one way or another connected with dangerous substances, biological preparations, a high probability of fires, explosions, etc., as well as other objects that under certain circumstances can create a real threat of accidents, are potentially hazardous objects or objects of increased danger.

A potentially hazardous facility (PHF) is an object where dangerous substances, biological preparations and other objects can be used, manufactured, processed, stored or transported, which under certain circumstances can create a real threat of accidents.

An object of increased danger (OID) is an object in the use of which there are dangerous substances or categories of substances in an amount equal to or exceeding the normatively established threshold masses.

In order to assess the degree of risk from the implementation of economic activity, the criteria for the distribution of business entities according to the degree of risk of their economic activities for the safety of life and health of the population and the environment are established.

3.3. Emergencies of anthropogenic nature

3.3.1. Industrial accidents, catastrophes and their consequences

The accident is a dangerous event of anthropogenic nature that creates a threat to the life and health of people at the site, territory or water area and leads to the destruction of buildings, structures, equipment and vehicles, the disruption of the production process or harms the environment.

Accidents caused by the violation of the operation of technical facilities, began to acquire a catastrophic character in scale, already in the 1920s.

The main causes of accidents in Ukraine:

- emergency technogenic load of the territory;
- low level of application of progressive resource-saving and environmentally safe technologies;
- unsatisfactory state of preservation, utilization and disposal of highly toxic and radioactive waste;

- significant deterioration of the main production assets of most enterprises;
- violation of the requirements of the technological process and safety rules;
- imperfection of modern systems of dangerous processes management;
- low professional training of personnel for actions in extreme conditions.

Accidents fall into two categories:

- Category I includes accidents, as a result of which: 5 or injured 10 or more people died; there was an emission of toxic, radioactive, dangerous substances in the sanitary-protective zone of the enterprise; the concentration of pollutants in the environment has increased by more than 10 times; destroyed buildings, structures or basic structures of the facility, which created a threat to the life and health of employees of the enterprise or population;
- Category II includes accidents, which resulted in: death to 5 or injured from 4 to 10 people; destroyed buildings, structures or basic structures of the facility, which posed a threat to the life and health of workers in the workshop or plot (a workshop, a section with 100 or more employees) is taken into account.

Cases of violation of technological processes, equipment operation, temporary shutdown of production as a result of triggering of automatic safety interlocks and other local disruptions in the work of workshops, sections and individual objects, drop of supports and breakage of power transmission lines do not belong to accidents having categories.

According to the size and the harm caused, light, medium, heavy and especially severe accidents are distinguished. Especially severe accidents lead to great destruction and are accompanied, by great sacrifices. The analysis of the consequences of accidents, the nature of their impact on the environment has led to their distribution by species.

A catastrophe is a large-scale accident that leads to severe consequences for humans, flora and fauna, changing the conditions of the habitat. Global catastrophes cover entire continents and their development threatens the existence of the entire biosphere.

Losses from accidents can be direct and indirect. They are distributed according to the ratio 70:30.

The direct losses include:

- damage and destruction of residential and industrial buildings, railways and roads, power lines and communications, land reclamation systems and others;
- death of livestock and crop of crops, destruction and damage of raw materials, fuel, food, feed, fertilizers and others;
- expenses for evacuation of the population and material values to safe places;
- removal from use of a fertile layer of soils, water resources.

Indirect losses include:

- the cost of purchasing and delivering food, construction materials, and animal feed to the affected areas;
- reduction in output and slowdown in the development of the national economy;
- deterioration of living conditions of the population;
- impossibility of rational use of the territory;
- increase in depreciation expenses for maintenance of buildings in normal condition, in case of their possible further use.

The impact of accidents sometimes transcends state boundaries and covers entire regions. The unfavorable ecological situation caused by these accidents can last from several days to many years. Elimination of the consequences of such accidents requires large funds and the involvement of many specialists.

3.3.2. A special period. Martial law. Rights and duties of citizens

Defense of Ukraine is a system of political, economic, social, military, scientific, scientific, technical, information, legal, organizational and other measures of the state for the preparation for armed defense and its protection in case of armed aggression or armed conflict.

Armed aggression is the use by another state or group of states of armed force against Ukraine.

Armed aggression against Ukraine is considered to be any of the following:

- the invasion or attack of the armed forces of another state or group of states on the territory of Ukraine, as well as the occupation or annexation of part of the territory of Ukraine;
- blockade of ports, coast or airspace, violation of communications of Ukraine by the armed forces of another state or group of states;
- an attack by the armed forces of another state or group of states on military land, sea or air forces or civil naval or air fleets of Ukraine;
- the sending by another state or on behalf of armed groups of regular or irregular forces committing acts of using armed force against Ukraine, including the significant participation of a third state in such actions;
- the use of units of the armed forces of another state or group of states that are on the territory of Ukraine in accordance with international treaties concluded with Ukraine, against a third state or group of states, other violation of the conditions provided for by such treaties, or extension of the stay of these units on the territory of Ukraine after termination actions of the said contracts.

A special period is the period that begins after the announcement of the mobilization decision (except for the target), or bringing it to the performers with regard to covert mobilization, or from the moment of martial law introduction in Ukraine or in its separate areas, and covers the time of mobilization, wartime and partially a recovery period after the end of hostilities (Section I of the 1st Law of Ukraine "On the Defense of Ukraine"). In Ukraine, a special period began on March 17, 2014, when the Decree of the President of March 17, 2014 was published. № 303/2014 "On partial mobilization" and continues to this day.

The legal basis for the introduction of martial law is the Constitution of Ukraine, the Law of Ukraine "On the Legal Regime of Martial Law" dated May 12, 2015, No. 389-VIII [59].

Martial law is a special legal regime introduced in Ukraine or in its separate areas in case of armed aggression or threat of attack, the danger of Ukraine's state independence and its territorial integrity.

In the sphere of civil defense (CD) during the war time:

- the procedure for using protective structures of the CD is established;
- evacuation of the population is carried out if there is a threat to its life or health, as well as material and cultural values, if there is a threat of their damage or destruction, in accordance with the list approved by the Cabinet of Ministers of Ukraine;
- if it is necessary, there are standardized provision of the population with basic food and non-food products, medical products are introduced.

Since the announcement of the war or the actual beginning of hostilities has been accepted, **war time** comes to an end, ending in the day and time of the war end.

3.4. Protection of the population and territories from emergency situations

3.4.1. Basic principles and methods of defend people and territories from emergency situations

The complex of preparatory protective measures for the Defense of the population and territories in the event of the threat and occurrence of the ES is the same for both peaceful and military purposes, since it takes into account the combination of the influence of the striking factors of all the ES and the possible aggressor's use of modern means of destruction.

The principles of population defense and territories from the ES provide the most effective solution to the problem, named:

- priority of tasks aimed at protecting people, preserving their health, and protecting the environment;
- mandatory early planning and implementation of measures to protect the population and territories taking into account economic, natural and other peculiarities of the region, as well as the probability of the emergence;

- complex use of methods and means of defense and choice of the most rational;
- free access of the population to information on defense from the ES;
- personal responsibility of the CD authorities and the care of citizens about their own safety, strict observance of their rules of conduct and actions in the ES.

The main ways of defend the population and territories from the affecting factors of the emerging peace and war memoranda are as follows:

- alerting and informing the population;
- use of personal protective equipment;
- shelter of people in protective structures of civil defense;
- implementation of evacuation measures;
- medical and psychological defense of people,
- ensuring sanitary and epidemiological well-being;
- biological defense of people, animals and plants;
- engineering defense of territories;
- radiation and chemical defense of population and territories.

3.4.2. Notification and information in the field of the Civil Defense

Notification of a threat or emergence of an emergency is to promptly bring such information to the civil defense authorities, civil defense forces, business entities and the public.

Notification is provided by:

- operation of national, territorial, local automated systems of centralized alert, as well as special, local and object notification systems;
- centralized use of telecommunication networks of general use, networks of national, regional and local broadcasting and television and other technical means of transmitting (displaying) information;
- automation of the process of transmission of signals and messages;
- operation of high-risk objects of automated systems for early detection of emergencies and alerts;

- organizational and technical integration of various systems of centralized alert about the threat or emergence of emergencies and automated systems for early detection of emergencies and alerts;
- operation of signal-loudspeaker devices and electronic information boards for the transfer of information on civil defense issues.

The installation of signal-loudspeaker devices and electronic information boards and their location rests on local self-government bodies and business entities.

The CD management are obliged to provide prompt and reliable information about the ES that are projected or arisen, with the definition of their classification, the limits of distribution and consequences and methods of defense against them, as well as their activities on civil defense, in that number available for people with visual and hearing impairment.

Information should be provided to the population through the mass media (press, radio, television, etc.) and through the issuance of special booklets, leaflets, leaflets by central and local executive authorities and executive bodies of the councils.

The information should include: the identity of the subject providing and its field of activity, the nature of the potential risk in the event of an accident, including the impact on people and the environment, how to inform the public in the event of a threat or accident and the behaviour which should be respected.

Information in the field of defense from the ES, the activities of central and local executive bodies, and executive bodies of the councils in this area should be public and free.

The system of notification is a complex of organizational and technical measures, equipment and technical means of notification and communication channels, intended for the timely delivery of signals and information on emergencies of man-made and natural disasters to central and local executive authorities, enterprises, institutions, organizations and population.

In accordance with the "Regulations on the organization of alert and communication in emergencies" [60], **the notification system in our country**

consists of: national, regional and special centralized alert systems, communicative alert systems, circular calling systems.

The automated alert system can provide alerting the population by connecting the local telephone network and the mobile communication network to the signal “Attention to all” and full information with the help of broadcasting and television.

This signal can be duplicated with the help of a local radio transmitting unit, hubs of enterprises, a siren of transport, bumps in rails, bells. He informs the population about the ES in peacetime and in the event of a threat of enemy attack during wartime.

Long beeps mean warning

When you hear the beep, you need to turn on the radio, TV and listen to the information about the necessary actions. If there is no radio or TV or they are not working, you should find out information from other people who know about it. After receiving the information, you must follow all the instructions of the text of the signal information.

3.4.3. Means of individual and collective defense

Use of personal protective equipment

This method consists in the **timely** use of special individual means that provide defense of the respiratory system, the skin, increases the protective properties of the body from the effect of SDOR, PP and bacteriological agents (BP).

For complete and effective defense, the following conditions must be:

- provide the population in advance with means of individual defense;
- provide in a timely manner to people defense means (in case of emergence of ES);
- inform the population in a timely manner about the dangers and keep it informed of the state of the radioactive, chemical and biological conditions.

Use of collective defense facilities

*Protective structures*are intended to protect people from the consequences of accidents (disasters) and natural disasters, as well as from the damaging factors of weapons of mass destruction and conventional means of attack, the influence of secondary striking facts of a nuclear explosion.

Protective structures are divided into:

- by appointment: for the defense of the population; for placement of management organs and medical institutions.
- by location: embedded; stand alone; subways; mining works.
- in capacity: small (150–600 people); average (600–2000 people); large (more than 2000 people).

Protective structures of civil defense include:

A storage facility is sealed buildings for the defense of people in which, during a certain period of time, conditions are created and can exclude the influence of dangerous factors that arise as a result of an emergency, military (military) actions and terrorist acts.

The storage consists of main and auxiliary premises. The main are premises for people, control points, medical points.

The auxiliary ones include: filter ventilation rooms, sanitary units, protected diesel power stations, food storage facilities, tambour-locks, tambours, power screens, pumping stations, cylinders, dissymmetric control rooms, lockers, mud rooms, and showers. The storage facility is provided by electricity from the external power grid, and if necessary from an autonomous source, a protected diesel power plant. Emergency lighting from portable electric lights, batteries, accumulators and other sources is provided in case of disturbance of electricity supply in shelters.

The repository has a telephone connection with the control point of the object and the radio, connected to the district or local object radio broadcasting network. Water supply and drainage of storage facilities are carried out from general water supply and sewer networks. In addition, storage facilities provide for emergency water supplies.

Pipes of engineering networks inside the repository are painted in the appropriate color: white – air intake pipes of the regime of clean ventilation; yellow – air intake pipes of the filter ventilation mode; red – pipes of the ventilation regime during the fire (to the heat-generating filter); black –

electric wiring pipes; green – plumbing pipes; brown – pipes of the heating system. In all the pipes (except for wiring pipes), in the places where they are inserted, the direction of movement of air or water is indicated by arrows.

Protective properties of the storage facility are characterized by the limiting values of the excess pressure of the shock wave, which maintains the structure.

Coverage in the repositories is subject to:

- workers of the largest working change of economic entities, which are related to the corresponding categories of civil defense and located in zones of possible significant destruction of settlements, which continue their activities in a special period;
- personnel of nuclear power plants, other nuclear facilities and employees of economic entities that provide the operation of such plants (installations);
- the workers of the largest working change of economic entities that are classified as of special importance to the Central and outside of the zones of possible significant destruction of settlements, as well as employees of the next personnel of the business entities that provide the vital functions of the cities belonging to the relevant groups of civil defense;
- patients, medical and service personnel of health facilities that are not subject to evacuation or cannot be evacuated to a safe place.

Fall out shelter(FOS) is non-leak proof constructions for protecting people in which conditions are created that exclude the effect of ionizing radiation on them in the event of radioactive contamination of the area.

FOS are equipped primarily in basement floors of buildings and structures: it is here that the coefficient of defense has the maximum value for the whole structure. So, basements of 2–3-storied stone buildings reduce the radiation in 200–300 times, the average part of the cellar of a stone building on several floors – in 500–1000 times, cellars in wooden houses – 7–12 times.

For the FOS used ground floors of buildings and structures can also be used. It is the most suitable for these stone and brick buildings, which have capital walls and small openings. The first floors of multistory stone buildings reduce radiation by 5–7 times, while the upper ones (with the exception of the latter) are 50 times smaller. Pre-built FOS are not limited by capacity, the minimum capacity is justified – 5 people.

The SPF includes the main and auxiliary premises. The main ones include premises for people, to the auxiliary – sanitary knots, ventilation chambers, vestibules, rooms for storing contaminated outerwear, etc.

Coverage in the SPE is subject to:

- employees classified in the first and second categories of CD and located outside the zones of possible significant destruction of settlements that continue their activity in wartime;
- workers of economic entities, located in areas of possible destruction, dangerous and significant radioactive contamination around nuclear power plants;
- population of cities not included in the civil defense groups and other settlements, as well as the population evacuated from cities related to civil defense groups and areas of possible significant destruction;
- sick, medical and service personnel of health facilities situated outside the zones of possible significant destruction of cities belonging to civil defense groups and economic entities that fall under the categories of civil defense, as well as health facilities, which continue their activity in wartime.

Thequick-mounting protective civil defense facility is a protective structure built up of special structures in a short time to protect people from the effects of damage during a special period.

As well as built up in advance, it should have rooms for people, places for placing the simplest industrial equipment, bathrooms, emergency water supply, inputs and outputs, emergency exit.

Durable buildings and elemental shelters are also used to protect people from some of the hazards of emergencies resulting from emergency situations in peacetime and to the actions of means of destruction during a special period.

A dual purpose building is a ground or underground structure that can be used for the main functional purpose and for the defense of the population.

The simplest shelter is a fortification building, or basement, which reduces the combined damage of people from the dangerous consequences of emergencies, as well as the effects of the means of destruction in a special period.

In quick-mounting protective civil defense structures, the simplest shelters and dual-use buildings, there is an inclination – urban populations that belong to groups of civil defense that are not subject to evacuation to a safe place, as well as other settlements.

Protective structures in peacetime can be leased to meet economic, cultural and domestic needs, with the preservation of the intended use of such buildings, except those permanently ready for intended use, namely:

- in which control points are located;
- intended for shelter of employees of economic entities having high-risk objects;
- located in the areas of observation of nuclear power plants and intended to shelter the population during radiation accidents.

The control over the readiness of the protective structures of civil defense to its intended use is provided by the central executive body, which carries out state supervision in the spheres of man-made and fire safety, together with the relevant bodies and units of civil defense, by local state administrations.

3.4.4. Evacuation measures

Measures to evacuate the population are in advance (before the emergence of the NA, during the threat) the removal of the population from places of possible damage, catastrophic areas flooding (infection) into safe areas for temporary or permanent residence.

In conditions of incomplete provision of protective structures in cities and other settlements with high-risk objects, as well as in the event of war, evacuation is the main way of protecting the population, planning and preparing it in advance.

Evacuation is carried out at the state, regional, local or objects level.

Obligatory evacuation of the population is carried out in the event of a threat:

- accidents with the release of radioactive and potent toxic substances;
- catastrophic flooding of the area;
- massive forest and peat fires, earthquakes, landslides, other geological and hydro geological phenomena and processes;
- armed conflicts (from areas of possible military actions in safe areas, which are determined by the Ministry of Defense of Ukraine for a special period).

General evacuation is carried out by:

- in a special period by the decision of the Cabinet of Ministers of Ukraine;
- in the event of a threat to the population living in the zone of emergence of the ES military nature;
- in the case of possible radioactive contamination of territories around nuclear power plants;
- in the case of a threat of catastrophic flooding of the area with a four-hour run-off wave of breakthroughs, forest and peat fires, and other phenomena with severe consequences.

Partial evacuation of the population is carried out on the territory in case of occurrence or threat of emergence of the ES.

In the course of general or partial evacuation, first of all, people who are unemployed in the sphere of production and service of the population are taken out: small children, schoolchildren, students, orphanage pupils, together with teachers and educators, pensioners and invalids from homes for the elderly, along with service staff and their family members. .

Decisions on evacuation are taken:

- at the state level – the Cabinet of Ministers of Ukraine;
- at the regional level – regional and Kyiv city state administrations;
- at the local level – district, districtin the city of Kyiv state administrations, relevant local authorities;
- at the object level – managers of objects of economic activity.

In case of radiation accidents, the decision on evacuation of the population that may be in the zone of radioactive contamination is taken by local state administrations on the basis of the conclusion of the sanitary and epidemiological service in accordance with the projected dose load on the population or information of the entities operating the nuclear facilities, about cases of violations in their work.

The evacuation is provided by:

- formation of regional, local and object bodies for evacuation;
- evacuation planning;
- definition of safe areas suitable for accommodating evacuated population and property;
- organization of the announcement of the heads of business entities and the population about the beginning of the evacuation;
- organization of evacuation management;
- life support of the evacuated population in places of their safe placement;
- training the population in actions during evacuation.

By the decision of the relevant bodies for the removal or removal of the main part of the population from the zone of emergency, areas of possible military action involved in the procedure prescribed by law, vehicles of business entities, and in the case of direct threat to the life or health of the population – all available vehicles business entities and citizens.

Evacuation of material and cultural values is carried out in the event of a threat or emergence of emergencies that could cause them harm, in the presence of time to conduct it.

Depending on the prevailing conditions, evacuation is carried out within a separate region from the territory that may be affected by the NN of man-made or natural nature, or from cities and industrial districts – in the event of a threat of war. Moving a large number of people in a short space of time in difficult conditions and at considerable distances requires organizing and controlling the process at all its stages for the timely conduct and prevention of panic and preventing death of people.

Country zone is area outside the zone of possible weak destruction, outside the areas of possible chemical, radioactive contamination, catastrophic flooding.

The population from the zone of possible weak destruction is not evacuated, because the population density is small and there is a possibility to protect people in their places of residence.

The population subject to evacuation is divided into two categories.

The first category includes employees and employees who will work during the war at enterprises and establishments whose products are needed for defense, as well as employees of municipal enterprises of the city. Protecting people from the change that is working is provided in the repositories on the objects. Defense of family members and people from other changes is provided in the country zone. For this category of people, evacuation measures are called **dispersal of employeesand employees** acting on the principle: to live outside the city, to work in the city. Therefore, for them, the areas of placement appoint closer to the city, along with transport highways, taking into account that the time for travel to work and back to the suburban area did not exceed 4–5 hours.

Evacuation is called the export or removal from the city in the suburban zone of the second category of the population.

The second category of the population includes workers and employees of facilities that cease to work during the war or transfer it to a suburban area, and are not employed in the sphere of production and service of the population. The evacuated population lives in a suburban area to a special disposal.

Distribution and evacuation may be carried out in the following ways:

– transportation of the population;

– walking out;

– combined.

In the combined mode of transport, workers are taken out of functioning facilities, the formation of the central nervous system, the disabled, the sick, women with children under 10 years.

After dispersal and evacuation in cities there is only a change that works.

Distribution and evacuation of workers, employees, members of their families are planned and organized according to the territorial principle of production, that is, workers are subject to economic activity, and the population, which has no relation to production, – by place of residence, through housing and operating organizations.

The evacuees, the employees and employees of the operating enterprises are hunted in the country zone on the living space of local residents, in clubs adapted for living in service and industrial buildings, recreation homes, boarding houses, villages,

For direct control of the preparation and conduct of evacuation measures, evacuation bodies are created, which include: urban, district and object **evacuation commissions (EC);Collective evacuation points (CEP);** in the suburban area – **evacuation receptacles (ER), reception evacuation points (REP) and intermediate evacuation points (IEP).**

Evacuation commissions carries out planning, preparation, organization and management of evacuation measures.

Collective evacuation points are designed to organize the collection, registration, registration and dispatch of urban population in the suburban area. They are hunted near stations, harbors, landing points for transport. Approximate composition of CEP: leader, his deputy, groups – notification, registration and accounting, defense of public order, commandant and duty officers, heads of echelons (columns). At the evacuation point, a medical point, a mother's and a baby’s room and a desk are organized. Pre-defined objects and a part of the population are attributed to the CEP.

Reception evacuation points are created for reception and resettlement in the suburban area of the urban population. They are located near stations, departures of the population. The approximate composition of the PE administration is the same as that of CEP.

Intermediate evacuation points are arranged for reception and temporary accommodation of the population, evacuated from the city on foot, and then forwarded by its transport to the places of resettlement.

The population evacuated on foot is divided into columns of 500–1000 people, and the columns – for groups of 30–50 people. Heads of objects appoint the chiefs of the columns and the main ones in the groups. Columns move on foot, roads, unmanned cars, and other routes. On the pedestrian route appoint the chief of the route with the control group, communication facilities (1–2 radio stations, 2–3 motorcycles, 1–2 cars), representatives of the service of public order defense, medical service formations. The movement of pedestrian columns is planned, as a rule, at a distance of one day's transition to the IEP (35–40 km). From IEP to REP and further to the locations of the population, they are transported by the transport of rural areas (for small distances the population can walk on foot).

Speed of foot column of 4–5 km/h, the distance between the columns – 500 m. For the rest of people every couple of hours prescribed small halts for 10–15 minutes, and early in the second half of the daily transition – a big camp 1–2 hours. Places of hiding, especially large ones are chosen taking into account the protective properties of the area, availability of water sources, medical points. To control the movement of the columns, assign a point of departure (usually outside the city to regulate the start of the movement) and control points on the route. Each column through these points must pass at the time set for it. On the routes, medical items are created, and in hot weather in the harbor places and on the IEP, there are heating points.

After receiving notification of holding evacuation measures, leaders of RCD facilities management together with the recovery fees, CH alert workers, employees, their family members on arrival in CEP.

Under the guidance of evacuation (evacuation) commissions, areas are deployed by the CEP, IEP, and REP and lead them to readiness. Heads of transport result in readiness stations, stations and wharf landing and disembarkation of people, vehicles, trains and convoys form (20–30 cars) and organized the export of the population according to the schedule of trains, convoys.

Receiving alerts on evacuation, citizens must collect the necessary things: personal protective equipment, food for 2–3 days, supply of drinking water, first aid kit, money, documents (passport, diploma, military ticket, work book, pension certificate, marriage certificate and the birth of children), prepare for the evacuation of children of preschool age. In the apartment you need to remove the curtains and curtains from the windows, to hide flammable things. Before entering the CEP, turn off the gas, electric devices; close all the doors, doors. In due time, arrive at the CEP, in the future to clearly follow the instructions of the evacuation authorities, to adhere to discipline.

When arriving by city transport on the CEP, the population is registered, distributed on trains (autoclaves, vessels), at the foot of the column. Upon arrival at the station (point) landings, the population registers to the REP and resettled on the instruction of the administration of this item. It is not allowed to leave the place automatically. Local authorities, business leaders take measures to employ the urban population and provide life support for evacuees.

The implementation of evacuation measures requires comprehensive provision, which includes: radiation, chemical and medical defense, material, technical, and transport and public order defense, organized by the Central Office under the direction of the head of the facility.

Medical defense for evacuation events is organized at all stages of dispersal and evacuation of the population. At CEP, REP, PEE create medical items consisting of two or three health care workers, one or two parts of the sanitary wives, and, if necessary, a doctor. They are obliged to provide urgent medical care to patients, to detect and isolate infectious patients with the subsequent evacuation of them into medical institutions.

In order to maintain public order at sites, CEP, REP, PPE, stations (landing places, points) landing and landing, in places of resettlement in a suburban zone establish public security guard posts, organize patrols. The implementation of these measures involves the formation of public order defense (teams, groups), which are created at the expense of departmental paramilitary and guardianship and voluntary wives.

3.4.5. Disaster medicine

The medical assistance to the population is provided by the service of disaster medicine, the leadership of which is carried out by the central executive body, which ensures the formation and implementation of state policy in the field of health care.

Anti-epidemic defense of the population

In the territories affected by the accident, disaster, natural disaster, a sharp deterioration of the sanitary and epidemic situation – that is, the state of the environment of life and the condition of this health of the population in the affected area.

Biological defenseof the population, animals and plants includes:

- timely detection of factors and cells of biological contamination, its localization and liquidation;
- prediction of the scale and effects of biological contamination, the development and introduction of timely anti-epidemic, prophylactic, ant epizootic, ant epiphytic and therapeutic measures;
- carrying out emergency non-specific and specific prevention of biological contamination of the population;
- timely application of means of individual and collective defense;
- introduction of restrictive anti-epidemic measures, observation and quarantine;
- implementation of disinfection measures in the area of infection, disinfection of business entities, animals and sanitary processing of the population;
- provision of emergency medical aid to affected biological pathogens.

In a place of emergency, illness can be detected, in the case of a disease, which patients and people who had contact with them, are subject to quarantine isolation; territories, objects of management, installations, units, clothes, personal protective equipment, foodstuffs, etc. can be contaminated and require **disinfection**, and people – **sanitary treatment**.

To determine the type of agent and the boundary of the infection center, conduct biological exploration with the entire network of observation posts, intelligence units, as well as special formations and institutions of the medical service of the Civil defense. If the intelligence confirms the presence of suspects for particularly dangerous diseases, it will set quarantine or observation mode.

Quarantine is a complex of restrictive medical and sanitary and administrative measures aimed at preventing the spread of infectious diseases. It is announced in case of detection of especially dangerous infections: plague, cholera, smallpox and the like.

Only medical and other forms of civil defense that are directly involved in the eradication of the epidemic cell can access the quarantine cell. Personnel of formations in advance make preventive vaccinations against especially dangerous infections, and immediately before entering the cell they carry out emergency prevention.

Exit from the infection site is often prohibited. Industrial products produced by enterprises located in the epidemic cell, are taken out through special transshipment (receiving and transmitting) items only after careful disinfection and further control. Similarly, in the cell are imported industrial raw materials, food products and other vital items.

Regarding the surveillance regime, for the prevention of the spread of infectious diseases, regular medical observation with the timely detection of persons who are ill or suspected of the disease, their isolation and hospitalization are conducted. In addition, they conduct emergency prevention of the entire population in the infection zone, and if necessary – after identifying the nature of the disease and its pathogen – specific prevention.

In Ukraine, the procedure for the implementation of quarantine measures for the elimination of cells of quarantine diseases is regulated by the Rules of sanitary defense of the territory of Ukraine.

Terms of temporary isolation and medical supervision of persons, who have contacted patients or arrived from countries that are unsuccessful in relation to quarantine diseases, correspond to the incubation period (with plague – 6 days, with cholera – 5, with yellow fever – 10). Local authorities are obliged to inform the Ministry of Ukraine Health about each case of plague, cholera or yellow fever, as well as a fatal outcome from them.

It is in these diseases that the quarantine of the epidemic center and the complete set of quarantine measures extend in Ukraine.

The quarantine stops after the expiration of the maximum incubation period of the disease (from the moment the patient is detected and isolated), if during this time there was no new disease in the quarantine team.

Psychological defense of the population

During major natural disasters, catastrophes in humans arise neuron-psychiatric disorders, mental arousal, and obscuration of consciousness. Major natural disasters and catastrophes are accompanied not only by large destructions, injuries, burns, but also panic, confusion, which leads to paralysis of the instinct of self-preservation, which makes people unable to self-defense and assist the victims.

Measures of psychological defense of the population are aimed at reducing and neutralizing negative mental states and reactions among the population in case of threat and emergencies, and include:

- planning activities related to psychological defense;
- timely application of licensed and authorized information, psycho prophylaxis and psycho-correction methods in Ukraine to influence the personality;
- identification by means of psychological methods of factors that contribute to the emergence of socio-psychological tension;
- use of modern psychological technologies to neutralize the negative influence of factors of emergency situations on the population;
- implementation of other measures of psychological defense depending on the situation.

In sanatorium and spa establishments, regardless of the form of ownership, centers of medical and psychological rehabilitation of rescuers and other persons involved in the execution of emergency rescue and other urgent works, the extinguishing of fires are formed.

3.5. Localization of the ES and liquidation of their consequences

3.5.1. Organization of work on emergency response

In order to coordinate actions of state authorities and local self-government bodies, management bodies and civil defense forces, as well as the organized and planned implementation of a set of measures and works on the elimination of the consequences emergencies:

- control points and emergency management centers are used;
- special commissions for the emergency response are formed;
- heads of emergency response work are appointed;
- emergency response headquarters are formed;
- the need for civil defense forces is determined.

Prior to the establishment of a special commission for the elimination of the consequences of emergencies or the appointment of a head of emergency response, the organization of emergency response measures shall be carried out by relevant commissions on technogenic and ecological safety and emergency situations.

General management of the organization and implementation of measures and works on the elimination of the consequences of emergencies, restoration works, depending on the level and nature of the origin of the emergency situation. The Cabinet of Ministers of Ukraine, the Council of Ministers of the Autonomous Republic of Crimea, central executive authorities, local state administrations, local self-government bodies, objects of management in the administrative territory or territory in which an emergency occurred.

3.5.2. Emergency rescue and other urgent work

Rescue and other urgent work (NRC) are carried out in order to save people and provide assistance to victims, eliminate and localize accidents, create conditions for further restoration of the production activity of the object.

Rescue works include the following actions:

- exploration of districts, zones, sites, objects of work on liquidation of consequences of ES; exploration of the routes of the imposition of the formation of the medias of the defeat;

- definition and localization of the zone of an emergency;
- identification and designation of areas that have undergone radioactive, chemical pollution or biological contamination (except areas of combat operations);
- forecasting the zone of possible spread of the emergency situation and the extent of possible consequences;
- liquidation or minimization of the influence of dangerous factors that have arisen as a result of an emergency;
- localization and extinction of fires;
- search and rescue of victims, provision of emergency medical care and transportation to health care facilities;
- air supply to the damaged protective structures;
- the opening of infested protective structures and the salvation of people who are in them;
- removal of people from hazardous areas into safe places;
- evacuation or resettlement of victims;
- detection and disposal of explosive objects;
- sanitary treatment of the population and special treatment of clothing, equipment, protective equipment, buildings, structures and territories that have undergone radioactive, chemical pollution or biological contamination;
- provision of medical care to victims, sanitary and anti-epidemic measures, provision of sanitary and epidemiological well-being of the population in the area of emergence of the ES and places of temporary accommodation of the victims; introduction of restrictive measures, observation and quarantine;
- providing psychological and material assistance to the victims, carrying out their medical and psychological rehabilitation;
- provision of public order in the area of emergency;
- carrying out of the primary repair and restoration of damaged objects of life support of the population, transport and communication;

- implementation of measures for social defense of victims as a result of emergency situations.

Emergency work is carried out in order to ensure the salvation of people and include the following measures:

- localization and extinction of fires;
- creation of passes (passes) in the rubble and in the contaminated area;
- localization and liquidation of accidents on the municipal power and technological networks;
- restoration of broken lines of communication;
- reinforcement or destruction of unstable structures, which threatens the carrying out of rescue work;
- disposal and destruction of found ammunition and other explosive objects.

3.5.3. Life support for victims in the areas of the ES

One of the most important functions of the civil defense bodies in the territories where the emergency occurred is the organization of life support of the population.

In the event of a threat of occurrence ES, provision is made for measures developed by state authorities, central government bodies, administration of enterprises, organizations in advance, as well as in the event of emergencies in order to create conditions for survival of the population, which may be in areas of accidents, natural disasters and lesions of the defeat.

Life support is the provision of a normative minimum of the vital needs of the population who has suffered as a result of an emergency, provision of housing and communal services and the observance of established social guarantees for the period of rescue work.

The main measures of life support are: organization of a food supply base in the area of disaster and temporary resettlement in safe areas during the rescue work; providing the population with clothing, footwear and basic necessities; providing financial assistance to the victim; medical care and sanitary and epidemiological surveillance in areas of temporary accommodation.

Failure to comply with legal requirements of officials of a specially authorized central executive body, whose competence includes the defense of population and territories from emergencies of an industrial and natural nature, entails imposing a fine on officials from 10 to 20 tax-free minimum incomes. The same act committed repeatedly within a year after the imposition of an administrative penalty results in the imposition of a fine on officials from 20 to 50 non-taxable minimum incomes of citizens (Article 18816 of the Code of Ukraine on Administrative Offenses).

3.5.4. Elimination of ES consequences

In order to identify operational preventive and urgent measures for the defense of the population and territories, the detection and assessment of the situation in the vicinity of the ES is carried out by conducting radiation, chemical and bacteriological intelligence.

The nature of the situation in the vicinity of the ES depends on the events that caused the ES: in the case of explosions – the engineering situation, radiation situation occurs during the radiation accident, in the event of an accident on the chemically hazardous object CHO – chemical situation.

The situation is characterized by the size of the zones of infection, the nature and degree of infection. Forecasting the situation can be operational (long-term) and emergency.

Operational forecasting is carried out in advance (before the accident), to determine the possible scale and nature of the infection (destruction), the necessary forces and means to eliminate the consequences of the accident, the preparation of plans for the safety of life in the area of possible ES.

Emergency forecasting is carried out at the time of the accident in order to determine the possible consequences and order of actions, ways of protecting the population in the pollution zone.

The characteristics of the situation are determined in the process of its identification and evaluation.

The detection of the situation – is the definition of the boundaries of areas of infection (destruction, fire) and putting them on a map (plan of the area). The detection of the situation is carried out by two methods: the method of forecasting and the intelligence (in this case, the actual, real situation is revealed).

Assessment of the situation is the definition of the degree of danger for people and the environment, as well as the necessary measures for defense and behaviour in the vicinity of the ES, which exclude or reduce the risk of damage.

Assessing the situation, solve typical problems and form conclusions from the analysis of the consequences and degree of influence of the environment on people's livelihoods and the choice of the optimal variant of action and methods of defense.

The detection and assessment of the situation is the only process, the quintessence of which is the conclusions and proposals on the elimination of the consequences of the actions of all the striking factors in the situation that arose, protecting people and reducing the risk of their loss.

The search and rescue of people from under the rubble, destroyed buildings

Rescue of victims from under the rubble begins with an overview of the rubble, the choice of approaches to them and the definition of ways and means of action.

To rescue the victims, who are in the upper parts of the fallout, carefully disassemble the bang from above.

To save people under the rubble inside the house arrange narrow passages in the very blockade near one of the side walls. Arranging passages, using cavities and cracks formed between the destroyed elements of the building. Throughout the length of the passage reinforced with racks and props.

Rescuing people from semi-destroyed burning houses, carry out fire-fighting formation simultaneously with the extinguishing of fires. These works involve the formation of general purpose and medical formations. For descent people use forced and assault ladders, ropes and rope stairs, automobile telescopic towers and hoists. Helicopters can be used to remove people from the upper floors of buildings that are threatened with fire or destruction.

Rescuing people from sunken storage facilities is carried out in the following sequence: finding repositories among the ruins, establishing links with rescued people, supplying air to a sunken storage facility (if necessary), airing in damaged protective structures, opening a sunken storage facility, providing first medical care victims and evacuate them to the medical unit.

It is possible to find a repository among the ruins according to the plans of placing object's repositories according to local features (landmarks).

You can use radio communication to connect with people in the repository. If this is not possible, communication with people is carried out through air intakes, hatches and interlocks through water supply or heating risers.

If the filter ventilation system is violated, the air intake channels are cleared to air in the storage, or if this is not possible, the hole in the wall or the overlap will be drilled and the air is fed by a portable fan or compressor.

In order to clear the repository, it is necessary to clear the main, emergency or exit and to arrange a hole in an overlap or wall using the means of mechanization: a bulldozer, an escalator, a crane, and a drill hammer.

The provision of the first medical aid to the victim directly in place gives a personal composition of medical formations (sanitary wives). They also evacuate the victims to the delivery points for transport to be sent to a health facility.

The laying of the columnar paths (bypasses) and the installation of the passage in the rubble is carried out when there is no road, it is impossible to use the existing roads, the streets covered in the city. For the arrangement of the column path, all obstacles are eliminated, road surfaces are aligned, and road structures (small size) are reduced, using bulldozers, roadblocks.

Immediately in the foci of lesion on the streets of the city arrange passages and passages in the traffic jams. In areas where the height of the fall does not exceed 1.0 m, the paths are laid, clearing the gates of the bulldozer to the surface of the roadway, and in zones of solid debris, where their height exceeds 1 m, the paths laid on the fall: eliminate large-sized elements (boulders crushed, amethal the beams are cut), then the blockage is flattened by bulldozers.

The width of the road for one-way traffic must be not less than 3–3,5 m. For the drive of opposite cars are equipped through every 150–200 m special platforms. For the two-way traffic there are passes with a width of 6–7 m.

The elimination of accidents on utility networks carries out prepared and equipped with a special tool of emergency technical formation.

In order to eliminate the accident on the water supply networks, it is necessary to find the place of destruction (damage) of the water supply and to unplug this area from the highway. The holes in the pipes of the water risers supply network are hammered with wooden cork or blocked by latches.

If there is a risk of flooding the streets and blurring the roadway, the water is taken to a safe place by means of trays, drainage pipes.

Cracks in the working tubes are eliminated by wrapping the damaged place in the insulating strip in several rows. On top of the strips the pipe is wrapped with sheet metal and pulled by clamps.

Before beginning the liquidation of accidents on gas networks, it is necessary to remove people from the zone contaminated with gas, to surround the infected area, to block the gas pipeline. The destroyed areas of pipes should be closed with wooden cork and clay. If the gas burns, then gradually turning on the shut-off lock, stop the flow of gas to the place of damage. When the flame reaches insignificant sizes, it can be extinguished, pairing the place of release with clay or raw earth.

In the elimination of accidents on power supply networks, first of all, it is necessary to disable the line by unlocking damaged areas of district networks. The damaged lines are unlocked at the substations. After disconnection, first of all, it is restored the least destroyed sources (power plants, equipment) and power lines, connecting broken electric cables.

If the destroyed sewage networks and approaches to the storage are flooded with sewage, they block the pipes, drain the sewage over temporary breaks, and then arrange the pumping of sewage from basements in which the storage facilities are equipped. The broken pipes are dug out, they clog wooden cork or cover with sandbags. If it is impossible to arrange overflow, waste water is taken to lower places along trays and ditches and surrounded by an earth shaft.

Fixing or destroying unstable constructions of buildings threatening to collapse is carried out in the following way:

- structures and walls of small houses in height up to 6 m strengthen with simple wooden or metal slopes;
- houses in height 12 m or more are reinforced with double wooden slopes or slopes of metal beams.

Unstable buildings that threaten the collapse are destroyed in the event that they can not be strengthened with the help of a winch and a cable or cable and tractor. The cable is fixed to the top of the wall, it is tensioned, gradually increasing the tension to the destruction of the wall.

In the center of radiation contamination

In radiation accidents, radionuclides rise to the atmosphere and are transferred in the form of aerosols at a considerable distance, forming a zone of radioactive contamination on the ground. The degree of radiation hazard for the population is determined by the number and composition of radionuclides, the distance from the accident to the locality, meteorological conditions, sometimes year.

During the elimination of the effects of radiation contamination, the following measures are taken:

- alerting the population about the accident and its constant informing about the current situation and procedures in these conditions;
- use of collective and individual defense means;
- organization of dosimetric control;
- carrying out iodine prophylaxis of the population in the zone of radioactive contamination;
- introduction of limited population stays in the open air (radiation defense regimes);
- evacuation of the population and other measures.

After the evacuation of the population begin to decontaminate the territory, structures and equipment.

During the elimination of the consequences of chemical contamination, the following measures are taken:

- provision of the first medical aid to the victim in the cell of chemical contamination;
- the use of antidote;
- putting gas masks on the victims;
- sorting and rapid evacuation of victims in the first medical care units;
- degassing of the territory.

To ensure the actions of medical and other teams of decontamination disinfecting passages and passages, and then undergo complete degassing of the territory, structures and equipment.

Protecting food and water from contamination by radioactive, chemical and bacterial means

In contaminated areas, food and water can be contaminated, which is hazardous to humans.

Radioactive substances in the form of radiation dust infect solid products superficially, while in bulk go deep into the sausage, cheese – up to 4 cm. Vegetables (potatoes, beets, carrots) and fruits are polluted superficially.

In liquid products and water, radioactive substances settle down at the bottom and partially dissolve.

You can use solid products in general, having washed it beforehand and removing the contaminated layer, but it is better not to use them without further processing.

For food products of plant and animal origin that have grown (or been grown) on contaminated terrain, the radioactive substances are inside them.

To reduce the amount of radionuclides in foods, it is recommended to use special cooking methods during cooking. So, boiling for 10 minutes of cleaned vegetables, meat, fish reduces the content of radionuclides by 30–60 %. Contaminated milk is better processed on sour cream and butter. Mushrooms are the most contaminated with radioactive substances. The concentration of radionuclides in mushrooms significantly exceeds their content in the soil on which they grow. Before using them, it is recommended to cook twice for 10 minutes, draining each time a decoction.

In the case of highly active poisonous substances, they are in a droplet state capable of penetrating rapidly into porous food and pasta products up to 16 cm, sugar up to 12 cm, flour up to 4 cm, bread to 2 cm, frozen meat – up to 1.5 cm in the boil – up to 7 cm in fruit and vegetables – up to 2 cm. Liquid products are completely infected.

Bacterial (or pathogenic microorganisms) fall into food, they live and multiply for a long time. For example, the cholera agent remains on vegetables and fruits for up to 8 days, in bread – up to 26 days, in milk – up to 1 month. The longer the plague pathogen persists. Foods that are contaminated with poisonous substances and bacterial agents may be dangerous.

Basic measures to protect food and water from infection:

- sealing of premises where products are stored;
- storage of products in tightly closed containers (banks, packages);
- defense of water supply sources.

Sealing of premises involves limiting the penetration of radioactive, chemical poisonous substances, bacterial means through windows, doors, ventilation ducts, etc. After sealing the premises the degree of pollution is reduced by 100 times.

Protective packaging significantly reduces the likelihood of contamination of products. The protective properties of the container are divided into three categories: higher (metal, glass) – protects against all types of contamination; the first (polymeric and combined) – protects only from radioactive substances and bacterial means; second (plywood, cardboard, paper) – protects only radiation dust.

At home, the food is best preserved from contaminated food in tightly closed glass and plastic jars and in polyethylene bags.

Defense of water supply sources is carried out by separating them from the environment. In the countryside, wells should be closed from radiation droplets penetration. In urban water supply, in most cases, water is not infected, but if water in the water supply system has become infected, then it is necessary to use water from underground sources (pump rooms).

Water can be stored in tightly closed glass, plastic or metal (preferably enameled) receptacles.

Disinfection of territory, structures and equipment

To disinfect and prevent the defeat of humans and animals, the emergence of the epidemic is carried out by:

Decontamination – removal of radioactive substances from contaminated surfaces to allowable rates of infection from the surface of the area, structures, objects, clothes, foodstuffs, etc. To determine the need for decontamination, conduct dissymmetric control of radioactive contamination.

Degustation – the neutralization of toxic substances or their removal from infected objects of objects, equipment, structures and terrain.

Disinfection – is destruction in the environment of human activity of pathogens of infectious diseases, their toxins and carriers of diseases – rodents (**deracination**) and insects (**disinfection**).

Methods of decontamination

During the disinfecting, it should be kept in mind: the area for disinfection should be sufficient to ensure the necessary actions of people and equipment, the placement of animals and all that is to be disinfected. People, equipment, animals should be placed from the leeward side of the accident site. Disinfection must be started on a principle from simple to complex; first allocate a large contaminated mass to prevent unwanted contacts with a high concentration zone.

Strictly control the stay in the means of personal defense. In the cold season, the action of people is slack, there are difficulties in their service, in the case of freezing of infected areas there are additional difficulties in the elimination of the consequences. When preparing and using solutions for decontamination, it should be kept in mind that not all solutions are compatible with each other.

The results of decontamination are significantly influenced by the amount of water and its pressure. To disinfect equipment, equipment, devices, etc. it is possible to apply pairs under low and high pressure, but it is necessary to remember that under high pressure conditions an infectious aerosol can develop, which can spread beyond the cell of infection.

Sanitary treatment of people

Sanitary treatment of people and disinfection of clothes, footwear and protective means are performed partly or in full and accordingly divided into partial and complete.

Partial sanitary treatment is the mechanical cleaning and treatment of exposed skin areas, the outer surface of clothing, footwear, PPE or treatment by means of individual anti-chemical packages. Performing it at the victim's center during rescue and urgent work, it is a temporary measure.

In the case of contamination by radioactive dust, partial sanitary treatment is carried out as follows: the outer clothing is poisoned, cleaned, the footwear is washed with water or wiped with a damp cloth. In winter, you can use non-infected snow.

Disinfection of clothes and shoes are carried out in a gas mask or respirator and gloves. Then clean the dust bag from the gas mask, and remove the filter carton and mask with a damp cloth. Face, neck and hands are washed with no contaminated water with soap or solution from an individual anti-chemical package.

In the case of contamination with drip-liquid poisonous substances, partial sanitary treatment is carried out immediately after their exposure to clothing or leather covers. To do this, use a degasser from an individual anti-chemical package. A strongly moistened swab are carefully wipe open areas of the neck, arms and legs, the edge of the collar and cuff, as well as the front part of the mask. The treatment is carried out in one direction from top to bottom, each time swinging the swab or replacing it with a new one. At the first opportunity, the treated areas should be washed with soap and water and clean with a clean towel (a piece of fabric).

Complete sanitary treatment consists in thorough washing of the whole body with warm water with soap and a washcloth at the points of special treatment (Push), deployed units of parts of the Central Plant; on stationary wash basins (SOPs), which are created on the basis of baths, sanatoria, showers pavilions; on washbasins located in the field, using disinfection and shower facilities (DDA). At the same time, the sanitary treatment of people is carried out and disinfection of linen, clothes, footwear, and individual means of defense. Highly infected with radioactive or poisonous substances, the items of clothing and shoes are replaced by clean.

Social defense of the victims

An injured person in the event of an emergency is a person who has suffered moral, physical or material damage as a result of an emergency or works to eliminate its consequences.

Measures of social defense and compensation of material losses to the victims as a result of an emergency include:

- provision (payment) of material assistance (compensation);
- housing provision;
- provision of medical and psychological assistance;
- provision of humanitarian aid;
- other types of assistance.

Measures of social defense and compensation of material losses to the victims are carried out at the expense of:

- funds of state and local budgets;
- funds of business entities or natural persons guilty of emergencies;
- funds under voluntary insurance contracts concluded in accordance with the insurance law;
- voluntary donations of individuals and legal entities, charitable organizations and associations of citizens.

Emergency assistance may be provided to the victims at the expense of the funds of the state and local budgets in accordance with the level of emergency, as well as material reserves for the prevention and liquidation of the consequences of emergencies.

Provision of housing for victims, whose housing has become unfit for accommodation as a result of an emergency, is carried out by local state administrations, local self-government bodies and economic entities.

Construction or purchase of residential buildings or apartments for the victims is carried out at the expense of state funds allocated for the indicated purposes, taking into account the area of living (non-residential) premises and the number of rooms that the victim owned.

Purchase of residential houses or apartments for the victims may be carried out in the settlement where he lived, or with their consent in any settlement of Ukraine.

Victims who have been paid monetary compensation for a destroyed or damaged apartment (dwelling house), housing at the expense of the state are not provided.

The amount of monetary compensation for a destroyed or damaged apartment (dwelling house) is determined by the indicators of indirect cost of housing construction in the regions of Ukraine according to the location of such property.

Victims who are being evacuated are relocated to a new place of residence in connection with emergencies and the following compensation and benefits:

- payment of the cost of travel, expenses for the transportation of property by rail, water or motor transport (except for cases when vehicles are provided free of charge);
- obtaining an interest-free loan for a business in the order and amount established by the Cabinet of Ministers of Ukraine.

Victims of emergencies have the right to provide them with free medical care. Minors affected by emergency situations are provided with psychological rehabilitation in sanatorium and resort facilities, in which centers of medical and psychological rehabilitation are established.

SELF-CONTROL QUESTIONS TO SECTION 3. CIVIL DEFENSE OF THE POPULATION AND TERRITORIES

1. To determine the legal basis of civil defense.

2. Formulate the basic principles of civil defense.

3. Identify and describe the purpose, objectives, subjects of civil defense.

4. Analyse and explain the basic principles of civil defense of the population and territories of Ukraine.

5. Analyse and explain the general structure of the unified state system of civil defense.

6. Identify the main tasks of a single state system of civil defense.

7. Analyse the structure of the organization of civil defense at the object of economic activity.

8. Define the tasks and functional responsibilities of economic entities in the field of civil defense.

9. Define and explain a set of organizational and protective measures in the field of civil defense at the object of economic activity.

10. Describe international cooperation in the field of civil defense.

11. Describe the criteria for the transition of a dangerous event into an emergency.

12. Give and describe the classification of emergencies by reasons of origin.

13. Describe the state of emergency.

14. Describe the emergency situation at the regional level.

15. Describe the local emergency.

16. Describe the emergency situation of the object level.

17. Explain the structure and purpose of the classifier of emergencies.

18. Explain what an earthquake is. Determine the impact factor of the earthquake and its main parameter. Give the rules of behaviour of the population during earthquakes.

19. Describe the striking factors of dangerous meteorological phenomena and their negative impact on human life and the functioning of the economy.

20. Give the algorithm of human actions during storms and hurricanes.

21. Describe ice as a dangerous meteorological phenomenon and provide recommendations on rules of conduct.

22. Describe the types of fog, their impact, provide recommendations on rules of conduct.

23. Give the main measures to protect the population from catastrophic floods and recommendations for rules of conduct.

24. Describe avalanches and provide recommendations on rules of conduct.

25. Describe fires in natural ecosystems, their impact factors, the nature of manifestations and consequences.

26. Describe the stages of forest fire fighting. Provide recommendations on rules of conduct.

27. List and analyse the types of emergencies of man-made nature.

28. Describe industrial accidents, catastrophes and their consequences.

29. Explain what are the levels of industrial accidents depending on their scale.

30. Identify and characterize man-made fires and explosions, their factors, impact on people and the environment.

31. Give the classification of hazardous chemicals by degree of toxicity, flammability.

32. Explain the causes of accidents at hydrodynamic objects. Describe areas of catastrophic flooding.

33. Give a classification and describe the types of conflicts.

34. Describe terrorism, its types and striking factors.

35. Give an algorithm for detecting an explosive device in places of mass presence of people.

36. Provide an algorithm for action if you are taken hostage by criminals.

37. Describe the principles of combating terrorism.

38. Describe the rights and responsibilities of citizens during the martial law.

39. Provide algorithms of behaviour for the civilian population, which was in the combat zone (at risk of small arms, air danger).

40. Identify the basic principles and explain ways to protect the population in an emergency, their nature and ways of implementation.

41. Describe personal protective equipment by purpose and principle of action.

42. Explain the assessment of the classification of protective structures of civil defense by their properties.

43. Describe the repositories of civil defense.

44. Methods and ways of notification and information in the field of civil defense.

45. Describe the types of evacuation depending on the characteristics of emergencies. Identify the categories of the population that must be taken out of the city by truck during the evacuation.

46. Provide an algorithm of actions for the civilian population during the temporary evacuation from the dangerous area.

47. Explain what measures are being taken to prevent adverse effects on the health of the population of harmful environmental factors and the consequences of emergencies.

48. Explain the principles of organization of work to eliminate the consequences of emergencies.

49. Explain what measures are implemented to support the victims of emergencies.

50. Explain the actions of the population that is in the center of infectious diseases.

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