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1. INTRODUCTION

The problem of personal and occupational safety becomes one of the most current problems today in relation to the growing industries and the degrading ecology in some regions and on the whole planet. Personal safety is a subject that concerns both human life and occupation. By expert assessment, safety is a balanced condition that regards individuals, society, country, etc.

Knowledge of safety will expand the psychological field of security for individuals and enable self-care, satisfaction, and enjoyment of life. Active input of every citizen into taking care of the environment and themselves is a safety guarantee for a person, society, and humankind, which tends to balanced development. Everyone who participates in social and cultural life turns this input into an essential component.

The objective of personal and occupational safety research should be represented as 'Man-Machine (Technology)' and 'Man-Society-Nature' systems. The research subject includes the law of their appearance and the safety of their functioning. Therefore, safety and risk can be considered as a capability of such systems to maintain functional conditions that, with some probability, prevent accidents involving faults in the surrounding and occupational environments.

The risk rate for injury or occupational illness is estimated to be considerably higher in developing countries than in those with developed industries. For example, in the European Union, the annual statistics of occupational accidents and illnesses make about 10 million records, which is a dozen times less than in countries of the Third World.

The basic causal factors of accidents in many countries are:

- insufficient training of employees and employers and poor knowledge of occupational safety;
- poor control of the safety performance of the workplace and in compliance with safety standards;
- deficient in providing workers with personal protective equipment;
- insufficient deployment of collective safety measures in the occupational environment;
- wear of technological equipment and tools.

The priority of occupational safety and health becomes the most essential component of social progress to provide. Economic growth, saving natural resources, and environmental security are interdependent and connected to each other. Today, as never before, ecological principles are urgently needed in natural science and humanitarian knowledge; a person and nature must be considered united in the complete system of 'society and nature'.

2. BASICS OF OCCUPATIONAL SAFETY

2.1. Occupational Sanitation and Hygiene

Occupational conditions can be referred to one of the four classes.

Class 1: optimal occupational conditions provide protection of health and, moreover, maintain high work capacity of workers.

Class 2: acceptable occupational conditions expose factors in the workplace that do not exceed acceptable hygienic limits, they may exert some physiological effect, which is fully recovered for rest.

Class 3: harmful occupational conditions expose occupational factors that are harmful, as they exceed acceptable hygienic limits and exert adverse effects on workers' health.

Class 4: dangerous (extreme) occupational conditions expose occupational factors of such level that makes high risk of acute occupational lesion, poisoning, crippling and threat to the life of a worker being exposed to.

Occupational factors include microclimate parameters, airborne contaminants, illumination, sound levels, vibration, and electricity present in the work zone or area.

2.1.1. Work Area Microclimate

The microclimate (meteorological conditions) is assumed to be the climate of the internal environment of the work area that is introduced as a common action of the following parameters: air temperature, air humidity, air circulation, and radiant heat.

2.1.1.1. Biological Effect of Microclimate Parameters

The environment outside the human's body is able to accept the heat, which is worked out by the human. Heat is transferred to the environment due to temperature conductivity through the cloth, convection while air contacts open skin areas, radiant heat, vaporization of water from the skin surface, and heating of air on respiration. The balance between the heat extracted by the body and the absorbed by the environment maintains the normal thermal and functional condition of human.

Imbalance of heat exchange causes overheating or overcooling, then loss of consciousness, or even thermal death. Heat extraction depends on physical exertion and makes from 85 Joules per second (easy work) to 500 Joules per second (heavy work).

Human organism keeps its temperature stable in a wide range of environmental parameters. The body maintains a temperature at about 36.6 degrees C when the air temperature changes from -40 to +40 degrees C. However, some parts of the body may have a temperature varying from +24 to +37.1 deg C.

The intense heat exchange occurs in the liver – its temperature is equal to 38.0-38.5 deg C. It is also known as the biological cycle of skin temperature: maximal (37.0-37.1 deg C) at 4.00 to 7.00 p.m., minimal (36.0-36.2 deg C) at 2.0 to 4.00 a.m.

Lung ventilation is the volume of air inhaled per hour. It depends on physical exertion, humidity of the air, and temperature of the air.

The thermal condition of the person depends on physical exertion, the temperature of the surrounding objects, and the microclimate parameters (air temperature, air circulation, air humidity, and atmospheric pressure).

Low air temperature causes rising heat emission through convection and radiation and may lead to overcooling of the organism.

High air temperature causes the opposite process. It is in fact that the work capacity of a person descends at an air temperature greater than 30 deg C. Insufficient air humidity causes intense vaporization from mucous membranes, their drying and chapping, and consequently, their infecting. The water and saline removed by sweating should be replaced because their loss brings about blood clotting and affects the cardiovascular system.

6% of the dehydration of the organism violates brain activity and worsens vision. 15-20% dehydration may be fatal. A low concentration of saline deprives the blood of the ability to hold water and violates the cardiovascular system. At high air temperatures, the organism loses carbohydrates, fat, and protein.

Longtime being at high air temperature and humidity may cause heat accumulation in an organism and its hyperthermia, when body temperature rises to 38…40 deg C. Headache, dizziness, incorrect color perception, weakness, dry mouth, vomiting, and sweating are symptoms of hyperthermia. Increasing heart rate and respiration riches blood with residual nitrogen and carbon dioxide, which is present in paleness, blue skin color, wide pupils, sometimes cramps, and loss of consciousness.

Lowering the temperature causes overcooling (hypothermia). The decreasing frequency of respiration follows hypothermia; inhaling takes more volume. Then comes muscle tremor, which is a body reaction that transfers muscle contraction to heat. This allows holding up lowering temperate for a while. Cold injury is a consequence of low temperature.

Appropriate air circulation also makes for normal occupational conditions. The human organism is already sensitive to airflow at 0.15 meters per second. The air flow temperature up to 36 deg C makes it feel chilling, and over 40°C has inhibiting effect.

Heat transfer from a hot or melted surface goes through convection, heat conductivity, and heat radiation. Convection is the process of heat transfer through a fluid (steam flow, air, liquid), caused by movement of molecules from cool regions to warmer regions of lower density; heat conductivity is the property of transmitting heat in a solid body; radiant heat is heat transferred in the form of electromagnetic radiation rather than by conduction or convection (infrared radiation), infrared radiation transfers into thermal energy only being incident to a surface.

Radiant energy may cause burns after direct contact with hot surfaces. Burns are classified according to the depth of tissue affected:

- first-degree burn: painful and red;
- second-degree burn: blisters appear on the skin;
- third-degree burn: destruction of both epidermis and dermis.

Heat regulation is called the ability of the organism to regulate heat exchange with the environment and keep body temperature constant at a normal level regardless of outer conditions and physical activity.

The basic factor of heat regulation is the ability to extend or contract blood flow in the peripheral vascular system. Overheating makes the vascular system extend and heat transfers outside more intensive. Overcooling causes contraction of the vascular system.

2.1.1.2. Meteorological Standards

The basic meteorological standards regulate microclimate parameters and include the thermal characteristics of the work area, work category, and the year period. It provides standards for optimal and acceptable meteorological conditions.

Optimal meteorological conditions are provided by such microclimate parameters, which ensure the normal thermal and functional condition of the human organism without heat regulation stress. They give the feeling of thermal comfort and create conditions for high productivity of the workforce.

Acceptable meteorological conditions are provided by microclimate parameters, which may induce some changes in thermal and functional condition, but heat regulation stress is relieved in a short time. It does not impact health, but can cause some discomfort and worsen workability.

Considering total energy consumption required for physical activity, every work can be referred to easy, normal, or hard work category.

Easy physical work (Category I) is an activity with an energy consumption of up to 150 kilocalories per hour (174 watts).

Easy physical work divides into Category Ia, energy consumption up to 120 kilocalories per hour (139 watts), and Category Ib, energy consumption is 121-150 kilocalories per hour (140-174 watts).

Category I*a* includes work in sitting or standing position, which requires slight physical exertion (work applied in precise instrument-machine engineering, clothing manufacture, offices, etc.).

Category I*b* includes work in the sitting, standing position or walking position, which requires some physical exertion (work applied in the printing industry, communication services, checkers, experts in any industry, etc.).

Normal physical work (Category II) is an activity with energy consumption of 151-250 kilocalories per hour (175-290 watts).

Normal physical work divides into Category IIa, where energy consumption is 151-200 kilocalories per hour (175-232 watts) and Category IIb, where energy consumption is 201-250 kilocalories per hour (233-290 watts).

Category II*a* includes work with constant walking, moving small things (up to 1 kg weight) sitting or standing, and taking some physical exertion (work applied in mechanical workshops, in machine engineering, spinning factory, etc.).

Category II*b* includes work with constant walking, moving, and carrying weights up to 1 kg and takes moderate physical exertion (work applied in foundry, rolling, forge, heat, and welding workshops, etc.).

Hard physical work (Category III) is an activity with energy consumption greater than 250 kilocalories per hour (290 watts).

Category III includes work with constant walking, moving, and carrying heavy weights (over 10 kg) and requires great physical effort (work applied in forge workshops with manual ramming and casting in machine engineering and metallurgical works, etc.).

The calendar year is divided into two periods: a warm period having an average daily temperature of the external air +10 deg C and higher; and a cold period - an average daily temperature of the external air below +10 deg C.

2.1.2. Airborne Contamination

2.1.2.1. Biological effect of Airborne Contaminants

An airborne contaminant is a potentially harmful substance that is either naturally absent from air or present in an unnaturally high concentration and to which workers may be exposed in their working environment. During contact with the human body, it can cause injury, disease, or illness that can be detected by modern methods, such as during occupational activity and so in some periods of life of this and future generations.

The uptake of airborne contaminants occurs throughout the respiratory system, digestive organs, skin, and mucous membrane. The dominant driving force in the uptake of gases, vapors, and dust is in the respiratory system, liquid substances, through the skin. Contaminants enter the digestive tract while swallowing due to dirty hands.

Poisoning by harmful substances depends on their toxicity, quantity, exposure time, and individual organism. Acute poisoning occurs after one time exposure of the contaminant in large quantities. Chronic poisoning develops during the long-term exposure of the person to the contaminant in low concentration. The harmful substances taken up by the organism are distributed in it. Lead accumulates basically in bones, fluorine – in teeth, manganese – in the liver.

Airborne contaminants introduced in work areas are divided into chemical substances and dust.

Chemical substances are divided by character of influence into 6 groups:

1. toxic – induce poisoning of the whole organism (carbon oxide, lead, mercury);
2. irritant – inducing irritation of the respiratory tract and mucous membrane (chlorine, acetone, ozone);
3. sensitizer – influence as allergen (formaldehyde, various lacquers, solvents);
4. carcinogenic – inducing cancer (nickel and its compounds, chrome oxide, asbestos);
5. gene mutation – changing information about heredity (lead, manganese, radioactive substances);
6. teratogenic (mercury, lead, manganese, and radioactive substances).

It is possible to use various classifications, such as contaminants that affect exact organs (liver, kidneys, heart, alimentary tract) and also asphyxiating, nervous ones,, etc.

Dusts are solid particles generated and dispersed into the air by, for example, handling, crushing, and grinding of organic or inorganic materials such as rock, ore, metal, coal, wood, and grain.

The health effects caused by particulate exposure are equally diverse. Skin contact with some dusts, such as organic dusts from flour and grains, can cause irritation or allergic responses in sensitized persons, whereas inhalation of other organic dusts, particularly some wood dusts, has been shown to cause nasal cancer in highly exposed workers. However, the main health effects are usually found in the lungs, where particulate matter can penetrate deep into the gas exchange region (the alveoli) and cause severe fibrotic reactions. An example of this is silicosis, which results from exposure to silica. Other lung reactions include bronchitis, which is an overproduction of mucous associated with inflammation of the bronchi; asthma which is a constriction of the bronchial tubes; and cancer. Restricted lung function can place a burden on the right side of the heart, and this additional stress can cause irreversible heart damage over time.

The dust floating in the air is called aerosol and the aerogel that adheres to the surface is called aerogel.

It is classified by toxicity and particulate size.

In terms of toxicity, dust can be toxic, such as lead, manganese, or cadmium being absorbed into the blood, it can exert an adverse effect on tissues or organs that may be remote from the site of entry or untoxic (having no poisoning effect). Toxic dust dissolved in saliva or on the mucous membrane of the respiratory tract is converted into poison.

The size of the particles is critical to determine where the particulates will settle in the lung.

By its size, dust is classified as following:

- INHALABLE dust has a 50% cut-point of 100 micrometer,
- THORACIC dust has a 50% cut-point of 10 micrometers,
- RESPIRABLE (smoke) dust has a 50% cut-point of 5 micrometer; that dust is so small in size that it can get through the lung defense mechanisms of the human body and get down deep into the gas exchange (alveolar) region of the lung.

2.1.2.2. Airborne Contaminant Exposure Standard

Exposure standards represent airborne concentrations of individual chemical substances, which, according to current knowledge, should neither impair the health of nor cause undue discomfort to nearly all workers. Additionally, exposure standards are believed to protect against narcosis or irritation that could precipitate occupational accidents.

The threshold limit value (TLV) refers to airborne concentrations of substances to which nearly all workers are believed to be repeatedly exposed day after day without adverse effect.

There are three categories of exposure standards:

- 8-hour time-weighted averages (TWAs),
- Short-Term Exposure Limits (STELs),
- Peak Limitations or Ceiling Values.

8-hour time-weighted averages (TWA): average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week.

8-hour TWA exposures are calculated as follows:

$$TWA = (C_1T_1 + C_2T_2 + C_3T_3 - + C_NT_N)/8 \tag{2.1}$$

where: C – concentration of contaminant; and T – incremental exposure time.

Short Term Exposure Limits (STEL): Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL. This is to avoid acute and chronic health effects.

Some substances can cause intolerable irritation or other acute effects after brief overexposure, although the primary toxic effects may be due to long-term exposure through accumulation of substances in the body or through gradual health impairment with repeated exposures. Under these circumstances, exposure should not exceed STEL to avoid acute and chronic health effects.

Peak limits are concentrations that should not be exceeded even for an instant during any part of the workday.

For some rapidly acting gases or vapours, averaging the airborne concentration over an eight-hour period is inappropriate.

These substances may induce acute effects after relatively brief exposure to high concentrations, and so the exposure standard for these substances represents a maximum or peak concentration to which workers may be exposed. Examples of gases or vapours with peak limitation exposure standards are hydrogen fluoride, acetic anhydride, n-butyl alcohol, chlorine, ethyl acrylate, ozone, and glutaraldehyde.

Airborne contaminants are classified into four classes by their *TWA*:

1st class – extremely hazardous substances with a *TWA* less than 0.1 mg/m^3 (lead, mercury, ozone);

2nd class – highly hazardous substances with a *TWA* within 0.1-1.0 mg/m^3 (sulfuric and hydrochloric acid, chlorine, phenol);

3rd class – medium hazardous substances with a *TWA* within 1.1-10.0 mg/m^3 (toluene, methyl spirit);

4th class – low hazardous substances with a *TWA* greater than 10 mg/m^3 (ammonia, gasoline, acetone).

Standard may have a letter that points to the effect that is produced by the contaminant that is exposed to the person, for example 'O', acute effect; 'A', allergic effect; 'K', carcinogenic effect; 'F', fibrotic effect.

If there are some multidirectional hazardous substances simultaneously in the air of the work zone, then the concentration of everyone should not exceed the correspondent TLV.

Airborne contaminants may force them to have antagonistic or synergistic effects.

In the first case, they are of multidirectional action, in the second they are unidirectional.

Acceptable condition for multidirectional hazards $C_1 \leq TWA_1$, $C_2 \leq TWA_2$-

Acceptable condition for unidirectional ones:

$$\frac{C_1}{TWA_1} + \frac{C_2}{TWA_2} + ... + \frac{C_N}{TWA_N} \leq 1 \qquad (2.2)$$

Various sampling methods are used in sampling of gases, vapors, and dust:

- express method, based on the colorimetric method;
- laboratory method, which implies sampling in work zone with further physical and chemical analysis in laboratory conditions;
- automatic control method using gas analyzers and gas signaling systems.

The class of substance, concentration, and hazard of health impact define the periodicity of sampling.

To secure workplace atmospheres, which are as free as practicable from hazardous contaminant after control, measures are developed:

- substituting a dangerous substance with one that is not as dangerous;

- improving technology;
- remote control of manufacturing process;
- isolation of manufacturing equipment, using local ventilation;
- normal operation of the heating system;
- medical examination of workers working with harmful substances;
- sampling of airborne contaminants in the air of work zone;
- using personal protective equipment.

2.1.3. Ventilation Systems

The ventilation system is a combination of methods and equipment aimed at ensuring the safe environment of work, which is as free as practicable from hazardous contaminants and abnormal meteorological conditions. A ventilation system works to exhaust contaminated or heated air from the work area and influx fresh air.

Ventilation is classified as follows:

- by air circulation it is classified into natural and mechanical ventilation, combined (together action of natural and mechanical ventilation);
- by direction of airflow: influx, exhaust, influx and exhaust ventilation;
- by location: general ventilation, local ventilation, and combined ventilation;
- by time of operation: regular and emergency ventilation.

2.1.3.1. Natural Ventilation

Natural ventilation is classified as organized and disorganized. Disorganized ventilation provides airflow influx and exhaust depending on the direction and force of the wind and the temperature of the indoor and outdoor air. It consists of infiltration and airing.

Infiltration is air through voids in windows and doors. The air is circulated through open doors and windows.

Organized natural ventilation is called aeration. It is arranged through a ventilation opening in the walls to influx the air, ventipane in the roof, or top section of the building to exhaust the air. Deflectors mounted on the ventilation shaft and vent tube improve the effectiveness of ventilation.

Natural ventilation is cheap and easy to operate; however, influx air is not previously purified and may be contaminated.

2.1.3.2. Mechanical Ventilation

Mechanical ventilation defers from natural ventilation in its ability to purify exhaust air before its ejecting into the atmosphere, catch airborne contaminants, and provide air conditioning in the workplace. In addition, it makes it possible to arrange the air intake for the ventilation of the influx in the least contaminated zones of an enterprise or even beyond it.

Ventilation should ensure that the air in a work area remains clean and free of contaminants. It is applied to exhausting heat with air that has no toxic emission, and also when it is impossible to use local ventilation for technological reasons.

If gases or vapors spreading in the work area are denser than air, general ventilation should provide 60% air exhaust from lower zone of area and 40% – from upper one.

Influx and exhaust ventilation with general influx and local exhaust from the place where contaminants are emitted is the most practicable for occupational condition.

In the work area, where the atmosphere contains a large amount of gases, vapors, and dust, exhaust ventilation should be 10% higher than the influx, which prevents the flow of contaminants from that area to neighboring areas.

The ventilation system can be used to bring in not only outside air but also air from the work area after its purification. Such repeated use of the air is called recirculation recommended in cold year period to keep warm inside.

Local ventilation as a general one can be influx and exhaust.

Local ventilation is performed as airflow shower, air and air-heated curtains used for focused air influx.

The airflow shower is aimed at protecting workers from overheating in hot workshops; air and air-heated curtains prevent work areas from incoming cold air from outside.

Local exhaust ventilation works by means of exhaust hoods, panels, etc. A maximum catch of contaminants should be achieved with a minimum quantity of exhaust air.

To choose appropriate ventilation system they consider characteristics of harmful emission (temperature, vapor density, toxicity), worker position in the workplace and technology.

Emergency ventilation is installed in work areas where dangerous or explosive gases may rapidly enter the air in great quantity. The gas generator and compressor areas are referred to such work areas. Emergency ventilation is only exhaust.

2.1.3.3. Ventilation System Requirements

The sanitation and hygiene regulations applied to ventilation systems are as follows:

- air conditioning (air temperature, air humidity and air circulation);
- removing airborne contaminants (gases, vapors, dusts, aerosols) or reducing their concentration to acceptable limits;
- preventing drafts or fast overcooling;
- maintainability during operation;
- low noise and vibration.

2.1.4. Heating Systems

The heating system is a complex of components necessary to heat areas during the cold season period. It consists of heat source, heat supply, and heating installation. Heat-transfer can use water, vapor, or air.

Heating systems are local and central.

Local systems are arranged by means of burner or air heating, and also heating by gas and electric installations. Local heating systems are installed in dwellings, amenities rooms, and in work areas of small-scale enterprises.

Central heating systems can be performed as water, steam, panel, air, and combined heating.

Since the water heating system satisfies sanitation and hygiene requirements, it is widely used in homes and workplaces. One of its primary benefits is that the area is heated equally, the water temperature is controlled centrally, no smoke or dust is produced; the air stays humid; and the system is fire-safe. However, it also has disadvantages: risk of water freezing in cold year period during its emergency stopping; slow heating large areas after its long time off.

Steam heating is used when steam is part of the technology in an enterprise. It has disadvantages such as fire danger, possible burns, and smoke. Steam heating cannot be used in fire-risk areas or areas with a large amount of dust.

Panel heating is applied in administrative buildings and dwellings. Equal heating, stable air temperature and humidity, and small size owing to the absence of heating devices are its advantages. The disadvantages are the high price of installation and poor maintenance.

There are central and local air-heating systems. The rapid thermal effect and low price make them advantageous.

Combined heat is very effective, especially when combined with low-pressure water heating and general ventilation.

2.1.5. Illumination of Work Areas

2.1.5.1. Biological Effect and Technical Light Characteristics

Subjective perception of visual information accounts for approximately 90% of the total. In conditions of insufficient or changing illumination,, visual organs have to get accustomed to the environment, which is possible due to functions such as adaptation, accommodation, and convergence.

Adaptation is the process by which the eye’s retina adapts to varying luminance.

Accommodation is the automatic or voluntary adjustment of the thickness of the eye lens for far or near vision.

Convergence is the turning of the eyes inward in order to fixate an object closer to that previously being fixed.

Moreover, light has a great physiological effect. Poor lighting leads to fast fatigue and the risk of accidents; it can also cause occupational diseases such as myopia, short vision, and accommodation spasm.

Color is the characteristic of light by which a human observer may distinguish between two structure-free patches of light of the same size and shape. Appropriate coloring can increase illumination by 20-40%, make smooth shadows, and improve uniformity of illumination.

Illumination variations and unequal brightness of the surroundings often lead to readaptation of the eyes and rapid fatigue. The illumination of occupational areas is evaluated by quantitative and qualitative characteristics. Quantitative characteristics include luminous flux, intensity, illuminance, luminance, and reflectance. Qualitative characteristics include background, contrast of an object against its immediate background, visibility, uniformity of luminous flux.

Luminous Flux: the time rate of flow of light. Lumen (lm) is the SI unit of luminous flux. The luminous flux emitted within a unit solid angle (one steradian) by a point source having a uniform luminous intensity of one candela.

Intensity: luminous intensity or radiant intensity is often misused for the level of illuminance. The candela (cd) is the SI unit of luminous intensity; one candela is one lumen per steradian.

$$I = \frac{F}{\omega} \text{ (cd)} \tag{2.3}$$

Luminance: the physical measure of brightness: the luminous intensity per unit of projected area of any surface, measured from a specific direction. (English unit: Footlambert. Metric unit: Candela per square meter).

$$L = \frac{I \cdot \rho}{S} \text{ (cd/m}^2\text{)} \tag{2.4}$$

where ρ – reflectance, S – surface area.

Illuminance: the density of the luminous flux incident on a surface, expressed in units of footcandles or lux.

$$E = \frac{F}{S} \text{ (lux)} \tag{2.5}$$

Reflectance: the ratio of reflected flux to incident flux.

$$\rho = \frac{F_{ref}}{F_{inc}} \tag{2.6}$$

Vision always deals with two subjects: object and background. The background is the surface adjacent to the object being observed. The background can be light, medium, and dark, depending on the reflectance. It's light when $\rho > 0.4$, medium when $\rho = 0.2\text{-}0.4$, dark when $\rho < 0.2$.

Owing to the difference between luminances of object and background and also color, people distinguish things around. That is why another characteristic called contrast is studied.

Contrast: the relationship between the luminance of an object and its immediate background. Mathematically, the difference between the luminances is divided by the luminance of the background.

$$C = \frac{L_o - L_b}{L_b} \tag{2.7}$$

where L_o, Lb, object and background luminances.

The contrast is high when $C > 0.5$, medium when $C = 0.2\text{-}0.5$, low when $\rho < 0.2$.

Visibility: the quality or state of being perceivable by the eye. It evaluates visual acuity and considers illuminance, size of object, its luminance, contrast of object against background, exposure duration:

$$V = C/C_{thr} \tag{2.8}$$

where C – contrast of the object against the background; C_{thr} – visible contrast threshold.

2.1.5.2. Requirements for Work Area Illumination

The following requirements for illumination of the work area provide visual comfort and prevent occupational diseases and accidents:

- the illumination in the workplace should be appropriate to the visual task (category);
- illumination should not make a glare from the source of light or surrounding objects;
- illumination in the work area should be uniform and stable to avoid frequent eyes' re-adaptation;
- sharp and deep shadows are not allowed in the work plane;
- the contrast of illuminated objects should be sufficient;
- illumination should not be hazardous or harmful;
- illumination should be simple, reliable, reasonable, and aesthetic.

2.1.5.3. Types of Illumination of a Work Area

The illumination of the work area can be natural or artificial. Sunlight, horizon, moon, and stars make natural illumination, electric radiant sources – lamps make artificial illumination, there is also combined illumination including both previous types.

Natural illumination can be arranged as side, overhead, or combined lighting.

Side lighting: the use of daylight apertures on the walls of buildings to provide daylight on tasks. It can be one-sided and two-sided.

Overhead lighting: daylighting concepts on the roof of a building that provide light from above to illuminate horizontal, sloped, or vertical work planes.

Combined lighting comprises the overhead and side one.

Artificial illumination can be performed as general and combined lighting.

General illumination is a lighting system in which luminaries are set in overhead space of the area (as lowest 2.5 m above the floor) uniformly (general uniform lighting) or focused over the work planes (general focal lighting).

Combined lighting comprises general and focal illumination. It provides high visual acuity. Luminaries focusing their luminous flux directly in work plane create focal lighting. The application of focal lighting only in work areas is not recommended for the prevention of occupational accidents and diseases.

Depending on functional purpose, artificial illumination is classified as work, emergency, evacuation, security, and stand-by lighting.

Work lighting provides visibility needed for production, moving, transporting and is obligate for all occupational areas.

Emergency lighting is aimed at preventing explosion, fire, injuries, damages, etc., when the work lighting is occasionally shutdown.

The purpose of evacuation lighting is to help evacuate in a situation when the work lighting is off. It is mounted in passages of personality, in areas with personality, which may count more than 100 persons present there simultaneously, in stairwells, in occupational areas with personality over 50 persons.

Security lighting is installed on the perimeter of the protected territory.

Standby lighting is foreseen in overtime.

2.1.5.4. Natural Illumination

It is evident that there is a coherent relationship between natural light and health in humans. Each of the effects of light on mammalian tissue can be classified as direct or indirect depending on whether its immediate cause is a photochemical reaction occurring within that tissue or a neuroendocrine signal generated by a photoreceptor. One of the best known direct effects of light on man is that of stimulating vitamin D synthesis in the skin and subcutaneous tissue by sunlight. The second group of effects is the indirect ones, those whereby light exerts an effect by way of the eyes on various metabolic, hormonal, and organic functions. Circadian rhythms are entrained by the light-dark cycle zeitgeiber in this way.

However, prediction of natural illumination is complicated owing to its varying during a day or year or weather, not uniform lighting the work area, and possible glare.

In particular, natural illumination is affected by the following factors: light climate, window area and its orientation, visual transmittance of glazing, color of walls, floor, and ceiling.

Natural illumination is evaluated by the daylight factor (*DF*). *DF* is a relative measure of daylight illuminance at an interior point or plane expressed as the ratio of the illuminance on the given plane (E_{in}) to the simultaneous exterior illuminance (E_{out}) on a horizontal plane from the whole unobstructed sky. Direct sunlight is excluded from both the interior and exterior values of illuminance.

$$DF = \frac{E_{in}}{E_{out}} \cdot 100\% \tag{2.9}$$

Illuminance inside the work area is measured in the point that is located according to the type of lighting. For one-sided lighting, it is found in crossing line of plane making central vertical section of the area and another horizontal plane, which is at the height of work plane 0.8 m at the distance 1 m from the wall opposite the window. For overhead lighting – in the crossing line of plane making central vertical section of the area and another horizontal plane, which is at the height of workplace 0.8 m at the distance 1 m from the most dark wall.

DF standards are provided by the ‘Construction Regulations’.

The prediction of natural light is associated with the calculation of the opening area of the window (windows, skylights) area and its assessment against the *DF* standard.

The window opening area is calculated using the following formula:

$$S_w = \frac{S_a \cdot DF_{st} \cdot h_w \cdot d}{100 \cdot \tau_0 \cdot r_1} \text{ for side illumination} \tag{2.10}$$

$$S_s = \frac{S_a \cdot DF_{st} \cdot h_s}{100 \cdot \tau_0 \cdot r_2} \text{ for overhead illumination} \tag{2.11}$$

where S_w, S_s – windows or skylight areas; S_a – work area; DF_{st} – *DF* standard; h_w, h_s – window-to-wall ratio; *d* – shading from outdoor obstruction; τ_0 – effective aperture; r_1, r_2 – internally reflected component.

The *DF* standard comprises visual task and light climate:

$$DF_{st} = DF_{st}^{III} \cdot m \cdot C \tag{2.12}$$

where *m* – light climate factor in the light zone where the building is situated; *C* – sun climate factor.

2.1.5.5. Artificial Illumination

Artificial illumination is applied in all areas where natural illumination is insufficient and also to illuminate the area when it is dark.

There is general, focal, and combined lighting. Arranging only focal lighting in occupational areas is not recommended at all.

The most familiar type of artificial light is the incandescent lamp in which the radiant source is a hot filament of tungsten. The incandescent filament in a typical 100 W bulb has a temperature of only about 2850 degrees K, so its radiation is strongly shifted to the red end of the spectrum. In fact, about 90% of the total emission of an incandescent lamp lies in the infrared.

Incandescent lamps are cheap, easy to manufacture, convenient to use, they have a a wide range of voltages and power. The main disadvantages are high brightness (may be blinding), not uniform luminous flux, low luminous efficiency (7-20 lm/watts), and low durability (2,500 hrs).

Unlike incandescent lamps and the sun, fluorescent lamps generate light by a nonthermal mechanism. Within the glass tube of a fluorescent lamp, a mercury vapor arc generates ultraviolet photons. The inner surface of the tube is coated with phosphors, luminescent compounds that emit visible radiation of characteristic colors when they are bombarded with ultra-violet photons. The standard 'cool white' fluorescent lamp has been designed to achieve maximum brightness for a given energy consumption.

The advantages of fluorescent lamps are high luminous efficiency (40-100 lm/watts); durability makes about 14,000 hrs. Disadvantages are luminous flux pulsing, which can result in a a stroboscopic effect, complicated design and structure, the the necessity to use special starting units, cause the the initial voltage to turn them on is higher than that in the the power line, and the the starting time is quite long, throttle noise, expensive.

Fluorescent lamps are manufactured as luminescent, mercury, and xenon lamps. Xenon lamps are prohibited for use in occupational areas. Luminescent lamps (low-pressure) are the most commonly used. Fluorescent high-pressure lamps are recommended for high luminous efficiency, stability to external factors,, and compact design.

Since fluorescent lamps are the most widely used source of light in factories, offices,, and other workplaces,, manufacturers produce lamps corresponding to their implement. There are day light fluorescent lamps (LD), day light with advanced color rendering lamps (LDC), cool white lamps (LHB), and warm white lamps (LTB).

Lamps are used in a single assembly with luminaries.

The luminar is the assembly of the lamp and lighting armature. Lighting armature focus luminous flux in the space or transfers its properties so as to protect eyes of workers from blinding effect and it also protects lamp from fire, explosion, or chemically active environment, mechanical damage, dust, atmospheric factors.

Luminaries are classified as follows:

- purpose, for general and focal lighting;
- design, open, covered, water-proof, dust-ignition-proof;
- luminous flux focusing, accent lighting, diffuse lighting, reflected lighting.

2.1.5.6. Artificial Illumination Standards

Artificial illumination standards provide quantitative (minimum illuminance) and qualitative (glare index, lighting pulsation factors) characteristics.

The standards are divided to describe different lamps and lighting systems.

The topic of illumination standards is associated with visual tasks. Visual Task: conventionally designates those details and objects that must be seen for the performance of a given activity; includes the immediate background of the details or objects and contrast of object against its immediate background.

The standard describes eight categories. The first six categories are determined by the size of the objects. Categories I-V have 4 subcategories where the illuminance standard comprises contrast of object against background and reflectance.

For instance, the highest illuminance standard makes 5000 lux for Category I*a* and the lowest one – 30 lux (Category VIII*c*).

2.1.5.7. Methods for Artificial Illumination Design

Artificial illumination can be designed using four methods: point, power density, graphic, and efficacy methods.

The point method is used to predict focal and combined lighting and also lighting incline planes. It is based on the equation:

$$E = \frac{I_a \cdot \cos a}{r^2} \tag{2.13}$$

where I_a – luminous intensity incident to a point, a – angle of incidence: angle at which light rays strike a surface, measured between the ray and a line perpendicular to the surface; r – distance from the lamp to a point. *The Ia* value is given in the lookup tables.

The power density method is considered the most simple but least precise method, used for proximate calculations. It allows finding every lamp power to reach illumination standard in the area:

$$P_l = \frac{p \cdot S}{N} \tag{2.14}$$

where p – power density, W/m^2 (reference value); S – work area, m^2; N – number of lamps in the lighting system.

The graphic method is the most precise to predict direct lighting. It comprises the direct beam component and the internally reflected component.

The luminance flux of the lamp is calculated by the formula:

$$F_l = \frac{E \cdot S \cdot k_r \cdot Z}{N \cdot n \cdot \eta} \quad (2.15)$$

where E – illuminance standard, lux; S – illuminated area, m^2; k_r – light-loss factor: a factor used in calculating the illuminance taking into account temperature, voltage variations, lamp depreciation, dirt accumulation on luminaire and room surfaces, maintenance procedures and atmosphere conditions (k_r = 1.3…1.8); Z – factor of lighting unevenness (Z = 1.1-1.15); N – number of luminaries; n – number of lamps in luminarier; η – luminous efficacy.

Luminous efficacy η is given in look-up tables comprising the area index i and the reflectance of the walls and ceiling. The area index is calculated using the following formula:

$$i = \frac{a \cdot b}{h_p \cdot (a + b)} \quad (2.16)$$

where a, b – depth and width of the area, m; h_p – luminarier elevation above the work plane, m.

Calculated luminous flux is used to select a lamp resorting to a look-up table and to calculate the power required for the whole lighting system.

2.1.6. Protection from Noise and Vibration

2.1.6.1. Physical Characteristics of Noise

Noise produces a negative effect on the human organism and first of all on the central nervous system and cardio-vascular system. Long-time exposure to noise may cause hearing worsening and sometimes deafness. In occupational conditions long exposure to noise can cause accidents, occupational diseases, and the reduction of work capacity.

In noisy conditions, work production decreases down to 60%, and errors grow at 50%. Necessity to speak load effects mental activity. It is a proven fact that for 30% of people, noise is the cause of early aging.

For successful noise control, it is important to know its physical nature, its generating, and distribution.

Noise is a type of sound that tends to sound unpleasant.

The occupational noise generated in workplaces is caused by machines.

Noise is classified as noise to hinder communication; disturbing noise (causing over fatigue); harmful noise (provokes chronic disease, hypertension, tuberculosis, ulcer, and hearing worsening); injurious noise (invades into physiological functions).

As a physical phenomenon, noise is a chaotic composition made up of many sounds with different unrelated frequencies and intensities.

The basic physical characteristics of noise are frequency, pressure, and intensity.

The sound frequency is the number of sound wave oscillations per second measured in hertz (Hz). The sound spectrum is divided into three diapasons:

- infra sound with frequency lower 20 Hz;
- sound with frequency within 20-20000 Hz;
- ultra sound with frequency over 20000 Hz.

The human ear can respond to sound in the frequency spectrum of 20 to 20000 Hz. This sound spectrum is divided into:

- low frequency, under 400 Hz;
- medium frequency, 400 to 1000 Hz;
- high frequency, over 1000 Hz.

Sound wave distribution transfers energy. The energy transferred by the sound wave through the surface perpendicular to the direction of sound distribution per second is called the sound intensity.

$$I = \frac{P^2}{\rho \cdot V} \tag{2.17}$$

where P – sound pressure; ρ – density of a substance sound is passing through; V – sound velocity in the substance.

Sound spreading in air is called air sound, in a solid body, structural sound. Part of the air captured by the oscillations is called the sound field. The sound field is called free if the sound waves spread in it without obstacles (free land, special acoustic chamber equipped with sound absorbing walls). The sound field is called diffuse if sound waves come to every point in it with the same probability from all directions (rooms having high sound reflectance).

In real conditions, the sound wave field can be near the ultimate ones – a free or diffuse sound field.

The human ear responds to sounds over a very wide range of sound intensities. The threshold of hearing (the quietest sound we can hear) is 0.00000000001 watts/m^2 (often written 10^{-12} watts/m^2). The sound intensity at the pain threshold is about 10 watts/m^2.

To handle this large range we make use of a logarithmic ratio scale called the decibel scale.

In general, a decibel scale for any quantity, I, is defined as:

$$L_I = 10 \cdot \log \frac{I}{I_{ref}} \qquad (2.18)$$

where I – sound intensity whose level is specified, in watts/m^2 and I_{ref} – reference intensity = 10^{-12} watts/m^2 (the threshold of hearing).

Note that the decibel is not an absolute measure but is referenced to a selected quantity, I_{ref}.

Another reason for using this scale is that the ear itself 'hears' logarithmically, and humans judge the relative loudness of two sounds by the ratio of their intensities, a logarithmic behavior.

When the sound intensity is expressed as a decibel, it is referred to as the sound intensity level and is given the symbol L_I.

The sound pressure level is calculated using the formula:

$$L_P = 10 \cdot \log \frac{P^2}{P_{ref}^2} = 20 \cdot \log \frac{P}{P_{ref}} \qquad (2.19)$$

where P – rms sound pressure in Pa; P_{ref} = 2×10^{-5} Pa (sometimes written as 20 micro Pa = 20×10^{-6} Pa, which is the sound pressure at the hearing threshold at 1000 Hz).

The sound intensity level and the sound pressure level are related as follows:

$$L_I = L_P + 10 \cdot \log \frac{\rho_0 \cdot V_0}{\rho \cdot V} \qquad (2.20)$$

where ρ_0, V_0 – density of a substance sound is passing through and sound velocity in the substance in normal conditions; ρ, V – real measured values.

To assess simple sounds in octave bands, the term ‘sound pressure level’ is used; for complicated sounds it is ‘sound level’ and we denote this by writing the unit dB (A) (when the A weighting networks have been used in a measurement).

The human ear does not have an equal response to sounds of different frequencies. It is maximum in medium and high frequencies (from 800 to 4000 Hz), minimum in low frequencies (from 20 to 100 Hz).

It is often necessary to obtain information about the frequency spectrum of a sound to design effective noise control and to select appropriate personal hearing protectors.

In most cases,, it is sufficient to measure the sound pressure level in bands of frequencies, rather than at individual frequencies. The width of the band usually chosen is the octave band – this is a band where the upper frequency is twice that of the lower. Each band is denoted by its center frequency:

$$f = \sqrt{f_1 \cdot f_2} \tag{2.21}$$

where f_1 – lower frequency, Hz; f_2 – upper frequency, Hz.

The sound power is the basic characteristic of any source of noise. It is defined as the total energy radiated into the environment.

The sound power, W, can also be expressed in decibels and is then called the sound power level, L_w.

$$L_W = 10 \cdot \log \frac{W}{W_{ref}} \tag{2.22}$$

where W – sound power of the source in watts; W_{ref} – reference sound power = = 10^{-12} watts.

2.1.6.2. Noise Exposure Standards

The noise exposure standards provide threshold limit values for sound levels that are measured by two frequency weighting networks. A – a frequency weighting network measures only one level throughout the hearing diffraction, which is referred to as total sound level, measured in dBA. C – frequency weighting network measures nine sound pressure levels in octave bands, referred to as sound levels, measured in dB(C). The one which has been found to commonly describe the damaging effect of noise is the A-weighting network. Zones with a sound level exceeding 85 dB need isolation and setting of signal labels. Everyone who works in such a zone should use personal protective equipment.

If the sound level in any octave band exceeds 135 dB such an area is restricted.

Machinery or other equipment is referred to as noisy if the sound level in the workplace exceeds the exposure standard by 10 dB.

The equivalent sound pressure level is applied to calculate the average level for period T taking into account every interval t_1 during which the level L_i was specified:

$$L_e = 10 \cdot \log \frac{1}{T} \sum_{i=1}^{n} t_i \times 10^{0.1 L_i} \tag{2.23}$$

where i – interval number (i = 1.2 – n).

Summary sound level estimates common action of a number of equal noise sources with levels $L_1 = L_2 .. = L_n$:

$$L_\Sigma = L_1 + 10 \log n \tag{2.24}$$

where n – number of noise sources.

2.1.6.3. Noise Control

Noise control at the source is the most effective. Once the cause of noise is identified, some modifications can be introduced to address it.

For excessive noise generated by mechanical impacts, control options may include reducing the driving force, reducing the distance between components, balancing rotating equipment, or installing vibration isolation fittings.

The full enclosure of noisy machines is normally used when high noise reduction is required. It is possible to achieve a reduction of 10-25 dB for single-shell enclosures with absorbent lining and 20-50 dB for double-shell enclosures with absorbent lining.

To design an enclosure that will perform well and reduce noise levels significantly, the following points should be observed:

- the outer shell should be made of stiff and heavy materials that reflect sound waves. Usually used materials are sheet metal, plasterboard, masonry, timber, glass, and loaded vinyl;
- the inner shell must be lined with a sound absorbing material to reduce the sound inside the enclosure. The preferred materials are mineral wool, glass wool, foam, or polyurethane. Sound-absorbing materials often need to have a protective facing to prevent any damage or dirt build up. The protective facing can be perforated sheet metal, perforated foil, or vinyl;
- any gaps or openings should be properly sealed or blocked by flexible flaps if openings are necessary. A 10% opening will limit the reduction to 10 dB;
- any windows can be double-glazed for better reduction;
- doors, windows, hatches, or removable panels should be installed with full seals on every edge;
- cooling air intakes and exhausts should be fitted with noise attenuators;
- no enclosure parts should touch any vibrating parts of the enclosed machine. In the case of pipework that goes through the enclosure, all gaps must be sealed with a soft sealant.

Isolation means separating noise sources from people involved in the work or those standing nearby. It could mean relocating the noise source or relocating the operators or others to positions away from the noise source. For example, by doubling the distance from the source inside a workshop, the noise level decreases by about 2…4 dB(A), or in the open space, the noise level decreases by 6 dB(A).

Barriers and shields are used in situations where only a small reduction in noise levels of about 5 dB is needed.

Barriers and shields work in the same way, redirecting sound away from a receiver. Shields are usually small transparent barriers such as a 5mm thick perspex placed between a worker and a noise source. They can also be mounted on a machine and used as a safety shield.

An acoustic barrier is a larger piece of solid material, usually free-standing on the floor. Barriers and shields are most effective when both workers and a source are close to them, and the ceiling and other nearby reflecting surfaces are lined with sound absorbing material.

The materials used to build barriers are sheet metal, plywood, clear plastic, or safety glass. The best results are achieved when at least some parts are covered with absorbing material to minimize sound reflection.

The transmission of sound to a nearby room or from outside can be minimized by increasing the sound insulation of walls, ceiling, doors,, and windows. The amount of sound that will pass through depends on the characteristics of the material used for the partitions and, most importantly, on the mass per unit area. The higher the mass, the higher is the sound reduction. The frequency of the passing sound is also important, as the higher frequencies are easier to stop from penetrating through. In general, an increase in airborne sound insulation of about 5 dB is obtained when the mass per unit area is doubled.

Current developments in some industries are directed towards automated machines and processes, thus allowing operators to operate from a control or monitoring room and so minimizing the amount of time spent near noisy machinery to starting, repairing, and maintenance work.

A properly designed control room can achieve a reduction of up to 30 dB. The room has to be properly ventilated, with ventilation openings fitted with attenuators, acoustic louvers, or a silenced air conditioner unit. Care should be exercised to ensure cables, pipes, and fittings are not rigidly connected and doors and windows are properly sealed.

In general terms, the noise received by the operator consists of noise coming directly from noise sources and noise reflected from walls, floor, ceiling and other equipment. After treating all direct noise sources, all reflector surfaces should be treated to reduce the noise received by the operator. This is achieved by applying sound-absorbing material, which helps reduce the reflected sound.

A convenient method of employing sound absorption is the installation of acoustic baffles. Where large surface areas are to be treated, a spray-on treatment may be more economical.

2.1.6.4. Infrasound

Infra sound is an oscillation spreading through the air, liquid, or solid body with frequency lower than 16 Hz.

We cannot hear the infrasound, but we can feel it. The high-level infrasound violates the vestibular system, causing dizziness and headache. It reduces attention and work capacity, people may feel fear and total weakness.

All mechanisms working with rotational frequency lower than 20 revolutions per second radiate infrasound. A car moving at a speed over 100 km per hour also radiates infrasound. In machine engineering, the infra sound sources are fans, compressors, combustion engines, diesel engines. Infrasound is impossible to reduce by modifying the way it is transmitted or by absorbing or isolating.

Protective equipment is also not effective. It is practicable to reduce infrasound exposure by control measures at the source. They include:

- increasing shaft rotation frequency to 20 revolutions per second and more;
- increasing rigidity of big oscillating constructions;
- elimination of low frequency vibration.

2.1.6.5. Ultra-sound

Occupational technologies widely use ultra sound. Generators, purifying and degreasing equipment radiate ultra sound. Loading and unloading operations connects with contact ultra sound exposure. Ultra-sound generators are used for plasma diffusion welding, cutting meals,, and coating metals. Intensive ultra sound exposure takes place during cleaning operations, chemical etching, and compressed air blasting of details and assembly operations.

Ultrasound impacts the nervous system, causes headache, changes blood pressure and blood structure, loss of hearing, and fatigue. It action is transmitted through air, liquid, or solid body.

To protect people from ultra sound isolation method is applied. Shields are installed to separate the ultra-sound source from the people. Ultra-sound machines should be placed in specially equipped rooms. A properly designed control room can effectively reduce excessive levels. This is achieved by applying sound-absorbing material such as steel, duraluminium, plexiglas.

The total enclosure of the ultra-sonic machines should have a blocking network, which turns off the machine if the enclosure is damaged.

2.1.6.6. Vibration Exposure

Among all types of mechanical hazards, vibration is the most dangerous. Vibration is a mechanical oscillation (elastic wave) transferred through the solid body. Every elastic body or system driven out of balance has a period and frequency of oscillation. Oscillations of that kind are called natural oscillations, which fade in time for motion energy to transfer into friction and eventually heat.

The biological effect of vibration also depends on the part of the body to which it is applied to. There are two major types of human exposure to vibration: vibration transmitted to the whole-body through a supporting surface, for example, the feet of a standing person or the buttock of a seated person; and vibration applied to a part of the body i.e. segmental vibration. When vibration is applied to the hand, it is termed a 'hand-arm' vibration.

Vibration affects the physiological and functional condition of a person. Stable changes in physiological condition are called vibration disease. Symptoms of vibration disease include headache, fingers numb, wrist and forearm pain, cramps, increased sensitivity to cold, and and sleeplessness. It also causes pathological changes in the spinal cord, cardiovascular system, bones and joints, and capillary blood circulation. Each part of the human body has its own natural frequency of vibration, therefore the extent to which the human body is affected depends on the vibration frequency. Vibration whose frequency is close to the vital frequency of the internal organs, most of which is within 6-30 Hz, is extremely dangerous. It causes resonance which, in turn, results in shifting organs or even damages.

Resonance frequency of some organs:

- eyes – 22-27 Hz;
- throat – 6-12 Hz;
- chest – 2-12 Hz;
- head – 8-27 Hz;
- face – 4-27 Hz;
- stomach – 4-12 Hz;
- arms and feet – 2-8 Hz;
- spine – 4-14 Hz.

Local vibration may have an impact on the heart and nervous system. The most unfavorable for a person is the simultaneous action of vibration, noise, and low temperature.

Local vibration is classified by source:

- transport vibration produced by moving vehicles;
- transport and technological vibration produced by machines working;
- technological vibration transferred to operators of stationary machines or to workplaces that do not have vibration themselves.

Vibration is characterized by three parameters: shift amplitude, oscillation velocity, and oscillation acceleration. However, only two of them are practicable: shift amplitude (m) and oscillation velocity (mps). The oscillation velocity can be denoted on a logarithmic scale. In this case, it will be referred as oscillation velocity level, vibro-velocity level:

$$L_{\nu} = 10\log\frac{\nu}{\nu_{ref}} \quad (2.25)$$

where ν – oscillation velocity in specified point; ν_{ref} – referenced value, what is the threshold oscillation velocity equal $5 \cdot 10^{-8}$ mps.

Vibration assessment is carried out by the following methods:

- frequency (spectral) analysis of the specified parameter;
- integral analysis of the frequency of specified parameter;
- vibration doze.

2.1.6.7. Vibration Control

General methods for vibration control are classified as engineering, administrative, and prophylactic control.

Engineering control methods include: using new equipment, which eliminates risk of contact with vibration; design changes of machinery; adequate velocity; improving stiffness.

Administrative control methods include assembly and installation control, preventive maintenance,, and service.

Prophylactic control provides microclimate conditions and complex of physiotherapy procedures (bath, massage, gymnastic, ultraviolet exposure).

Vibration damping, vibration reduction, vibration isolation, and protective equipment are also applied as vibration control.

The term 'damping' refers to a property of materials that converts vibration energy into heat energy.

There are two types of damping: external surface damping; and constrained layer damping.

External surface damping can be in the form of a sheet bonded to the structure being damped, or a layer which is sprayed or painted on.

Constrained layer damping involves sandwiching a layer of viscoelastic material between the structure being damped and an outer constraining layer. This type of damping is used in applications where a large reduction in vibration is required. The constraint layer is chosen to be 2-3 times more thick than the damped structures.

Damping can also be reached by using lubricant between two machine parts which the the the the possibility of their contact and reduces friction, which is a vibration source.

Vibration reduction is achieved by including into the oscillating system of additional masses or increasing its stiffness. To reduce vibration spring, pendular, eccentric, and hydraulic dynamic reducers are applied. Their common disadvantage is that they are effective only at resonance frequency.

Impact pendular vibration is applied to reduce vibration at frequency 0.4-2 Hz, spring – 2-10 Hz, floating reducers – over 10 Hz.

Massive engine seating is also used to reduce vibration. Its mass is chosen so that the seating oscillation is kept under 0.1-0.2 mm.

Vibration isolation techniques aim at disassociating the vibrating part from the force that causes it to vibrate.

The ideal system is that in which the vibration generator is separated from its supporting structure by a free space. In practice, placing an isolator between them normally separates it. There are various vibration isolators commercially available in the form of springs, rubber mounts, elastomer types (compressed or shear, ribbed Neoprene), other compressible materials such as cork, or fibrous mats made of felt or fibres.

Selecting a proper vibration isolator requires consulting expert to know the lowest forcing frequency of the machine to be isolated, the natural frequency of the isolator, total weight, and lowest forcing deflection required.

Once a suitable isolator (spring or pad) is chosen, uniform distribution of deflection should be ensured.

Protective equipment is the least step in the control hierarchy. It includes gloves, inserts, spacets to protect hands, special shoos, soles to protect legs, protective suits, and belts to protect the whole body.

Prophylaxis for vibration disease includes recommendations for the duration of the work shift. For example, manual handling work in contact with vibration should not take longer than 2/3 of the work shift. Therefore, the duration of direct contact with the vibrating tool, including short pauses, should not exceed 15-20 min. Additionally, two rest breaks are foreseen.

All vibration-activated employees must pass a medical examination before entering the job and periodically at least once a year.

2.2. Electrical Safety

2.2.1. Biological Effect of the Electric Current

Analysis of accident records shows that the amount of injuries caused by electric current makes up about 1% of the total occupational accidents. However, 40% of all occupational fatal accidents are caused by electricity, incidentally, 80% of those happen in the workplace under voltage up to 1000 V.

Electric current passing through the human body generates thermal, electrolytic, mechanical, and biological effects that are potentially hazardous to vital organs: brain, heart, and and lungs. Among other occupational hazards, electricity has specific features:

1) human organism has no organs capable of remotely sensing voltage, that is why it resists electricity only after contact;
2) current passing through the body causes not just injury in contact areas or ways to pass, but also reflex reaction that affects respiration organs, cardiovascular, and nervous system;
3) possible electric injury may occur not only through contact with machinery under voltage, but even without it through electric arc or pace voltage.

2.2.2. Types of Electrical Injuries

Electric current may cause burns, heating vascular and nervous system, heart, brain (thermal effect); electrolyze of liquid, violation of physical and chemical blood structure (chemical effect); tear of tissues, fracture (mechanical effect); changing biological processes and irritating tissues (biological effect). All mentioned effects result in electric injury and shock.

Electric traumatism is an event compiled from totality of electrical injuries occurring and repeating in occupational, home, recreational, or volunteer situations. Electrical injuries are caused by temporary or permanent situations that are followed by an accident during the exploration of power plants.

Electrical injury is a consequence of an electric current or an arc action. It may be of two types: those that are caused by electric current passing through the body and those that occur without electric current passing through the body.

There are local and total electrical injuries.

Local electrical injury results in local damage to the organism. Frequently, they cause damage to the skin, soft tissues, and bones. Local electrical injuries are typically reversible and recovery is complete or partial. However, heavy electric burns can be fatal.

Electrical injuries statistically have the following risk rating, %:

- electric burn – 40;
- electric trace – 7;
- electric metallisation – 3;
- mechanical damage – 0.5;
- electric ophthalmia – 1.5;
- electric injury of composite type – 23;
- total – 75.

Electric burn can be of two types: current burn, which occurs when electric current passes through the human body, and arc burn caused by high temperature of electric arc, that reaches over 3500°C.

Electric trace is the clearly identified spot of gray or light-yellow color of 1-5 mm in diameter that appears on the skin effected by electric current.

Electric metallisation is penetration into the skin of metal particles when it is sputtering and vaporizing under high voltage. It may occur on disconnecting the switch with a knife and short circuit. This injury is observed in about 10% of accidents.

Simultaneously with metallisation an arc burn occurs that is always even more hazardous than metallisation.

Mechanical damage to the body appears as a result of cramp during the passage of the electric current through the body. The consequences of that can be tears of ligament, skin, blood vessels, and nervous tissue, fractures of bone. They occur during long-term exposure to voltages up to 1000 V.

Electric ophthalmia is irritation of the mucous membrane of the eyes that occurs when exposed to intense ultraviolet luminous flux. This exposure is produced by an electric arc (short circuit). Electric ophthalmia develops 4-8 hours after exposure. It causes irritation to the skin, mucous membrane, tears, eye pus, eyelid cramps, and partial loss of sight. It feels headache and acute eye pain, which increases with light.

Electrical shock is a sensation of living tissues caused by an electric current followed by cramps. It is most dangerous to the heart or lungs and may be fatal. Electrical shocks may affect differently. The least shock feels slightly as muscle contraction close to the area where the current enters or exits. Shock of greater intensity can violate or even stop lungs and heart functioning, which means be fatal. Electrical shocks can be classified into five classes according to the consequences they cause:

I – slight muscle contraction;

II – cramp muscle contraction followed by great pain that can hardly be sustained without loss of consciousness;

III – cramp muscle contraction with loss of consciousness, but respiration and pulse are still present;

IV – loss of consciousness and violation of heart functioning or/and respiration;

V – clinical death, which is the absence of pulse and respiration.

Clinical death is a transient period from life to death. The indication of clinical death is the stop of heart functioning; consequently, it is observed as no pulse, no breathing, pale and blue skin color, wide eyes' pupils not reacting to light as a consequence of oxygen starvation of the brain. Brain cells die during clinical death. It lasts 6-8 minutes, then comes biological death.

2.2.3. Why Electrical Injury Can Be Fatal

The main causes why electrical injury can be fatal are cardiac arrest, respiratory arrest, or electric shock. Two or three of these causes can act simultaneously. Stopping the heartbeat is the most dangerous as it may be irreversible. The action of electric current on heart muscles can be direct, when the current passes through the heart, and reflex, which means through central nervous system when the current passes through some area even beyond the heart. Heart stop or fibrillation follows both cases.

Heart fibrillation is chaotic and not synchronous contraction of heart muscle fibres (fibrils), which does not provide blood circulation. Fibrillation may occur when current 50 mA with frequency 50 Hz passes through. The period is very sort and finishes as death.

An electric current greater than 25 mA at 50 Hz induces asphyxia, which is feeling sick due to the lack of oxygen and the overall amount of carbon dioxide. Consequently, losing consciousness, sensation, reflex, later stopping breathing and heartbeat or fibrillation and eventually clinical death follow asphyxia.

Electric shock is a heavy nervous and reflex reaction of the organism to electric current which is followed by a deep violation of blood circulation, respiration, and substance exchange. Shock may take from dozens of minutes to several days. During this period, a person can die from total fading of vital functions or can survive if medical help is applied in time.

2.2.4. Basic Factors Resulting in Electric Injury

The current is the most effective factor. The more current the higher is risk of injury. Threshold (minimum) currents (at the 50 Hz frequency) are classified below:

- The sensitivity threshold current is 0.5-1.5 mA of alternating current (AC) and 5-7 mA of direct current (DC);
- The cramp threshold current (current that results in irresistible muscle contraction of the arm holding the conductor during the electric current passing through the body) is 10-15 mA, AC and 50-80 mA, DC;
- The fibrillation threshold current (current that induces heart fibrillation during electric current passing through the body) is 100 mA, AC and 300 mA, DC.

The acceptable level of current in normal (nonemergency) operation of electric facilities should not exceed such values: 0.3 mA, AC, 50 Hz; 1 mA, DC. In a work zone with high air temperature (over 25°C) and high air humidity (over 75%) acceptable level should be 3 times reduced.

The electric resistance of the human body is the resistance to the current passing through part of the body between two electrodes that contact the body. It consists of the resistance of the surface skin layer of the the resistance and inner organs.

For practical calculation, the value of human body resistance is considered equal to 1000 ohm; however, several inner organs are differently sensitive to current.

The most dangerous for human beings is the current in the frequency range from 20 to 200 Hz. At the frequencies lower and upper that range, the danger of electric injury is reduced and completely disappears at 450-500 Hz, meaning that the current at such frequencies cannot cause fatal injury of heart, lungs or other vital organs. However, that current retains the danger of burns possible from an electric arc or in places of contact with the wire under voltage. The current value at 50-100 Hz frequencies doesn't practically change; it's 2 times higher at 200 Hz and three times higher at 400 Hz.

The direct current is 4-5 times safer than the alternative current at the 50 Hz frequency. Passing through the body, it causes muscle contraction of smaller intensity and is not as an painful as alternative current of the same value. A person feels pain only at the moment when the power is turned on or off as the muscles contact convulsive. The comparative analysis of alternative and direct current is true only for voltages under 500 V. There is an assumption that if voltage is higher 500 V DC becomes even more dangerous than AC at 50 Hz.

Duration of exposure to current is critical to determine its consequence: probability of major or even fatal injury grows with time the person is under voltage. Long-term exposure to current makes it possible to coincide with vulnerable heart phase (cardiocycle). In addition, the current grows with time, which is explained by decreasing body resistance because of the local heating of the skin and exciting tissues.

In fact, the heart is differently sensitive to the current in its different work phases. It is most vulnerable in the T phase which lasts for 0.2 seconds. If a current, of the certain value, coincides with the T phase, it results in fibrillation.

The consequences of electric shock depend on the way the current passes through the body. If it crosses vital organs such as the heart, lungs, or brain, that will be very dangerous. If it goes around vital organs, they will be affected only by reflex reaction. It is still dangerous, but unlikely. The human body has about 15 ways all together the current may pass through. These ways are called loops, the most frequent are: hand-hand, right hand-feet, left hand-feet, foot-foot, head-foot, head-hands. The most dangerous loops pass through the heart and brain.

In fact, healthy and physically strong people sustain electrical impact easier than weak or sick ones. People who have a problem with the skin, cardiovascular system, organs of inner secretion, lungs, and nervous system are most vulnerable to electric shock.

Psychological training for the risk of electrical shock is practicable. Most cases show that unexpected electric shock, even of a small voltage, may have a big consequence. On the contrary, when a person is ready for possible shock, the heaviness of consequence is significantly decreased. In this context, attention, focusing in work, and fatigue are considered. Experience and skills are important to evaluate the situation and find effective measures to break free from the voltage and allow accidents to be avoided. According to all said safety rules, medical examination of a personality who works with power facilities at the beginning of work and periodically.

Classification of electrical danger work areas. The consequence of the electrical impact depends on environmental conditions. All occupational areas are divided by electric danger into three categories.

1. High danger areas are those having one of the following conditions: high humidity exceeding 75%; floor (metallic, earth, ferroconcrete floor) or dust (metallic or carbon dust) conducting electricity; high air temperature exceeding 30 deg C; likely simultaneous touching of unguarded metallic cases of electric equipment and grounded constructions.

2. Extreme danger areas are those that have one of the following conditions: overall humidity about 100%; presence of chemical or organic active substances (vapours or condensates, which act destructively on insulation and conductors in the work area constantly or for a long time); simultaneous action of two conditions referred to high danger areas.

3. Areas without high danger do not have any conditions to be in high or extreme danger.

2.2.5. Causes of Electrical Injuries

The main causes of electric trauma are:

- personality low training, improper testing of knowledge, and giving qualification groups on safety rules;
- breaking operation and safety rules of power facility;
- improper organisation of work;

- breaking regulation referred to work in protected areas, electric cables, and transmission lines;
- insulation damage;
- grounding wire damage;
- using protective equipment not appropriate for work conditions;
- conduct mounting or repairing works under voltage;
- using wires and cables not admitted for certain work conditions and voltage;
- low quality of mounting and repair work;
- incorrect risk assessment of a pace voltage when the feet of person are at points with different electric potentials;
- repairing the neutral wire of the aerial power line when the power is on;
- power supply of several users from joint switch equipped with fuse designed to shut down the most powerful user;
- neglect the necessity of shutting power down in time off work;
- not using personal protective equipment or using one not tested one;
- periodic skipping check of insulation resistance (power line, engine winding, communication line, relay) and grounding resistance;
- using a power facility with insulation resistance lower the standard; using a not licenced power facility;
- low instructing workers handling manual power facilities;
- missing monitoring work by supervisors or employees;
- absence of labelling, signal words, blocking, signaling in restricted areas or repairing works.

Those causes can be classified by the following factors:

- touching conductor of facility under voltage caused by breaking safety rules, engineering defects, mounting defects;
- touching part of facility that turned out to be under voltage because of insulation damage, short circuit;
- accidental power supply of the facility operated by workers;
- missing reliable protective equipment.

2.2.6. Assessing Risk Associated with Operating Power Facilities

Assessing risk associated with operation of power facility is focused in estimation of current in all possible variants of its flowing through the human body, which turned out to be under voltage after touching conductor or some part of power facility not purposed to transfer electricity but being under voltage because of insulation damage, or under pace voltage.

Power lines are of two types: A and DC. Alternative current power lines can be one-phase or polyphase. The most widely spread polyphase power lines are three-phase AC power lines. Depending on the mood of neutral operation, power lines are those with insulated neutral and those with grounded neutral. Insulated neutral means that the neutral power line wire is insulated from grounding or is connected to it through a facility with very high resistance (voltage transformer, compensation coil). Neutral is called grounded when it is connected to grounding directly or through a facility with a small resistance (current transformer).

2.2.6.1. Danger of a One-Phase Power Line

One-phase power lines and direct current power lines can be insulated from the ground, have a ground pole, or have a centre tap.

During one-pole touching of the conductor, a person gets connected to another conductor through ground resistance (Fig. 2.1).

Since one-phase power lines are not extended, the capacitance of their conductors can be neglected, and as for DC lines, such capacitance equals zero. To simplify the formula for current calculation, ground currents of both conductors are assumed equal, so are their insulation resistances:

$$r_1 = r_2 = r \tag{2.26}$$

Current passing through the human body can be found in the scheme (fig. 2.1):

$$I_h = \frac{U}{r + 2R_h} \tag{2.27}$$

where U – resistance of the voltage, V; R_h – human body, ohm; r – conductors' insulation resistance of conductors, ohm.

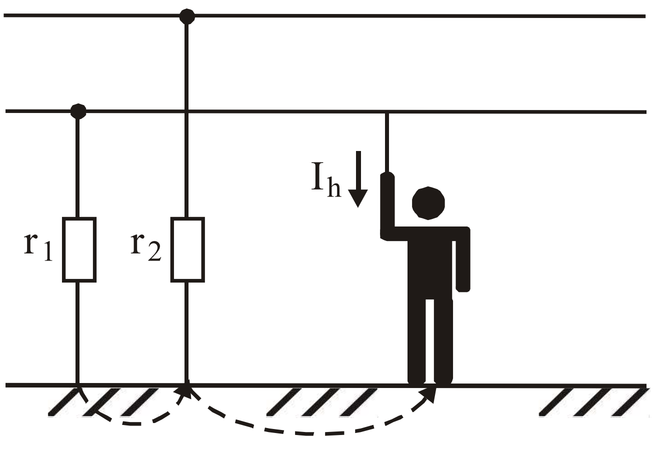


Fig. 2.1. Scheme of person connection to conductor of an insulated power line [43]

Touching a conductor of the power line not grounded with grounded pole (fig. 2.2) causes current passing through the human body that is:

$$I_h = \frac{U}{R_h + R_o} \tag{2.28}$$

where R_o – grounding resistance, ohm.

Taking into account that $R_o << R_h$ formula will look as:

$$I_h = \frac{U}{R_h} \tag{2.29}$$

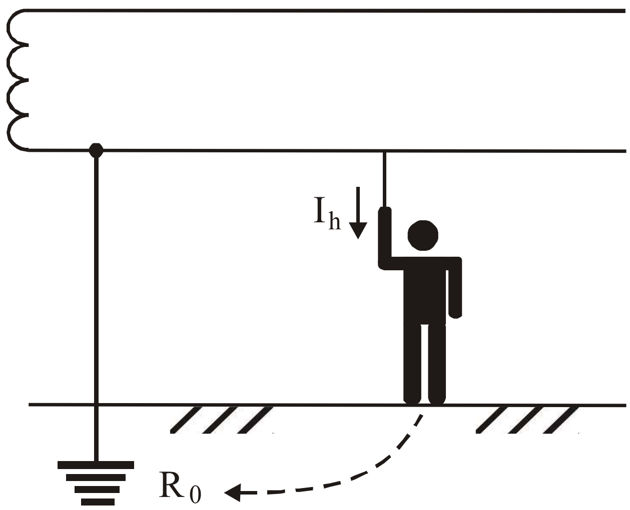


Fig. 2.2. Scheme of person connection to non-ground conductor of power line with grounded pole [43]

The connection to a normal conductor when another conductor is damaged and has a short circuit with the ground is shown in Fig. 2.3. This connection causes current:

$$I_h = \frac{U}{R_h + R_{sc}} \tag{2.30}$$

where R_{sc} – short circuit, ohm.

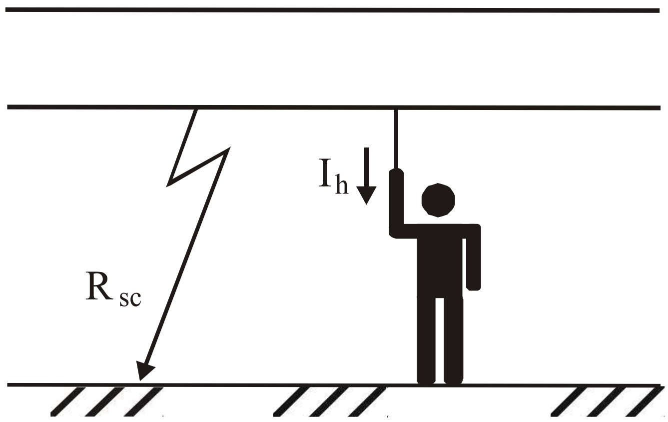


Fig. 2.3. Scheme of person connection to conductor of damaged power line [43]

If person touches a conductor of power line with grounded centre tap (Fig. 2.4), he turns out to be under voltage making half of total line voltage, so the current will be:

$$I_h = \frac{U}{2(R_h + R_{ct})} \tag{2.31}$$

where R_{ct} – grounding resistance of centre tap, ohm.

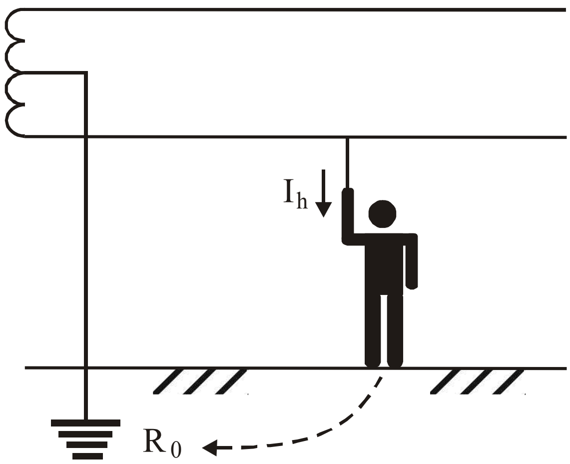


Fig. 2.4. Scheme of person connection to conductor of the power line with grounded centre tap [43]

The two-pole connection to the power line (Fig. 2.5) gets a person under total line voltage and current to be:

$$I_h = \frac{U}{R_h} \tag{2.32}$$

Analysis of all studied formulas testifies that the case of two-pole connection to the power line is the most dangerous regardless of neutral operation mode, because in this case the current passing through the person depends only on the resistance of the human body. The least dangerous is the connection to the conductor of the insulated power line in normal operation mode.

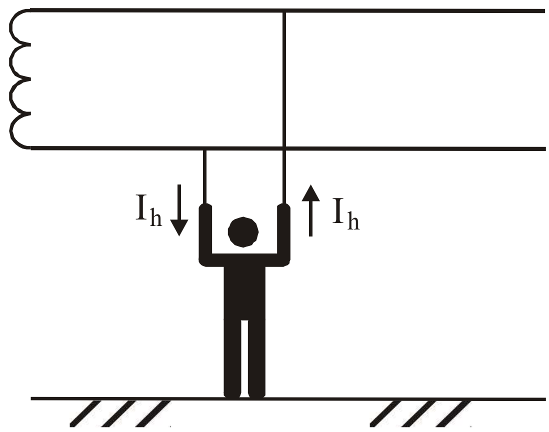


Fig. 2.5. Scheme of person connection to two conductors of the power line [43]

2.2.6.2. Danger of a Three-Phase Power Line with Insulated Neutral

As to the ground, all power line conductors have capacitance and resistance, which makes insulation that separates conductors from the ground (Fig. 2.6). Actually, the values of capacitance and resistance differ for different conductors. However, to simplify analysis, we will consider them the same:

$C_a = C_b = C_c =$ and $r_a = r_b = r_c = r$.

The case of a person touching one of the three phase conductors (one-phase connection) of the power line in a normal mode results in current that can be calculated by the formula:

$$I_h = \frac{3U_{ph}}{3R_h + Z} \tag{2.33}$$

where U_{ph} – phase voltage, V; Z – complex resistance of phase conductor to the ground:

$$Z = \frac{r}{1 + j\omega rC} \tag{2.34}$$

where $\omega = 2\pi f$ – angular frequency of the power line, f – current frequency.

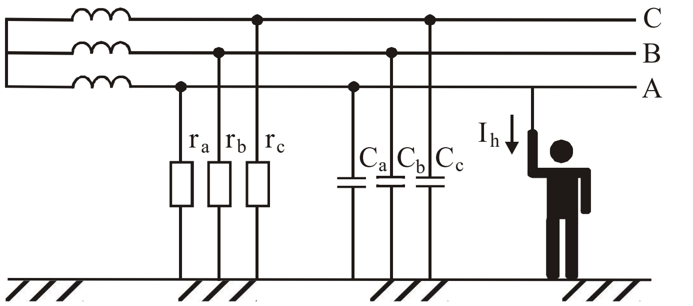


Fig. 2.6. Scheme of person connection to one phase of power line in normal mode [43]

If power lines are short, then phase conductors have a low capacitance to the ground (C = 0) formula to calculate the current passing through the person will look as follows:

$$I_h = \frac{3U_{ph}}{3R_h + r} \tag{2.35}$$

In case of a two-phase connection (Fig. 2.7) a person turns out to be under linear voltage, so the current will be:

$$I_h = \frac{U_1}{R_h},$$

where U_l – linear voltage, V; it is defined as: $U_l = \sqrt{3}U_{ph}$.

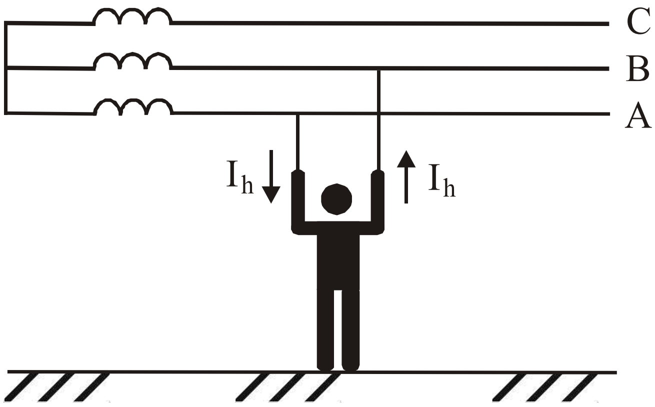


Fig. 2.7. Scheme of two-phase connection to a power line in normal mode [43]

Case of a one-phase connection to the power line in emergency mode (Fig. 2.8), when another phase has a short circuit with the ground, causes the current:

$$I_h = \frac{U_l}{R_h + R_{sc}} \tag{2.36}$$

If $R_{sc} << R_h$ then:

$$I_h = \frac{U_l}{R_h} \tag{2.37}$$

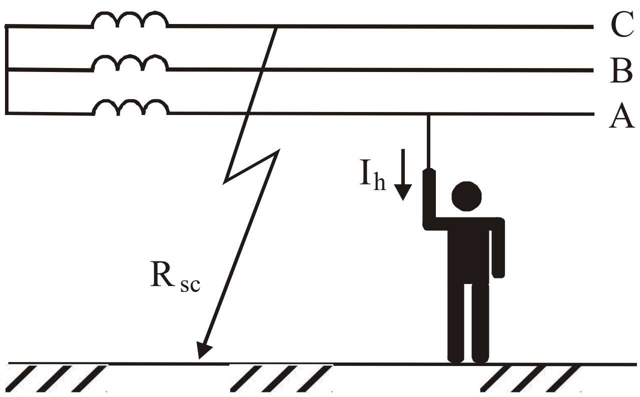


Fig. 2.8. Scheme of one-phase connection to a power line in emergency mode [43]

Thus, the current passing through the person in the case of a one-phase connection to a power line with an insulated neutral in normal mode depends on the insulation resistance and capacitance to the ground. The case of short circuit of one phase to the ground significantly increases the danger of one-phase connection since the person turns out to be under voltage close to linear. The most dangerous case is the case of two-phase connection.

2.2.6.3. Danger of a Three-Phase Power Line with Grounded Neutral

The three-phase power line with grounded neutral has low resistance between the neutral wire and the ground. In normal mode, the voltage of any phase wire to the ground is equal to phase one. The case of one-phase connection (Fig. 2.9) is characterized by current:

$$I_h = \frac{U_{ph}}{R_h + R_o} \tag{2.38}$$

where R_o – grounding resistance of neutral.

Since R_o << 10 ohm, it cannot be considered for calculation:

$$I_h = \frac{U_{ph}}{R_h} \tag{2.39}$$

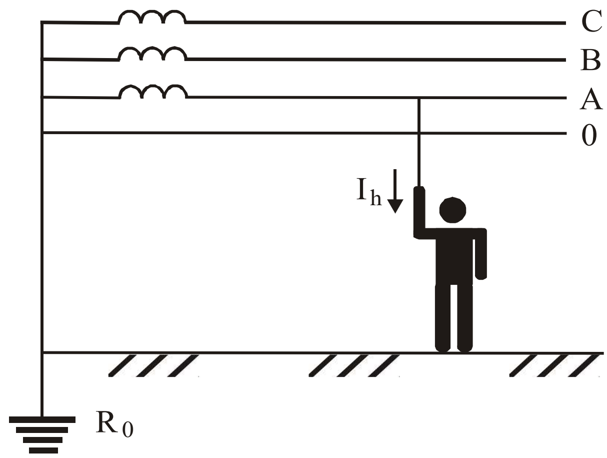


Fig. 2.9. Scheme of a one-phase connection to a power line with grounded neutral in normal mode [45]

The two-phase connection (Fig. 2.10) gets person under linear voltage just like in power lines with insulated neutral and the current is calculated by the formula:

$$I_h = \frac{U_l}{R_h} \tag{2.40}$$

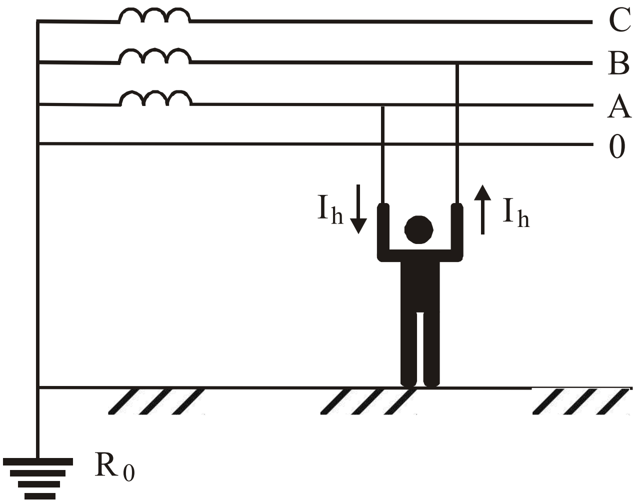


Fig. 2.10. Scheme of two-phase connection to a power line with grounded neutral in normal mode [45]

In emergency mode, the voltage of undamaged wires to the ground is different from the phase voltage because the damaged wire changes the voltage distribution on the ground. The person touching the undamaged phase wire person gets under voltage U_l', which is higher than phase one but lower than the linear one (Fig. 2.11) and the current will be calculated as:

$$I_h = \frac{U_l'}{R_h} \tag{2.41}$$

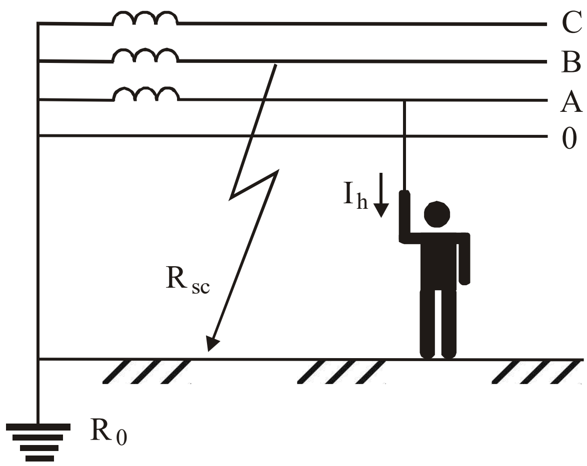


Fig. 2.11. Scheme of one-phase connection to a power line with grounded neutral in emergency mode [45]

Thus, the case of one-phase connection to the power line with the grounded neutral in emergency mode is more dangerous than the case in normal mode. The two-phase connection remains the most dangerous.

Analysis of various cases in which the person can be connected to a power line indicates the following:

- the least dangerous is the one-phase connection to a power line with neutral in normal mode;
- the emergency mode of power line operation is always more dangerous than the normal mode, regardless of the neutral mode;
- the most dangerous is the two-phase connection whatever neutral mode is.

Breakaway voltage – is the voltage between two points of an electric circuit a person simultaneously touches. It is equal to the difference in potentials in place of contact with facility's case φ_c and spot on the ground under the feet φ_f (fig. 2.12):

$$U_{bv} = \varphi_c - \varphi_f = \frac{I_g\rho}{2\pi}\left(\frac{1}{X_g} - \frac{1}{X}\right) = \frac{I_g\rho}{2\pi}\frac{X - X_g}{X} \qquad (2.42)$$

or

$$U_{bv} = U_g\alpha \qquad (2.43)$$

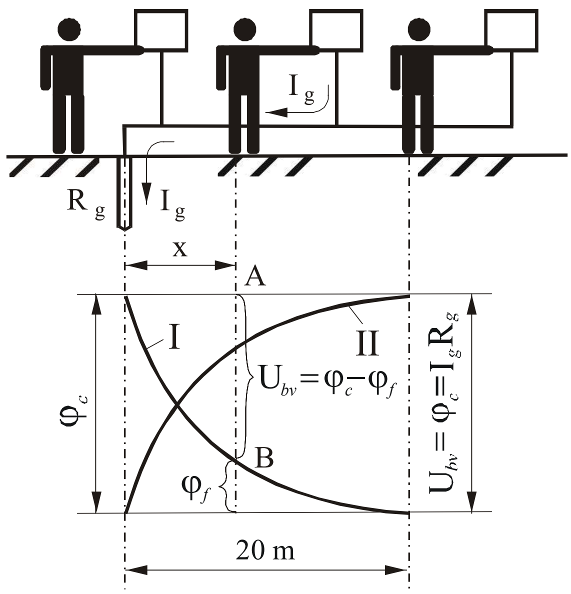


Fig. 2.12. Breakaway voltage in the presence of one grounding electrode: I – potential curve; II – curve that characterises the breakaway voltage U_{bv} according to the distance from the grounding electrode x [45]

Symbol α is called breakaway voltage factor. In current spreading zone $\alpha < 1$, and over its margins $\alpha = 1$.

Breakaway voltage increases with increasing distance to grounding and is equal to the voltage on the power facility's case outside the current spreading zone.

The current passing through the person is:

$$I_h = \frac{U_{bv}}{R_h} \tag{2.44}$$

Pace voltage – is the voltage between two points of electric circuit, which are at one step distance between one another and which a person is simultaneously standing on. It is equal to the difference of potentials in points under feet (Fig. 2.13).

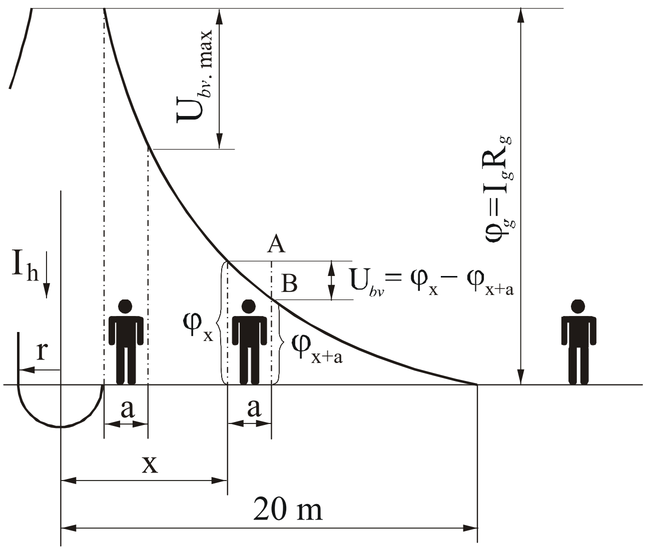


Fig. 2.13. Pace voltage [45]

When one foot of the person is at distance *x* from grounding and another is at distance of one step α from the first one (practicable $\alpha = 0.8$ m) pace voltage equals:

$$U_{pv} = \varphi_1 - \varphi_2 = \frac{I_g \rho}{2\pi}\left(\frac{1}{x} - \frac{1}{x+\alpha}\right) = \frac{I_g \rho}{2\pi}\frac{\alpha}{(x+\alpha)} \tag{2.45}$$

or

$$U_{pv} = U_g \beta \tag{2.46}$$

where β – pace voltage factor that depends on the type of grounding electrodes, distance from grounding, and step (the closer to the grounding and the wider is the step the more is β):

$$\beta = \frac{\alpha x_g}{x(x+\alpha)} \tag{2.47}$$

The pulse voltage is maximal close to the grounding and reduces with increasing distance from it. Out of the zone of current spreading, it equals zero. Also, the broader is a step, the more is pace voltage.

The current caused by pace voltage is:

$$I_h = \frac{U_{pv}}{R_h} \tag{2.48}$$

Breakaway and pace voltages are different to harm a person because they produce current passing different ways. Breakaway voltage causes current passing through the chest and pace voltage – through the lower loop. High pace voltage induces foot cramps making person fall down, later the current circuit gets in loop the whole body.

2.2.7. Electrical Safety Systems

Protective systems applied for power facilities are divided into two groups: those providing safety in normal mode of operation; and those providing safety in emergency mode.

2.2.7.1. Technical Protective Systems Applied to Power Plants in Normal Operation

Electric insulation is the nonconductor (dielectric) or the assembly made of dielectric, which covers conductor or separates conductors from each other. Electric power, dielectric loss, and electric resistance characterise insulation. Owing to high resistance, insulation prevents current from passing through it.

To provide reliable work of insulation, preventive measures are foreseen. Mechanical damage, moisturising, chemical substances, and dust should be removed. Insulation damage may cause a short circuit, which in turn leads to fire or electric injury. Therefore, insulation control should be conducted periodically (1 time for 3 years). Insulation resistance is measured by megger when tested line is shut down.

Insulation resistance standards are established for different conductors. For example, the insulation resistance of power and lighting conductors should be not less than 0.5 mega ohm. It is practicable to use double insulation made of the main insulation layer and the additional layer, which serves to protect from electrical damage if the main layer is damaged. Double insulation is used in facilities of not high voltage, such as electric drill with plastic case, electric razor, and electric fan. However, it does not provide reliable protection in the event of a contact of the conductor caused by facility damage or during repair. Double insulation is also used in power facilities, such as switchboard, switch, socket, plug, glow lamp socket, hand lamps, jack cords, electric measuring instruments, and electric manual tools.

One of the protective measures applied for facilities under voltage over 1000 V is using stationary guarding, which is solid and cage-style. Solid guarding that looks like a casing is used in facilities under voltage up to 1000 V. The cage guard has a lockable door. Guarding also includes temporary portable guarding (shield, insulating cover, insulating cap). The protection is equipped with a cover or door with lock or blockage.

Blocking is an automatic mechanism, which prevents someone from being misled or not paying attention. Blocking elements are mechanical appliance, detent, figure extrusion, block-contacts designed to prevent person connection into power line.

Electric blocking allows power to be shut down when facility's guarding is removed (opening the guarding door, cover etc.). Opening the door or cover disconnects blocking contacts mounted there. This provides safety even in case of occasionally open a guard door or cover, since power facility is off.

Setting conductors at an unreachable height or place provides safety without guarding and blocking. Aerial power lines are mounted at height depending on voltage and location.

Preventing electrical injuries is done by using manual electric tools if the insulation is damaged and voltage rises on the case surface. The acceptable limit for the voltage is 42 V. The current caused by the voltage below that limit is safe for person. Low voltage is used in local lighting of machine tools,, hand lamps, electric tools etc. Voltage up to 12 V is used to supply hand lamps in extremely dangerous areas.

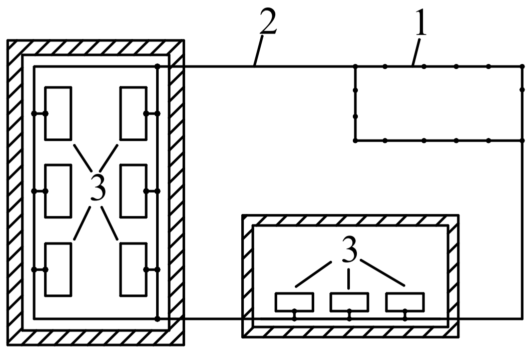
The step-down transformer, accumulator, rectifier, frequency converter, and galvanic cell battery produce low voltage.

Equaling potentials is lowering breakaway or pace voltage between points of an electric circuit to which a person may have a simultaneous connection. It is achieved by increasing the potential of the ground up to the level of the conductor potential.

Equalisation potentials are used for one-phase repairing of high voltage power lines.

2.2.7.2. Technical Protective Systems Applied to Power Plants in Emergency Operation

Protective grounding is dedicated electric connecting to the ground of metallic parts, which may turn out to be under voltage. Its purpose is to eliminate the risk of electrical injury when the power is short-circuit in the facility's case. The principle of its operation is to reduce the breakaway voltage and pace caused by short circuit to safe limits. It is achieved by equalising potentials of grounded facility and ground (Fig. 2.14).



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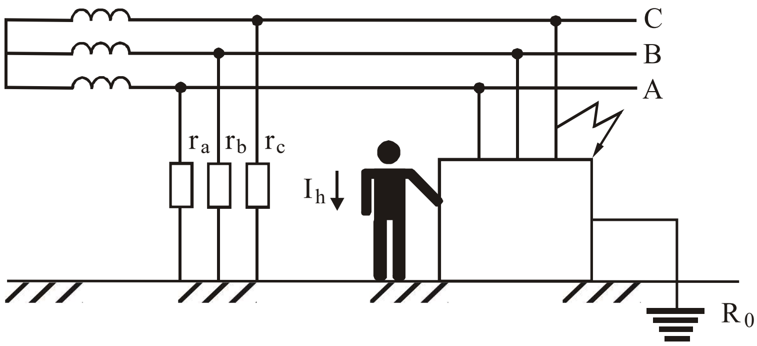

b

Fig. 2.14. Protective grounding: *a* – external grounding scheme (1 – grounding electrodes; 2 – ground wire; 3 – grounded facilities); *b* – person's connection to facility's case when phase has short circuit to the case [45]

Protective grounding is applied in three-phase power lines with voltage up to 1000 V with neutral operation of any mode of operation.

Constructively protective grounding is the assembly of ground wire and grounding electrodes.

The ground wire is a conductor to connect the grounded facility with the grounding electrodes.

Grounding electrodes are the assembly of conductors that contact the ground or its equivalent. They may be special vertical and horizontal electrodes or other metallic things put under ground.

Vertical electrodes are made from steel pipe 3-5 cm in diameter and steel corner plate having section size from 40×40 to 60×60 mm and length 2.5-3 m. It is also possible to use metallic wires of 10-12 mm in diameter. The horizontal electrode (flat bar) is used to connect all electrodes together in whole assembly, it can be made from a steel strip with section size 4×12 mm or steel pipe with diameter of 6 mm as minimum.

The grounding electrodes are deep into the ground so that the upper flat bar should be at 0.7-0.8 m under the earth. First, they dig a trench to the needed depth and then drive electrodes into the earth.

As 'natural' grounding electrodes, the following can be used:

- water supply pipelines, and other ones except those with inflammable substances or explosive gases or pipelines covered with corrosion-resistant insulation;
- casing of an artesian well, bore-hole, bore pit;
- steel armature, ferroconcrete reinforcement, which has contact with the ground;
- lead cover of cable installed on the ground.

Natural grounding usually has low ground resistance what makes it cheap and practicable. However, its use has some demerit as it is reachable for not electrical personality, so there remains the risk of damage and disconnecting it from all grounding system.

In accordance with the Rules for Installing Power Facilities (RIPF), the resistance of grounding should not exceed:

- 4 ohm – in power facilities under voltage up to 1000 V; using a generator or transformer with power up to 100 kilowatts, grounding resistance is allowed to be up to 10 ohm;
- 0.5 ohm – in power facilities under voltage over 1000 V with effective grounded neutral;
- $\frac{250}{I_g}$, 10 ohm as maximum – in power facilities under voltage over 1000 V with insulated neutral; if grounding is used simultaneously in power facilities under voltage up to 1000 V, grounding resistance should not exceed $\frac{250}{I_g}$, 10 ohm as maximum (or 4 ohm, if needed for power facilities under voltage up to 1000 V); I_g – current in the ground.

Protective grounding is applied to metallic parts of the facility, which may turn out to be under voltage caused by insulation damage. It is obligate to use in extreme-risk areas and for outside installations under voltage over 42 V of AC and over 110 V of DC, in areas without high danger – under voltage over 380 V of AC; over 440 V of DC. Only in explosion risk areas is grounding applied irrespective to the voltage.

Protective grounding is not applied to the case of facility, instrument or tool if they are installed in the grounded metallic construction, switchboard, distribution cabinet or tool frame of machine and mechanism and have reliable electric connection with grounded base, and also insulation armature of all types, exhaust ventilation, cantilever and lighting armature when they are installed at wooden beam of aerial power line, or wooden construction of outer substation.

Protective neutralizing is dedicated to connecting metallic parts, which may turn out to be under voltage to the neutral wire (Fig. 2.15). It is the basic way of preventing electric injury in case of a touching case of facility that turned out to be under voltage caused by insulation damage or a one-phase short circuit in facilities under voltage up to 1000 V of the power line with grounded neutral. Protective neutralising has the same purpose as protective grounding: to eliminate the risk of electric injury in case of phase short circuit in the power facility's case.

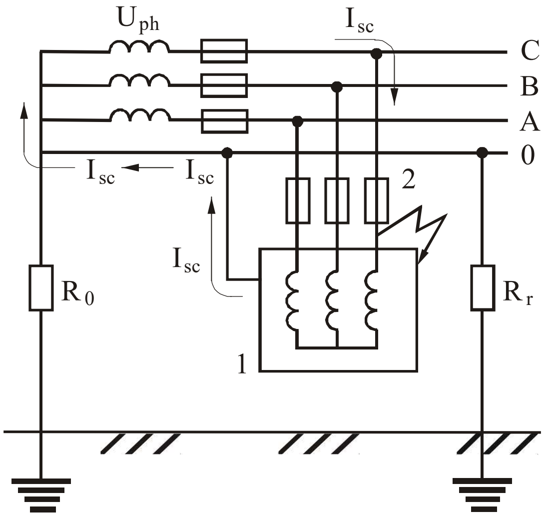

Fig. 2.15. Protective neutralizing: 1 case; 2 – short circuit preventive elements (pull-out fuse, fuse plug); R_o – resistance to neutral grounding; R_r – resistance of reserve neutral grounding; I_{sc} – short-circuit current [45]

It is achieved by automatically shutting down the damaged facility. It works protective when the case or cover of the electrical facility, which people may touch during operation, is under voltage due to insulation damage. This voltage is transferred into a one-phase short circuit, which is capable of shutdown power when quite high current passing through the fuse plug disconnects the power line.

For fast shutting down, the following condition should be fulfilled:

$$I_{sc} \geq kI_{nom} \tag{2.49}$$

where *Isc*, short circuit current, A; *Inom, nominal* fuse current, A; *k* – short circuit current ratio.

It is important to note that protective neutralizing never ensures complete safety as people may still be at the risk of electric injury until protective fuse reacts to short circuit. Protective neutralising is used in a three-phase power line under a voltage 1000 V as maximum with grounded neutral.

Protective shutdown is the fast measure to automatically disconnect the power facility when a danger of electric injury appears. The risk of electric injury can arise in the event of grounding failure, which may be caused by insulation damage and the reduction of the insulation resistance to the ground, in case of an overly high voltage in the power line caused by short circuit between high-voltage and low-voltage windings of the transformer. In these cases, the electric parameters of the power line get changed, which in turn can be used to activate protective shutdown. Protective shutdown should comply with the following requirements: high sensitivity (capability to react to small changes of the incoming signal), short turn-on time (under 0.2 sec), selective work (capability to shutdown power only of damaged facility), inside control (capability to shutdown power when protective shutdown is out of order), reliability.

Protective shutdown is recommended to use as basic or additional protection if it cannot be reached by installing protective grounding or if it is cheaper.

It is used in power facilities under voltage 1000 V as maximum, mobile facilities with insulated neutral, when the installation of protective grounding is inconvenient; using electric tools in stationary facilities; in conditions of high electric danger or high explosion risk.

2.2.8. Electrical Personal Protective Equipment

Electro-protective equipment includes portable means to protect people working on power facilities from electric current, electric arc, and electromagnetic field. All means are classified by their purpose: insulating, guarding, and additional equipment.

Insulating protective equipment is used to separate people from elements of power facility under voltage and also form the ground. It includes: insulated and measuring rods, rods to put temporary grounding; insulated and electro-measuring nippers; voltage indicators; insulated handles of mounters' tools; dielectric gloves, boots, overshoes; rubber carpets, maps, stands; insulated caps and covers; insulated step ladder.

Insulating protective equipment is divided into general and additional. General equipment is reliable to maintain the voltage of the power facility while touching conductor under voltage. Additional equipment cannot provide safety under voltage and serves as supplementary protection that is recommended to use together with general protection.

Protective protective equipment serves as temporary guarding from conductors. It includes mobile guarding (shields, screens, cages, barriers) and signal posters.

Additional protective equipment is to protect personality from falling from the height (safe belts and ropes), for safe climb (ladders, climbers), and also to protect from light, heat, mechanical, and chemical exposure (protective glasses, respirators, gloves, special uniform).

2.2.9. First Aid for Electrical Injuries

First aid is described as 'the immediate and temporary care of the victim of an accident, with the aim of preventing or reducing an acute threat to the life or health of the victim'. The description then refers to 'the application of immediate measures at the accident site by a person who may not be a physician, but is trained in first aid' and, 'has access to the necessary equipment and supplies'.

The key is that prompt first aid saves lives. The sooner help is available, the greater the chance of recovery.

First aid procedure:

- remove factors dangerous for the health or life of the victim and estimate his condition;
- identify the character and heaviness of the injury, and first aid sequence;
- apply first aid measures in order of their urgency (make sure that respiration tract is passable, apply artificial respiration and external cardiac massage);
- maintain main vital functions of the person until medical help arrives;
- call the ambulance or transport the victim to the nearest medical point.

The effectiveness of first aid depends on how fast a victim is released from under the voltage and also how fast and correct the first aid applied. Death caused by an electric current is often clinical, so never give up trying to apply first aid only because person's got no breathing and no pulse. The touching of the conductor under voltage induces muscle cramping and total exciting of living tissues that affect the heart or lungs. If the person grips the conductor it would be impossible to release. That is why the first action is to shut down the power. If you cannot do that try to release the victim from the conductors but do not touch him. To release victim form conductors under voltage up to 1000 V use rope, stick, board or any dry thing that does not conduct electricity. Someone who renders help should insulate his hands by putting on dielectric gloves or a winding scarf around the hand, covering the victim with a rubber carpet. Use only one hand to release the person from the conductor.

To release a person from conductors under voltage over 1000 V use dielectric gloves and boots and do it with rod with insulated nippers designed for appropriate voltage.

Don't forget about the pace voltage if the conductor is laying on the ground. Once victim is released, take him out of this zone. Without protective equipment, it is possible to walk in the current spread zone but holding feet as close as possible. The first aid procedure depends on the condition of the victim. Anyway, call the doctor.

If the victim regained consciousness, he should lay down, his clothes should be unbuttoned to provide easy respiration; he needs to have a rest, if needed, warm up his body. Victim who was unconscious and regained consciousness needs to drink 15…20 drops of valerian extract and hot tea.

The victim is not allowed to move and, moreover, work that may worsen his condition. If your respiration is frequent and convulsive, however, you must apply artificial respiration.

First aid aimed at resuscitation of vital functions, such as respiration and heart beat, should be applied to the victim in case the pulse and breathing are absent and consequently the skin and mucous membrane turn blue and the eyes open wide.

2.3. Occupational Safety Regulations

2.3.1. Protection from Atmospheric Electricity. Lightning-proof Categories and Zone Types

Lightning is a discharge of the spark of atmospheric electricity between clouds and the ground. Snail lightning is frequent and destructive. The weak lightning current produces electromagnetic, thermal, and mechanical effects on the object causing damage and fire. To provide protection from lightning for buildings and constructions, they use a range of measures.

Every building and construction regardless of its purpose is protected according to lightning-proof category and zone type (Table 2.1). According to the standard, all areas and buildings are divided into 5 categories of fire and explosion risk areas. Table 2.2 contains the expected average number of lightning strokes that reach 1 km2 of the ground.

Buildings referred to objects of categories I and II are protected from direct lightning stroke, electromagnetic and electrostatic induction, and high potentials transferring in through ground and underground constructions. Objects of category III are protected from direct lightning stroke and transferring in high potential through ground and underground constructions. The external objects referred to category II are protected from direct lightning stroke and its secondary factors, and those referred to category III are protected only from direct lightning stroke.

Buildings with rooms or areas, which need lightning-proof of the whole building, or building of categories I, II, and III are recommended to make lightning-proof following requirements referred to category I. If the area which needs lightning-proof makes less than 30% of the total area of a single-storey building, the whole building can be protected according to category II.

Buildings with rooms or areas that need lightning-proof of categories II and III are recommended to be lightning resistant following requirements to category II. If the floor area, which needs lightning-proof of category II makes less 30% of the total area of single-storey building, the whole building can be protected as category III, but protection from transferring high potential into areas of category II through the communication system should be foreseen.

Table 2.1. Category of lightning-proof equipment and protection zone type [28]

Building class by RIPF	Location	Protection zone type	Protective equipment category
1. B-I, B-II	All territory	Zone A	I
2. B-I*b*, B-I*a*	When $K \geq 10$	When $N < 1$ – zone B	II
3. Outside objects of category B-I*g*	All territory	Zone B	II
4. P-I, P-II, P-I*ia*	When $K \geq 20$	For buildings of class I and II of fire resistance when $0.1 < N < 2$ and III, IV and V class of fire resistance when $0.02 < N < 2$ – zone B; when $N > 2$ – zone A	III
5. Outside objects of category II and III	When $K \geq 20$	$0.1 < N < 2$ – zone B; when $N > 2$ – zone A	III
6. Fire resistance class III-V, which are not classified by RIPF	When $K \geq 20$	$0.1 < N < 2$ – zone B; when $N > 2$ – zone A	III
7. Stacks, towers over 15 m height	When $K \geq 20$	Zone B	III
8. Buildings of 30 m height, remote from the other buildings at distance over 400 m	When $K \geq 20$	Zone B	III

Note: K – average annual thunderstorm activity in hours per year; N – expected number of lightning strikes on buildings and structures that are not equipped with lightning-proof.

Table 2.2. Expected number of lightning strikes at 1 km^2 of the ground area n depending on the activity of the thunderstorm K [28]

Thunderstorm activity	Expected number of lightning strikes n
10-20	1
20-40	2
40-60	4
60-80	5.5
80-100	7.0
100 and more	8.5

Recommendations improving safety are: grounding electrodes are situated beyond public places, at the distance over 5 m from roads, under bitumen. To avoid pace voltage, grounding should be underground. The conductors must be mounted in an unreachable place.

2.3.2. Lightning-proof Installations

Lightning-proof and protection from atmospheric electric is ensured by:

- installing lightning-rod;
- installation of grounded metallic cells around outside objects;
- grounding facilities inside the building;
- making electric connection among close metallic elements of the building, such as pipelines, and grounding them.

Protection from lightning stroke is made with separate lightning rods or ropes set on building.

Lightning rods are selected according to the building plan. Lightning rods of objects referred to category I are not set on the building; however, they should have dielectric stand 8 m above the building, grounding resistance up to 10 m and be situated 8 m as nearest. The grounding resistance is to be 20 m as maximum in Category III.

To protect buildings and structures referred to categories II and III from lightning stroke, lightning rods are set separately or on the building as not insolated rods and ropes, or as metallic cell made from wire of 6…8 mm in diameter.

Connecting nearly situated metallic components of building, such as pipelines, in the places where less than 10 cm is between them along every 20…25 m prevents electric induction. The resistance of that connection should be 0.03 ohm as the maximum.

Grounding metallic parts of communication and other systems prevents the transfer of high electrical potential inside the building.

2.4. Fire Safety Systems

2.4.1. Fire Safety

The variety of technological processes and occupational objects presents many methods of preventing fires. Fire safety in areas with computer terminals is maintained by the Fire Safety Rules and other standards.

Buildings and their areas equipped with computers should have a second degree of fire resistance as minimum. Neighboring areas cannot be referred to category A and B of fire and explosion risk. The B category areas should be isolated from the areas with computers using fire resistant walls.

Fire-rated floors in computer areas are made from incombustible materials (or hard-combustible ones with fire resistance 30 min as minimum). The space under the detachable floor is separated with incombustible supports. The lower limit of the supports is 75 min. Communication cables are mounted through the supports in special rings using an incombustible seal to prevent spreading fire from one area to another.

Soundproof equipment is also made of incombustible or hard-combustible material.

Areas equipped with computers should have an automatic fire alarm system with smoke detectors and manual fire extinguishers in quantity 2 units for each 20 m^2 of the total floor area, which also considers limits of acceptable concentration of extinguishing substance.

Cables placed under the floor should be cleaned from dust at least.

2.4.2. Installations of Automatic Fire Detectors

Automatic fire detectors are installed throughout the work area to cover all dangerous and dangerous fire zones. Point fire detectors are recommended to be installed in the area using the triangle or square locating scheme.

Detectors are mounted under the cover. In exceptional cases, it is allowed to place them on the wall, beam, column, or hang on the rope as well.

Inside the area having a width of up to 3 m, the distance between smoke point detectors is allowed to increase up to 15 m along the length, besides first and last detectors should be distanced from the wall by at least 7.5 m.

Inside the height area of 8 m, linear detectors are set in two rows.

Maximal and maximal-differential heat detectors are activated by a temperature from at least 20 deg to 70 deg over the maximal acceptable air temperature. The maximum distance from the source radiating heat (incandescent lamp, etc.) to the detector is 0.5 m.

Fire detectors are installed undercover, on the walls, or on other building components. The detection angle, maximum detection distance, and controlled area of one detector should not exceed values established in its technical documents.

3. OCCUPATIONAL HEALTH AND SAFETY AT WORK WITH A COMPUTER

3.1. Regulatory and Legal Support for the Occupational Safety of PC Users

According to the law 'On Labor Protection', the employer must create safe and harmless working conditions in all enterprises, institutions and organizations. The main provisions of the above norms (numbered according to the relevant paragraphs):

1. Responsibility for compliance with these rules shall be imposed on officials, individuals engaged in business activities, and engaged in the development, manufacture, purchase, sale, and use of computers and PCs in administrative and industrial premises.
2. The heads of state bodies, enterprises, organisations and institutions, regardless of their form of ownership and subordination of production control, must arrange the workplaces of users of computers and PCs on VDTs in accordance with the requirements of these rules.
3. Space planning solutions of buildings and rooms for work with VDTs and PCs must meet the requirements of these Rules.
4. It is prohibited to place workstations for VDTs and PCs in the basement or on the basement floor.
5. The area per workstation shall be at least 6.0 m^2 and the volume shall be at least 20 m^3.
6. The rooms for VDT work must have natural and artificial lighting according to the standards.
7. Rooms for work with VDTs must be equipped with heating, air conditioning, or forced-exhaust ventilation systems. Normalised parameters of the microclimate, ionic composition of the air, and the content of hazardous substances must comply with the requirements of the norms.
8. For internal finishing of rooms with VDT, use diffuse-reflective materials with a reflexion coefficient for the ceiling 0.7-0.8, for the walls 0.5-0.6.
9. Flooring should be matt with a reflexion coefficient of 0.3-0.5. The floor surface must be flat, non-slip, and have antistatic properties.
10. It is forbidden to use polymeric materials (chipboard, washable wallpaper, rolled symmetrical materials, laminated paper plastic, etc.) that release chemicals into the air to finish the interior of the VDT rooms.

11. Production rooms may be equipped with filing cabinets, magnetic disks, shelves, racks, tubes, etc., taking into account the space requirements of the premises.

12. VDT-positive rooms should be moist cleaned daily.

13. The VDT rooms must be equipped with first aid kits.

14. Rooms with VDTs should be equipped with amenities for recreation during work and a psychological release room. The room for psychological relaxation should include devices to prepare and distribute tonic drinks, as well as places for physical training.

15. Optimal values of microclimate parameters: temperature, relative humidity, and air mobility must be provided in the production rooms at the workplaces with VDTs.

16. Artificial lighting in premises with work places equipped with PCs and PCs shall be provided by the uniform general uniform lighting. In production and administrative and public spaces, when primarily working with documents, it is allowed to use a combined lighting (in addition to the general lighting, local lighting fixtures shall be installed in addition to the system of general lighting system).

17. The illumination indication on the surface of a desk in the area where documents are located must be 300-500 lux. If these values of illumination cannot be provided by the general lighting system, it is allowed to use local lighting. In this case, the local light fixtures should be installed so as not to create glare on the screen surface, and the screen illumination should not exceed 300 lux.

18. The general lighting should consist of solid or intermittent fixtures lines of fixtures located on the sides of the workplace (mainly on the left), parallel to the line of the sight of workers.

19. The equipment and organisation of the workplace of those working with VDTs Computers and PCs must ensure that the design of all elements of the workplace and their mutual arrangement meet ergonomic requirements, taking into account the nature and characteristics of work activities.

20. The design of a computer workstation and a PC with a VDT shall ensure the maintenance of an optimal working posture.

21. Workstations with VDTs should be located relative to the world apertures so that the natural light falls mostly to the left.

22. When positioning workstations with VDTs, the distance between the side surfaces of the VDTs should be 1.2 m, the distance from the back of one VDT to the screen of another VDT 2.5 m.

23. The design of the desktop must meet modern ergonomic requirements and ensure optimal placement of the used equipment (display, keyboard, printer) and documents on the working surface.

24. The height of the working surface of a work table with a VDT shall be adjustable within the range of 680-800 mm, and its width and depth shall provide

the possibility of performing operations within the motor field reach (recommended dimensions: 600-1400 mm, depth: 800-1000 mm).

25. The working table must have a leg space of not less than 600 mm height, not less than 500 mm width, not less than 450 mm depth (at the knee level), at the level of the outstretched leg – 650 mm.

26. The work chair must be a lift and swivel chair, adjustable in height, with the angle and inclination of the seat and back and the distance from the back to the front edge of the seat, the surface of the seat must be flat, the front edge must be rounded. Adjustment for each of the parameters must be made independently, easily, and securely fixed. The adjustment term for each chair element should be: for linear dimensions 15…20 mm, for angular ones 2…5 degrees. The adjustment force must not exceed 20 N.

27. The height of the seat surface shall be adjustable within 400-500 mm, and the width and depth shall not be less than 400 mm. The angle of inclination of the seat is up to 15 degrees forward and up to 5 degrees backward.

28. The height of the back must be (300 ± 20) mm, the width must be at least 380 mm, and the curvature radius of the horizontal plane must be 400 mm. The angle of inclination of the backrest should be adjustable within 1 ° to 30 ° from the vertical. The distance from the backrest to the front edge of the seat shall be adjustable within 260-400 mm.

29. To reduce a static strain on the upper limb muscles, stationary or removable arm rests, at least 250 mm long, 50-70 mm wide, adjustable by height above the seat within the range 230-260 mm and the distance between the arm rests within the range 350-500 mm shall be used.

30. The surface of the seat and backrest shall be semi-soft with a non-slip airtight coating which is easy to clean and does not become electrified.

31. The working place shall be equipped with a footrest with a width of at least 300 mm, depth of at least 400 mm, adjustable in height up to 150 mm and the angle of inclination of the footrest surface up to 20 degrees. The stand should have a grooved surface and a 10 mm high edge along the front edge.

32. The keyboard should be placed on the table surface at a distance of 100-300 mm from the edge facing the employee. The keyboard should be equipped with a support device (made of high friction material, preventing spontaneous movement), which allows changing the keyboard surface tilt angle within 5 to 15 degrees. The height of the middle row of keys should not exceed 30 mm. The surface of the keyboard should be matte with a reflexion coefficient of 0.4.

33. The VDT workstation should be equipped with a lectern for easily moving documents.

3.2. Ergonomics of PC User Workbench

When working on a personal computer, the workplace should provide optimal placement of objects, adequate workspace, artificial and natural lighting, and a normal level of acoustic noise. In this regard, ergonomic aspects of PC users distinguish three zones of the workplace in a three-dimensional space:

- zone of motorial field – space of workbench, in which person makes moves;
- zone of maximal hand accessibility – part of the workbench motorial field limited by arcs of the person's hand accessibility;
- optimal zone – part of the motorial field limited by arcs that are circumscribed by elbows with a relatively immovable shoulder.

When considering the zones of the workplace in the horizontal plane, there are five zones (Fig. 3.1). Zone A is a zone of maximum hand reach; zone B is a zone of finger reach with outstretched hand; zone C is a zone of light palm reach; zone D is optimal space for rough manual work; zone E is optimal space for fine manual work.

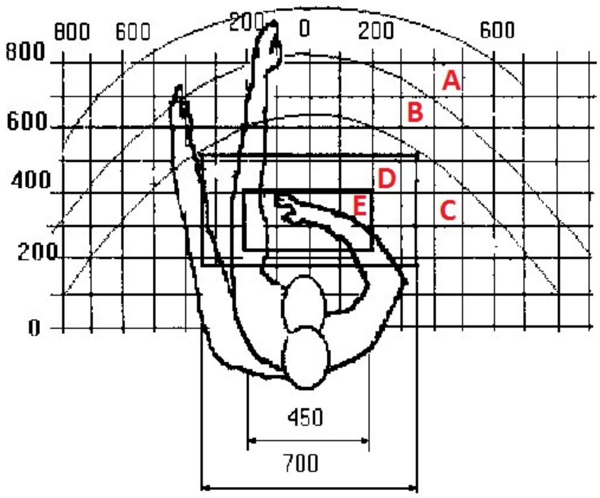

Fig. 3.1. Optimal placement of objects [27]

Researchers in the field of ergonomics have established the optimal placement of objects and elements of the PC workstation, which minimises the negative effects on health and the risk of occupational diseases, as well as increases the efficiency of the employee.

- display – in the centre of zone A;
- keyboard – in zone D/E;
- system unit – in zone B (to the left);
- printer – in zone (to the right);
- documentation, necessary for work – C (to the left);
- documentation that you use occasionally – inside drawers.

3.3. Safety Rules for Computer Operators

3.3.1 Visual Overloading

Occupancy in conditions of overloading nervous and emotional stress, long static loads, constrained physical activity causes neurosis, psychological disorder, skeletal-muscle system, cardio-vascular system disease, etc. Computers, televisions, and communication systems are sources of harmful exposure to electromagnetic radiation.

Investigations carried out by the International Labour and Health Organisation proved that computer users have problems with visual function, skeletal muscle, central nervous, cardio-vascular and immune and sexual system, and skin irritation. Operators frequently complain about having fast fatigue, headache, and visual worsening that makes an undesirable psychological and physiological effect.

Investigation of physicians, hygienists, psychologists, light specialists and experts of occupational safety and ergonomics testified that the modern profession of computer operator belongs to the category of intelligent occupancy characterised by high intensity of visual function, monotonous position, multiple stereotype motions with high coordination performed only by wrist's muscles on the background of total low physical activity and nervous stress. Except for the mentioned factors, there are physical factors such as electric static field, radio frequency, and *X*-ray exposure.

It is a proven fact that health of computer operator depends on what type of work he does and the condition at the workplace. All computer users can be divided into two groups: professional and non-professional. Not professional users work on computer periodically as not basic but additional tool (scientists, engineers, librarians, students, etc.).

The activity of professional computer users can be divided into three work categories.

1. Simple and repetitive operations, which don't take high mental stress. For example, computer typing, enquiry service.

2. Fulfil logic operations, which are repetitive. Planning engineers, designers, and operators of automatic technical facilities do this kind of work.

3. Working in connection with making decisions when a new algorithm of options is unknown. For example, programmers, rail transport, or airport dispatchers.

The operating computer carries the greatest load on all components of visual analyser.

The range of negative factors can cause possible visual perception worsening inherent for computer operators 15-20% more than for occupants not using computers.

The continuous focus on the display decreases the frequency of eyes blinking. It in turn brings to a decrease in the moistening of the eyeball by mucous liquid that protects the eye membrane from drying and dust. It may cause Sikk syndrome, which means drying and dulling of the iris and in the final stage blinding.

Headache, nervous, and psychological stress, and reducing work production are the consequences of intensive visual work on the computer as well.

Visual work on a computer is significantly affected by three groups of factors:

- workplace illumination parameters;
- display characteristics;
- work category.

That's why the attention of occupational safety and workers themselves should be focused on lighting the work place, using modern displays with improved characteristics, maintaining the work and rest time schedule.

As a result, blood circulation became worse, and eyes tissues feel oxygen starvation. It leads to the following consequences:

1. Near sight (myopia).
2. Decreasing of vision sensitivity.
3. Reddening.
4. Pain in the area of eyes and forehead, etc.

To preserve vision, PC users should follow the following preventive measures.

- ideal location of the table - next to the window, light falls from the left;
- even artificial lighting; it is prohibited to use only table lamps;
- display and eyeglasses must be clean;
- when working with text, it is better to work in black and white format (black letters on white background);
- when typing text from paper it is better to place paper closer to the screen;
- take a break every 45 minutes;
- do exercises for eyes every 2 hours.

3.3.2. Overexertion in the Skeletal-Muscle System

Working on computer is characterized by long time sitting in a static position, low physical activity and significant local dynamic load applied to the wrists. This type of work can cause the development of a disease called long-time static load syndrome. It involves localised fatigue, pain, cramps, and constraint (in the neck, back, arms, legs) appearing periodically or every day.

Overexertion of the skeletal-muscle system can be caused by:

- incorrect sitting position, when ergonomics is not taken into account;
- cyclic load, such as using a keyboard or mouse;
- limited physical activity.

To reduce the risk of musculoskeletal disorders, the employee should observe the correct position when working with the PC shown in Fig. 3.2.

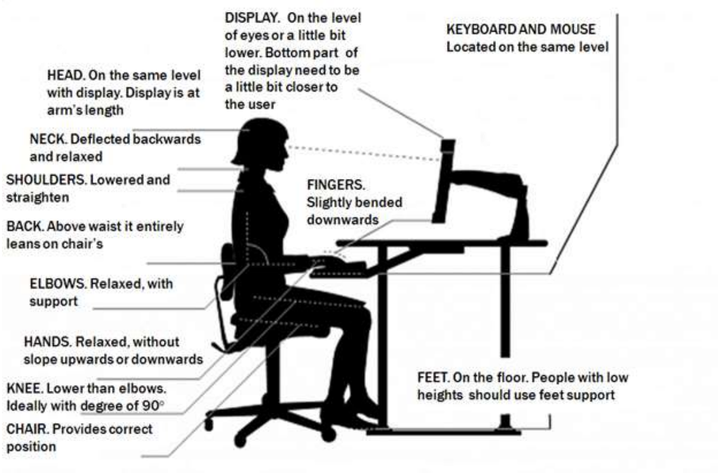

Fig. 3.2. Correct position [27]

3.3.3. Skin Irritation

Sometimes computer users may have skin irritation such as papule eruption, skin peeling, erythema, dermatitis. Scientific research carried out in computer places showed that the intensity of skin irritation is correlated with low air humidity and multiple electrostatic charges. The electrostatic field generated by the display reinforces the electrostatic charges on the operator's body. Recently, it was discovered that increasing air humidity in the room and restricting carpets, which usually accumulate electric charges, allowed the reduction of irritations. The setting of protective grounding and the cell display screen from metallic wire in some cases also reduced the frequency of skin irritation.

3.3.4. Central Nerve System Lesion

Factors that have an adverse effect on the central nervous system are the following:

- informational brain overload with time shortage;
- nervous expectation of information especially if it needs making a decision or option;
- high visual, nervous, and emotional stress;
- static load;
- monotony;
- high responsibility for final result;
- long-time isolation from communication, which is inherent for individual type of work.

The mentioned factors produce changes in the correlation between the exciting and inhibiting processes running in the cerebral cortex. Decreasing functional activity of the central nervous system and breaking the balance of the basic nervous process lead to dominating the inhibiting process. The organ feels fatigued. Most frequently, computer operators get mental fatigue, which has the following indications:

- decreased ability to concentrate attention;
- decreased perception of information;
- slowed thinking;
- worsened ability to remember information;
- emotional instability (depression, loss of emotional control);
- slowed sensory-motor function, which slows reaction and decreases coordination.

The necessity of processing large data massively in the condition of time shortage and high motivation and intensity of work are basic factors for emotional stress, which in turn activates the nervous system and works out biologically active substances changing functions of the blood circulation, respiration and digestive organs.

Working on a computer compared to other activities is much more provoking neurosis. The main symptoms of neurosis are low work productivity, loss of interest in the outer world, and shrinking fields of interest. Physically, people may feel headache, unstable emotional condition, sleeping disorder, hopeless.

3.3.5. Effects on Reproductive Function

Extensive work on the computer is extremely harmful to pregnant women, which can cause spontaneous abortion, stillbirth, and premature birth. In addition, it may cause inborn defects, such as insufficient brain development.

The main factor harmfully influencing reproductive function is the electric fields generated by computer. At some intensity, they are able to change and stop cell growth. That is why working on a computer is not recommended for pregnant women at all.

3.4. Occupational Safety Standards for Computer Workplace

Occupational safety standards for the computer workplace regulate the work regime by setting rest periods within the work shift in order to prevent fatigue and reduce production of the work.

The schedule of rest and breaks foreseen during the work shift is listed below:

- rest and lunch breaks;
- breaks for rest and personal needs (according to occupational standards);
- additional breaks required for some occupation.

Occupational law and internal regulations of enterprise, organisation, or establishment regulate lunchtime. Usually it takes 40-60 min. All breaks are regulated referenced to work category, intensity and heaviness of work and defined exclusively for exact occupation.

Sanitary standards establish shift work and rest time for 8-hour office time:

- 15 min rest after every hour provided for programmers;
- 15 min of rest after every two hours provided for operators;
- 10 min rest after every hour provided for computer typing.

For 12 hours office time, work and rest time is the same as mentioned above during first 8 hours, and during the rest 4 hours rest period should be 15 min every hour irrespective of the work category.

To release nervous and emotional stress and visual fatigue, to improve brain blood circulation, to overcome unfavorable consequence of hypodynamic work, to prevent fatigue sanitary rules recommend using some of the scheduled breaks for a routine of special prophylactic and rehabilitation exercises. It is also recommended to take psychological and physiological relaxation in specially equipped rooms during breaks and at the end of office time.

3.5. Preventive Healthcare

3.5.1. Medical Examination

Medical prophylaxis has a great place among technical, organisational, and other measures to preserve health and increase the productivity of computer operators. It includes the following:

- medical examination (initial and periodical);
- rational and prophylactic nutrition;
- special exercises, massage, and psychological relaxation.

Computer operators are required to pass periodic medical examination.

An initial medical examination is passed on the enrolment of new employees. This examination has the purpose of diagnosing the physical and psychological applicability of a person for certain occupancy. It is important to detect persons who have medical indications due to which they cannot be accessed to work characterized by inherent hazards. The basic criteria of applicability to computer operation are vision characteristics: acuity of vision, refractivity indication, accommodation, binocular vision condition.

The contraindications of vision organs are listed below:

- acuity of vision with correlation not less than 0.5 for one eye and 0.5 – for another;
- refractivity: myopia greater than 6.0 D, hypermetropia greater than 4.0 D, astigmatism over 3.0 D;
- no binocular vision;
- lagophtalm;
- chronic ailment of the front section;

- visual nerve and retinal illness;
- glaucoma.

Periodic medical examination is conducted during occupation for workers referred to certain categories. Such examinations provide dynamic controlling health condition, detecting the first consequences of the hazard exposure, the illness due to which the employee cannot continue his work in such occupancy. Identifying exact hazards and considering specificity of work process, they set periodicity of medical examination, members of medical commission, list of laboratory and test to make during examination. Computer operators should pass a medical examination once for two years arranged by commission consisting of therapist, neuropathologist, and ophtalmologist. For female employees, the medical examination is performed by accoucheur-gynaecologist once a year. Female employees do not accessed to work on computer during the period of pregnancy and breast-feeding.

3.5.2. Nutrition

The diet recommended for computer operators should not only be rational, but also prophylactic. Prophylactic nutrition includes a meal rich in vitamins A, B1, B2, B12. Vitamin A (retinol) produces a light-sensitive substance in the retina. It is contained in animal food and its provitamin (carotene) in vegetable food. Vitamin A deficiency leads to a decrease in adaptive eye function, which dims the cornea of the eye. Animal liver, butter, egg yolk, milk fat are rich with vitamin A.

The green and orange parts of vegetables contain carotene, which is transferred in the organism to vitamin A. A large amount of carotene is contained in red carrots, red peppers, spinach, apricots, and green peas. The daily dose of vitamin A for adults makes 1…1.5 mg, for computer operators 1.5-2 mg.

The shortage of vitamins B causes the violation of eye nerve function and worsens corneal transparency. Vitamin B1 (thiamine) is found in yeast-bred kvass, cereals and legumes. The largest amount of animal-derived thiamine is in liver and pork deprived of fat.

Vitamin B2 (riboflavin) regulates the functioning of the central nervous system, substance exchange in the cornea, the crystalline lens, and the retina, and provides light and colour vision. The main source of riboflavin is eggs, cheese, milk, meat, peanuts, soy beans, and green beans.

Vitamin B12 (cyanocobalamin) plays a role in the synthesis of methionine and nuclein acid, hemogenic processes. B12 insufficiency develops when its intake is infringed and becomes a heavy form of anemia. B12 is basically found in animal food.

3.5.3. Psychological Relaxation

The day routine of not complicated physical exercises performed during work improves physical condition, maintains high work capacity and preserves health of workers.

Computer operation is characterised by high intensity of visual function, significant local physical exertion applied to the wrists in the background of low total mobility, high nervous and emotional stress. Long-time being in sitting position and low moving activity reduces intensity of substances exchange, blood circulation, provokes stagnant processes in region of sacrum pelvis, legs, weakens muscles. In such a condition, routine of special exercises allows to compensate for insufficient muscle activity. There are exercises and massage for eyes, gymnastic breathing, mental, and muscle exertion.

Psychological and physiological relaxation for computer operators should be carried out in specially equipped rooms during breaks or at the end of office time. It includes three periods of mental training:

First period – distract from the work environment. It is desirable to listen to music, bird's singing etc.

Second period – relaxation – renewing inhibition, listening to melodious music.

Third period – activation – phase of high excitement. One can use red light and happy music.

The session takes 10 minutes after which workers relieve fatigue, feel cheerful, get in high spirit.

4. LIFE SAFETY

4.1. Ergonomic and Psychological Basics of Safety

4.1.1. Ergonomic Basics of Safety

Safety is a complex discipline based on knowledge of related sciences. One of such sciences is ergonomics.

Ergonomics studies the functional possibilities of a person during activity and seeks to create such conditions, which make activity effective and ensure comfort for a person. In other words, the question is about determination of compatibility at person and medium characteristics. Ergonomics tries to adapt technological designs to a person. But it is not always a solvable problem. Safety also considers to the problem of adapting a person to technological environment.

The experts in ergonomics specify five types of compatibility, maintenance of which guarantees successful operation of systems ‘person-medium’ and ‘person-manufacturing’: informational, biophysical, power, space-anthropometrical and technical-aesthetic.

In complicated systems, an operator almost always does not manage physical processes directly. Frequently, he is remote from the place of their fulfilment. The objects of management can be invisible, imperceptible. The operator reads the indication of devices, screens, schemes, and hears signals, which monitor a progress. All of these devices are called data display methods (DDM). If necessary, the operator uses handles, buttons, switches, and other parts of management, which together make sensory-motor space. DDM and sensory-motor devices make up the information model of the machine (complex) through which the operator manages the most complicated systems. The aim of ergonomics is to provide creation of such an informational model, which would display all the necessary characteristics of machine at any moment and at the same time allow an operator to receive and process the information correctly, without overloading his attention and memory. This problem is very complicated. The safety, accuracy, quality, and productivity of an operator depend on its solution. In other words, the information model should correspond to the psychophysiological capabilities of the person. This requires compatibility with the information.

Biophysical compatibility means creating such an environment, which would ensure sufficient work capacity and normal physiological condition of an operator. This problem is related to the requirements of labour protection. The acceptable limits of the safety factor of the environment are set by the legislation, but they are not always coordinated with the functional problems and possibilities of an operator. Therefore, the development of machines requires special research of parameters of noise, vibration, illumination, air medium, etc.

The physical strength and power parameters of the person have certain limits. Actuating sensory-motor systems (buttons, switches, etc.) may take great or slight effort. Both cases are not good enough. In the first case, the person will get tired, that can entail undesirable consequences in managing system. In the second case, decreasing of the system operation accuracy is possible, as the operator does not feel a resistance of the handles. The power compatibility provides the coordination of machine operating control with optimum capabilities of an operator concerning the applied efforts, power, speed, and accuracy of movement.

The spatial anthropometric compatibility takes into account the sizes of the person's body, the external objective, and the position of an operator during work. Working out this problem includes determining the space in the workplace, the reach zones of the operator, the distance from an operator to the console, etc. Some difficulties of maintaining this compatibility are in the variety of anthropometrical parameters. A seat which satisfies a person of medium size can turn out to be extremely uncomfortable for the short person or very tall. What should we do about it? The answer is given by ergonomics.

The technical-aesthetic compatibility brings to the person a satisfaction from the dialogue with the machine and working process. We all know very well a positive feeling while using an elegantly made device or arrangement. For solution of numerous and extremely important technical-aesthetic problems, ergonomics uses art-designers.

4.1.2. Psychology of Safety

The psychology of safety ensures the important link in the structure of measures on the maintenance of the safe activity of the person. Problem of the rate and injuries in modern plants, factories, etc. cannot be solved by engineering methods only.

The experience testifies that the major causes of the accident rate and injuries are not the engineering-designer defects, but organisational - psychological causes, low professional training on safety, insufficient education, insufficient instructing the expert on safety laws keeping, admission to dangerous work with increased risk of injury people being under condition of fatigue or other psychological condition reducing workability (safety) of an expert.

International experience and research testify that from 60 to 90% of injuries in private life and in industry are caused by the victims' fault.

Psychology of safety implies applying psychological knowledge to provide the safety of the person. Psychology of safety studies mental processes, its properties, and in particular it analyzes various forms of mental condition in detail, which are observed during working.

The structure of mental activity of the person comprises three main groups of components: mental processes, properties, and conditions.

The efficiency of the activity is based on the level of mental stress. Mental stress up to the appropriate level produces a positive influence on the outcome of work. Exceeding the critical level of activation results in the loss of work result down to full disablement.

Excessive forms of mental stress effect as overloading. The normal load (emotional stimulation) of an operator should not exceed 40-60% of the maximum load.

More expressed forms of mental stress induce coordination losses that cause uncontrolled behaviour and other negative phenomena. Depending on dominating either excited or inhibited processes, two types of overloading mental stress, excited and inhibited, may be selected.

The inhibited type is characterised by restrictions and a decrease in the speed of movements. The expert cannot continue to work with such dexterity and speed as before. The speed of special reactions is reduced. The process of thinking is slowed down, memory worsens, there is confusion, and other negative indications unusual for the person in normal state.

The excited type is displayed as hyperactivity, verbiage, hands, and voice trembling. Operators make numerous actions induced by the concrete need for only one action. They check the condition of devices, fix a cloth, and rub hands. Speaking to others, they behave nervous, unusual for them to be sharp, rough, insulting.

Thus, overloading forms of mental stress are frequently basis for an error in operations and incorrect behaviour in a complicated situation. Long mental stress and, in particular, its overload create a certain fatigue condition.

The organisation of operators mental condition controlling is necessary because of possible emerging of special mental condition, which are not natural for a person, but arise spontaneously or under influence of external factors, which significantly change work capacity of the person. Among the special mental conditions, which matter for mental reliability of an operator, it is necessary to select paroxysmal disorder of consciousness, psychogene changes of mood, and states induced by using psychologically active means (stimulators, tranquilizers, alcoholic drinks).

Paroxysmal states form groups of disorder of various origin (organic brain diseases, epilepsy, insanity) which are characterised by short-term, from seconds up to minutes, loss of consciousness.

In extreme forms, fall and convulsive movements of the whole body and parts of the body are observed.

Paroxysmal interruptions during operator activity can have crucial consequences, which is true for truck drivers, steeplejacks, erectors, and constructors working at height.

Modern methods for psychophysiological research allow people with hidden predisposition to paroxysmal condition to detect themselves in time.

Psychogene changes in mood and temporary insanity come under the influence of mental activity. Being in low spirits and apathy can last for several hours up to 1…2 months. Losses of relatives and close people, conflict situations put the person in low spirits. Then comes apathy, slackness, total constraint, inhibited state, difficulties to switch attention, slowing down of thinking. The lowering of mood is followed by self-control worthiness and can cause industrial injuries.

Under the influence of insult, failures in work affect states (affect – explosion of emotions) can develop.

In the state of affect, consciousness survives its mental (emotional) shrink of volume. One can witness various movements, aggressive, and destructive acting. People prone to affective states belong to the category with increased risk of injury and should not be appointed for work with high risk or responsibility.

Medical and alcoholic changes in mental state are connected with the use of psychologically active means. Modern medicine has a wide range of psychopharmacological means, which influence mental activity and the condition of the person.

Practical experience testifies that taking easy stimulators (tea, coffee) helps fight sleepiness and can help increase work capacity for a short period. However, taking active stimulators at work is capable of inducing negative effects, worsening health, decreasing mobility, and speed of reaction.

The public distribution of tranquilizers is a special problem. Giving an expressed calm state and preventing the development of neurosis, these pills can reduce mental activity, slow the reaction, induce apathy and sleepy states, which are also dangerous when operations require attention are performed.

Drunkenness and alcoholism is also a serious problem for safety.

The inadmissibility of using alcoholic drinks in office time and their influence on work capacity are well known.

According to various facts, accidents on the road in 40-60% of cases are connected with using alcohol, and 56-64% of fatal cases in industry are caused by using alcohol and error operation.

Post-alcohol asthenia (hangover) takes a special place in safety of work. Progressing after the day that alcohol has been taken is not just reducing work capacity, but also leads to breakdown and decrease in the sense of safety.

Mental activity changing under the influence of private life and industrial activity puts before the engineers-organisers of industrial activity a problem of creation of the system controlling mental condition of an operator.

Safety in its essence is directed to protect a person from a danger. At the same time, it is necessary to remember that the person himself is the carrier of potential danger. This is about evolving harmful substances, radiating heat, which can cause various kinds of accidents owing to error operations.

Besides, it is necessary to remember that the behaviour of people in the crowd, especially in panic, has its own laws, which differ from the behaviour of one person. The laws of group psychology are necessary to take into account for analysis of dangerous (in particular, emergency) situations.

Psychological science gives some recommendations for correction of the reaction of people behaviour in extreme situations. Compatibility between the person and the medium elements makes the condition of the system 'person-medium' safe. When such compatibility is not present, the following consequences are possible:

- decrease of work capacity of the person;
- development of common and professional diseases;
- damage, fire, explosion;
- industrial injuries.

4.2. Environmental Health

The numerous stimuli different in quality and quantity and being internal or external act on the brain of the person. They call the formation of unconditional and conditional reflexes in the human body, which are systematized and result in dynamic balance. Working out conditional reflexes is a biological act that creates a basis for correct exchange of substances and energy between the organism and environment.

The environment in which a person lives is characterized by conditions that enable normal physiological functions. Human beings cannot live without air, which is one of the most important elements of the environment. Atmospheric air is the constant source of oxygen necessary for oxidation processes and the support of life. Oxygen and nitrogen are the key elements, with water, carbon dioxide, and other gases making up the total. On the other side, a human being excretes waste gaseous products in atmospheric air from respiration. Temperature of the air, its humidity, barometric pressure, air circulation, solar radiation, the processes of heat exchange between an organism and external environment all these climate-forming factors have the great significance. Water and food are also components of environment, without which life of a human is impossible. These components make up the structure of an organism; they are source of mineral substances, vitamins, proteins, fats, and carbohydrates which constantly participate in exchange between organism and environment.

The soil also has the same importance for the human's organism. It serves as a source of mineral, organic, and organic mineral substances and unique laboratory, in which the processes of the decomposition and synthesis of organic substances and also photochemical processes run. The soil influences the health of a human, being an important factor that forms geochemical processes that depend on the chemical complex of an organism. The soil is also a source of mineral substance necessary for substances circulation, plants growing, etc.

The factors of the natural environment have complex and different health effects.

Among factors which have negative influence, there are etiologic factors, which are causal factors, which directly predetermine development and expression of pathological process (disease), and risk factors, which are not the reason for the disease, but enable and reinforce the action of etiologic factors. For example, viruses, toxic substances, vibration are the reasons for certain diseases – flu, tuberculosis, mercury poisoning, vibrational disease, and overweight; smoking, nondynamic style of life can increase probability of diseases (hypertension, ischemia) that means affecting cardiovascular system diseases frequency, as well as negatively influence on their progress, making these and other diseases induced by etiologic factors less forecasted. Alcohol can also be a risk factor that enhances the unfavorable action of chemical substances that affect the nervous system; smoking brings substances that affect mainly lungs and respiratory tract. Insufficient nutrition (shortage of proteins, vitamins, etc.) can be an etiologic factor of elementary disorder and a risk factor of intoxication by heavy metals or radiation exposure for people working with them.

The negative influence of environmental factors on the human body can cause inflammation, dystrophic changes, allergic condition, changes in the development and damage of cell hereditary damage. 70…80% of all cancer cases have been caused by chemical carcinogen. Today, about 4% of newborns have genetic defects that lead to further hereditary diseases.

The danger of chemical and radiation pollution lies in the fact that its influence on an organism will develop further in many generations. Atomic power fatal affects 20% of the total all over the world, chemical compounds herbicides and pesticides – 80%.

Children living in regions polluted with atmospheric emissions often have low body weight and insufficient physical development, as well as functional deviations of cardiovascular and respiratory systems. Diseases of the respiratory organs make an average of 73.5% of the total.

Pesticides and mineral fertilisers cause extensive pollution and poisoning. Getting into the drink water and food, they provoke deviation in central nervous, cardiovascular, and other systems activity of an organism, stimulate anomalies of newborns, and decrease activity of the immune system. They can be a reason for the development of malignant swellings and decreasing of life duration.

We cannot overestimate the tragic consequences of the Chernobyl disaster, which became the fatal factor for Ukraine, entailing the danger to the genetic health of the nation. Radioactive waste has risen the radiation level which induced external and internal exposure of the people. Much of it got inside the organism through respiration, food, and skin.

Since the influence of a number of complemented radionuclides on the organism has been determined, the accessible limit of exposure doze for the person that corresponds to 35 rem is no longer valid. This magnitude is not scientifically grounded and is dangerous to health. This accessible limit doze can cause 250 cases of genetic anomalies among 1,000,000 people. Thousands of the residents of polluted region have already become its victims. In 1986 exposure to the thyroid gland was detected that increased the risk of cancer for 5,800 children and 7,000 adults. More than 4,000,000 people live on a territory polluted by nuclear radiation in Ukraine. Almost 100,000 people live below the radiation level being still dangerous to health. Demographers testify that for one – two generations, young population can be mostly mentally and physically defective taking into account appearing of millions of patients of that kind.

The number of cardiovascular diseases, in particular heart attack of the myocardium and ischemia, brain vascular affection, cancer, bronchial asthma, diabetes, allergic diseases, and diseases of the digestive tract increased noticeably. In the Chernovtsy region children suffer from hair loss and neurosis. In Kalush, the number of seriously ill children from birth is almost twice that of the whole country.

Due to the disastrous deterioration of the environment, the general health of the Ukrainian population has declined sharply in recent years. Death rate has exceeded the birth rate. Genetic processes were infringed, birth of children with various hereditary illnesses was increased 2…4 times. Ukraine occupied the first place in the world in the death rate of children. Duration of life has decreased for 8 years, the primary disablement parameter has grown.

4.3. Hazards of Drug Addiction and Toxic Substance Abuse

Social and economic difficulties in the country resulted in both a recession of vital potential and an increase of negative and extremely dangerous phenomena in society. One of such phenomena is the expansion of drug addiction. The drug addict is a person who looks for a way to escape from life difficulties. Frequently young people and children become drug addicts.

The only general parameter is that the reason for drug addiction is to be searched in social development. The law enforcement fight with drugs, in particular with their illegal trade. Mental dependence on drugs means that only with their help of them it is possible to gain emotional stability and keep the nerves under control. When using drugs a physical dependence appears; it is much worse, because the mentioned mental attraction to drugs is accompanied by physical sufferings. Drug addicts, in fact, unable to have a regular job commit crimes for living and satisfy the growing need for drugs.

The most widespread drugs, which cause physical and mental dependence, are of opium type (opium, morphine, heroin, codeine) and also partly barbiturate, tranquilizers, and vekaminos. Rehabilitation of drug addicts is possible only under special in-patient treatment. However, even after long-term treatment relapse is possible. If a drug addict cannot quit this ‘hell’, nothing can help his dying.

Recently, in many countries, toxic substance abuse has spread (toxin means poison). Toxic substance abuse attracts young people, mainly scholars in higher classes and students of technical training colleges. Intoxication is achieved by spraying light poisonous substances that are absorbed by lungs and penetrate fast into the brain during inhalation. Aerosol, as well as alcohol, detains supplying blood with oxygen, and the brain and central nervous system cannot manage without. Multiple aerosol intoxications can cause death. People drop out of the balconies, get under the the transport, choke under spray affecting.

Treatment of a drug addict is very hard and the outcomes are not always successful. The duration of treatment depends on the time it took to use a drug. The longer the treatment is, the more complicated and prolonged the treatment. For example, to eliminate the narcotic influence of a drug addict who had used drugs for one year, takes 3-4 months of intensive inpatient treatment.

Social danger and harmfulness of drug addiction:

- drug addicts are bad workers, their work capacity, physical and mental activity is strongly reduced, they always keep thinking about drug, how to get it;
- drug addiction brings significant material and moral losses, is the reason of industrial, transport and private accidents, injuries, diseases, and various criminal offences;
- drug addicts make an insufferable condition for their families which turn out to be out of livelihood, commit crimes as to their children because poor health of parents passes to the children;
- drug addicts degrade physically and morally becoming a burden for the society, involving in the dirty business new people, first of all young, and then prematurely die;
- using drugs is immoral. The essence of drug addiction consists in the ruining of healthy estimation of reality, moral standards which were created during education, goals and sense of life;
- drug illness in all its kinds is a dangerous social mental disease that threatens future of the nation, prosperity and health of the population of the whole country. This determines the universal and global significance of the problem.

4.4. Alcohol and Nicotine as Harmful Factors

Using alcohol and smoking are considered to be the social evil of the society. This is the certain reason for the shortening of life, the increase in death rate, and the defective generations.

Alcohol has a strong negative influence on the viability of a person. Alcohol or spirit is a narcotic poison that affects first the brain cells, paralyzing them. Dozing and making 7-8 g of pure spirit per 1 kg of body weight is fatal to a person. The adult person having weight 75 kg can die of one-time using 1 liter of 40°vodka. According to data of the World Health Organisation, alcoholism annually causes 6,000,000 deaths, more than from cancer. Alcohol negatively affects the human body. It produces a deep and long-term weakening action. For example, such a small doze of 80 g keeps active for 24 hours and poisons an organism. Alcohol results in the development of tuberculosis and other diseases.

Using alcohol causes prolonging pneumonia that is frequently followed by festering and gangrene. The defined fact is that people who regularly use alcoholic beverages are sick for podagra and cancer. Systematic drunkenness predetermines many diseases, causes early ageing, and reduces duration of life.

Drivers using alcohol cause many accidents. Scientific research shows that glass of beer drunk by the driver before driving increases an accident rate 7 times, using 50 g of vodka – 30 times, using 200 g of vodka – 130 times. Only in Europe did more than 250,000 people die from traffic accidents and 10,000,000 got injured. Adventures on the road are mostly caused by drivers in the age of 15…25 and the main reason for all is alcohol. Alcohol predetermines alcoholic hypertension or affects the myocardium, and also predetermines gepatit (inflammation of a liver), cirrhosis (scaring regeneration) of liver, affects the brain, induces sexual powerlessness.

Scientists have proved that safe dozes of alcohol do not exist. 100 g of vodka kills 7,500 actively working brain cells. Acceptance of 75 g of vodka in 30 minutes reduces muscle strength to 40%. Alcohol is an intracellular poison. It brakes the exchange of substances down in the cordial muscles, exhausts their energy. More than 25% of cardiac diseases are directly related to the use of alcohol. Alcohol affects in heart more often the people in the age of 30-45. Every fourth so-called sudden death is entailed by the use of alcoholic beverages.

Drunkenness and alcoholism are the reason of almost half of all divorces, 62.6% of all cases are initiated by women for the reason of men drunkenness.

Medical scientists investigating children with nervous diseases came to the conclusion that of 100 children – epileptics in 60 cases – fathers abused alcohol, in 40 cases of 100 mentally retarded children – fathers were alcoholics. Alcoholism is one of the reasons children bearing with various defects. Children in such families are born weak, unhealthy, behind in physical and mental development, study poorly, and begin using alcoholic drinks early. Academician V.I. Behterev on the basis of carried out researches clarified that every of 100 men-alcoholic produce 10 children having physical defects, 8 idiots, 15 epileptics, and 5 alcoholics.

Smoking is a widespread habit among men and less spread among women, teenagers. Scientific research confirms the harmful influence of nicotine on the body of a person. It has been shown that tobacco smoke contains poisonous substances. Besides nicotine, it contains harmful substances such as: charcoal gas, pyridines, hydrocianic acid, hydrogen sulfite, carbon dioxide, ammonia, nitrogen, and essential oils.

The smoke of 25 cigarettes contains about two drops of pure nicotine, that is enough to kill a dog. A mouse dies suddenly if one drop of nicotine if injected into its eye.

A 0.08-0.16 g doze of nicotine is fatal to a person. During the 30 years an adult uses in average 200,000 of cigarettes, or 160 kg of tobacco, which makes 800 g of nicotine equal to 10,000 fatal dozes.

As nicotine enters the organism of the person slowly and in small doses, the acute phenomena of poisoning are not observed. Tobacco has a harmful influence on the organism of the person, first of all, on the nervous system, causing it and then depressing.

Nicotine narrows the brain vascular system, reduces its elasticity, and complicates the supply of brain with blood, which predetermines deterioration of its work. Headache, dizziness, and excessive head weight are the consequences of it. There are known cases when smoking people feel sexual dysfunction. The loss of memory, attention, muscular strength, and intelligence appears under the influence of smoking. Researches testify that 8-hour work takes additional two hours if the worker is a smoker.

Smokers get sick with cancer and other malignant swellings five times more often. Extensive observations of the USA experts carried out on more than 1,000,000 patients have enabled us to draw such conclusion: disease and death rate due to cancer among smokers is 10 times higher than among nonsmokers, and people who smoke two packs per day are in for this risk, which is 24-30 times higher.

The hygienic aspect of smoking consists in poisoning not only the organism of a smoker but also the surrounding air, which is not his right. For nonsmokers staying in a room filled with the smoke is more dangerous for health than for smokers.

Smoking should be a struggle in all society. Struggle is to be carried out in such main directions:

- administrative measures restricting smoking in public places and in particular suppressing smoking among children and teenagers;
- everyone who smokes should realize all the harm he puts to health.

4.5. Risk of Acquired Immunodeficiency Syndrome (AIDS)

AIDS is one of the infectious diseases that spreads all over the continents of the Earth and induces thousands of diseases. This is one of the most tragic problems humanity faces today. The disease is spreading incredibly fast. None is insured from getting AIDS-infection.

AIDS is a virus that invades living tissues of an organism and induces fatal infectious disease.

The disease has a large character and has several stages. The term ‘syndrome’ means a number of symptoms. In each case, AIDS exhibits as a deep defeat of an immune system, precisely its insufficiency; therefore, its name has ‘Immuno-Deficiency’. As it appears in some moment of life, not at birth, it’s been named ‘acquired’ (in difference from ‘inborn’).

The first cases of the disease were registered in the USA. AIDS invades from one person to another mainly through sexual contact independently on its way; through blood transfusion, organ transplantation; through numerous use of needles and syringes (basically by drug addicts), piercing ears, tattooing; through damages of skin or mucous covers by medical instruments, etc.

The degree of risk depends on the way of infecting. Probability of being infected during blood transfusion exceeds 90%, using nonsterile medical instruments from 0.5 to 1%, casual injection with a virus up to 0.3%.

After infection, the moment of which is hard to define, comes the so called incubation period. It can last for 3- 6 weeks and then an acute phase occurs. The most common indicators of infection are high temperature, enlarging of lymphatic gland expansion, tonsillitis, rash on face and body, indigestion, headache, feeling sick. This condition lasts about 2-4 weeks and passes without any treatment. AIDS antibodies have not been formed yet and appear only after 1,5-3 months after the end of the acute phase, that is why in most cases infection cannot be detected on this stage.

After the acute infection phase, the nonsymptom infection phase occurs. Detecting the presence of the virus is possible only by special laboratory research tests, but the virus carrier is already dangerous to the health of a person. This period lasts up to 3…5 years and even more. This time, the person feels healthy but remains a carrier of infection. In this period, some indications of the disease progressing appear: the peripheral lymphatic glands are enlarged.

Then comes the period of ‘persisting generalized lymphoadenopatia’. Continuous enlargement of the lymphatic glands makes the patient visit a doctor. This stage can last for some years. This period is not yet late to visit doctor, the experts can slow down the deterioration of the immune system condition.

The next stage is the stage of secondary diseases. Enlargement of lymphatic glands is joined by such symptoms as indigestion, continuous (about 1 month) running a high temperature, loss of body weight reaching 10% and more. Fast fatigue and night sweats are observed. The addition of secondary infections induced by viruses, bacteria or protists, the development of the swellings, symptoms of nervous system and mental disorders testify about the final stage of AIDS.

At this stage, medical efforts are directed to reduce the suffering of the patient.

In the present time, the medicine has no methods which can cure the person from AIDS, but there are developed methods for treatment which stop the development of the disease.

By the time scientists discover effective methods for prophylaxis treatment of AIDS, it is possible to prevent its spreading by charging your own behaviour. People with high sexual activity and chaotic sexual life style have much more chances of being infected with AIDS than the other.

4.6. Environmental Risks

4.6.1. Exhaustible and Inexhaustible Natural Resources

The concept of 'environment' includes all natural elements and also part of nature changed by human activity (settlements, agricultural areas, reservoirs, and others). By natural resources we understand objects, conditions, and processes, which are used or can be used in manufacturing for satisfying the material, scientific and cultural needs of society.

Natural resources are divided into exhaustible and inexhaustible.

Inexhaustible natural resources include space (solar radiation and the energy of marine flows and waves) and climatic (wind power and Earth bowels) power resources. Taking into account huge masses of air and water medium of the planet, atmospheric air and water resources can be referred to as inexhaustible resources, too. But such reference is conditional, cause the chemical structure and physical condition of atmosphere and hydrosphere become changed under people activity influence (anthropogenic influence), which can bring about loss of their biological value and possibilities of using. That makes it necessary to execute a complex of works on supporting air and water purity.

Exhaustible resources, in turn, include renewable and non-renewable natural resources. Renewable resources can be recreated during their use. The renewal occurs at various rates: The formation of 1 cm of humus ground layer takes about 600 years, the growth of cut down wood – dozens of years, the population – up to 10 years. Thus, the rate of using renewed resources should be in balance with rate of their restoring. Non-renewable natural resources are those that cannot be renewed absolutely or their renewal goes slower than their using. Minerals which involve overcrop refer to such resources. Their protection should consist in economic, rational and complex using so that resources will have a minimum loss. Also, non-renewable resource is the space people live.

Every year they extract from bowels of the Earth 4 km^3 of rock, and hundred million tons of gases, solids and liquids are evolved polluting surroundings. Consequently, unequal manufacturing development in the northern hemisphere has 93.5% of industrial emissions, and southern hemisphere has only 6.5%. Wood, fish, and fresh water are used up ever more. About 10% of Earth's surface has been occupied by construction of cities, roads, pipelines, etc. Hydraulic engineering structures (dam, channels, and artificial reservoirs) change the rivers more than natural processes for thousands of years.

4.6.2. Atmospheric Air Protection

The main sources of atmospheric air pollution are industrial enterprises, thermoelectric power stations, motor transport, air transport and agricultural industry. Every year more than 200,000,000 tons of carbon dioxide, 150,000,000 tons of sulphur oxide, 500,000,000 tons of nitrogen oxides, 500,000,000 tons of various hydrocarbons, 250,000,000 tons of fine-dyspersated aerosols (dusts) and many other substances are evolved in the air.

Among industrial branches, ferrous metallurgy is the most polluting environment. The ferrous metallurgy plants evolve into atmosphere dust structures of manganese, arsenic, phosphorus, antimonies, lead and other metals. Non-ferrous metallurgy has an inherent toxic dust substance (structure of lead, arsenic, and other) and structures of fluorine. In the coal industry, the source of atmosphere pollution is burning of substances to form carbon oxides and sulfuric gas. The air emissions of the petroleum refining industry contain carbon, styrene, toluol, acetone, and other. Structure of chemical industry emissions varies: carbon dioxid, nitrogen, ammonia oxides, organic substances, chloride and fluoric structures, dust of inorganic productions. The manufacture of construction materials is followed by significant dust emissions in atmosphere. The thermoelectric power stations evolve in the atmosphere about 30% of the total amount of all harmful industrial emissions. These emissions contain carbon and sulphur dioxides, nitrogen oxides, water vapours, and plenty of ashes.

Cars are also dangerous to the environment and people health. Car exhaust gas is a compound of about 200 substances, including oxide and dioxide of carbon, aldehyde, and structures of lead.

Atmosphere pollution has a negative influence on people, flora, fauna, buildings, transport, and climate of the Earth.

The particularly negative influence on people, flora and fauna induces smog (dense fogs), which contains dust and dangerous gases. Smog usually appears in large industrial cities. Photochemical smog with relative humidity in air less than 70% is very dangerous to the environment. It is caused by extensive polluting of the air in cities by gas emissions from the chemical industry, and also by automobile exhaust gases. Photochemical smog induces inflammation of mucous envelopes, exacerbation of chronic lungs disease, kills pets, plants, makes metals corrosion and cloth damage. Bad visibility causes road accidents.

The growth of dust contents in the air results in microclimate deterioration: foggy days are more often, visibility and light exposure decrease. Growing carbon dioxidal content produces ‘greenhouse effect’ – essential temperature of Earth surface and surface layer due to decreasing of heat radiation from the Earth.

The protection of air is regulated by threshold limit values (TLV) of harmful substances in the air of settlements. TLV of harmful substances in the atmosphere covers 200 substances. Hygienic standards are set for more than 600 substances and 33 combinations of atmospheric polluters.

There are three categories of TLVs:

- 8-hour time-weighted averages (TWAs),
- Short-Term Exposure Limits (STELs),
- Peak Limitations or ceiling values.

8-hour time-weighted averages (TWA): average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week.

Short-term exposure limits (STEL): exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL. This is to avoid acute and chronic health effects.

Peak limitations are concentrations that should not be exceeded even for an instant during any part of the workday.

The protection of surroundings is achieved by purification of industrial emissions, reducing exhausted gas, selecting sanitary protective zones and applying wasteless productions.

Purification of emissions from dust can be coarse (when the coarse-dispersed dust with size of particles over 50 micron is intercepted), medium (when the medium-dispersed dust from 10 up to 50 micron is intercepted) and thin (when the fine-dispersed dust under 10 micron is intercepted). For dust there're dust catchers applied which can be divided into two groups – capturing dry dust ('dry' devices) and scrubber where dust is intercepted after humidifying ('wet' devices). 'Dry' devices are more applicable and, in addition, allow the return of intercepted dust into manufacturing.

The main types of devices for dry purification include cyclone separators, fabric filters, and electrofilters.

The purification of gases emissions is achieved by using adsorption and absorption methods.

Absorption methods are based on the removal of harmful impurities by the liquid. Contact of gases with the liquid is carried out by special means 'absorbers', gas and liquid move contraflow in which. Basically, the absorption process is not just a process of gas dissolution in the liquid but chemical interaction between dangerous substances present in gases and components absorbing solution. Absorption methods are simple, reliable, and have a high degree of purification; however, their use has some difficulties connected with applying cumbersome equipment and salvaging of worked-out solutions.

Adsorption methods for purification are based on taking up of impurities by a surface of rigid bodies (adsorbents). The important feature of adsorption is that the process passes without changing the chemical structure of the adsorbed substances and adsorbent. This allows to return adsorbed gases into manufacturing and multiply use of an adsorbent.

For some industries (for example, thermoelectric power plants, metallurgical works, etc) building filter-catchers and smoke stacks is effective enough. Smoke stacks allow one to carry off combustion product (harmful gases and rigid particles) in the upper layers of atmosphere and spread them on large territories. For example, the smoke stack with 100 m of height lets spread harmful substances around in radius of 20 km in safe concentration, and when its height is 250 m, the radius of spreading is increased to 75 km.

For atmospheric air protection from motor transport emissions, the use of neutralizers of exhaust gases is recommended, which catch carbon oxide and hydrocarbon; the use of diesel fuel exhaust gases of which almost contain carbon oxide and structures of lead; using of compressed gas; regulation of the intensity of city traffic and bridge constructing.

Industry or its separate structures with technological processes, which are sources of air polluting with harmful substances and ones having bad smell, are separated from living buildings by sanitary-protective zones (wood or ground spaces which border factories and living arrays). The size of the sanitary protection zones depends on the class of the factory (1st class needs 1000 m, 5th class – 50 m). Within the sanitary - protective zones construction of sports structures, parks, children establishments, schools, and other is restricted.

The most effective measure in protecting the air is creation and introduction of wasteless technologies. First of all, it concerns the metallurgical and chemical works. As Louis Button said: 'we have two choices: either people make less smoke in the air or the smoke will make less people on Earth'.

4.6.3. Water Resources Protection

Among natural resources, water takes the special place: first life on Earth appeared in water medium, water is in the structure of all living organisms and is the resource an economic activity is impossible without; oceans and seas occupy 70.8% (510,000,000 km^2) of total Earth surface. Water reserves on Earth are large – 1,400,000,000 km^3, but about 96% of this volume belongs to salt water of the great oceans. Fresh water reserves are slight – about 35,000,000 km^3, incidentally, 70% of it is concentrated in ice, almost 30% of world reserves are underground waters and only some part of it is accessible, a part of water is in a ground, atmosphere, living organisms. The waters of rivers, lakes, bogs make a minor part of the hydrosphere – less than 200,000 km^3 (or less than 0.02%).

Water consumption is constantly growing. Under the conditions of increasing volume of water supply and ejection sewage into reservoirs, the main danger consists of deterioration of water quality. Annually more than 450 km^3 of wastewater is ejected into rivers and other water reservoirs, and about half of them without previous purification.

The main polluter reservoirs are insufficiently purified industrial and public utilities that are not sufficiently purified, and also cattle-breeding complexes sewage; rain and melted snow waters wash off polluters from the city territories and fields, polluting the atmosphere which are caused by precipitation.

The industry uses more than 20% of the water reserves. The greater amount of it is used for cooling electric power plants and other technologies. During the last ten years, the need for water in industry grew due to applying modern water-retaining technologies. The most water-retaining technologies are chemical, pulp and the paper, and metallurgical industry. For example, 1 ton of ready-made synthesised fiber takes 2.500…5.000 m^3 of water; plastic - 500…1000 m^3; papers – from 400 up to 800 m^3; pig-iron - 160…200 m^3.

In public utilities, water is used for sufficing of household needs, working of consumer service establishments, that approximately makes 15% from industrial water consumption. Residents of such cities as London, Paris, daily use about 160 liters of water.

Industrial water wasting is rather slight; it is mainly reasoned by processes of evaporation, which are the most intensive in thermal and atomic power stations, and also in ferrous metallurgy.

Industrial sewage contains various harmful substances. Sewage from instrument-making and machine-building plants contains saline of various metals (copper, nickel, chromium, and cadmium), and waste water from galvanic workshops, cyanide. The wastewater from the chemical industry is most dangerous because it contains complicated organic substances. The sewers of cities are polluted by people's waste: washing liquids, dyes and also industrial wastes.

Recently, synthetic surface-active substances, soaps, washing-up liquids, emulsifiers which are widely used in household activities and technological processes, have become extended polluters. The special group of polluters is formed by pesticides because they are washed off and fall into the air while plane spraying. These substances are fatal to all living organisms in water reservoirs.

According to the phase-dispersion state in water all polluters are divided into soluble, colloidal, and insoluble substances, and by origin – into mineral, organic and bacterial ones. Mineral polluters include solid suspension (sand, clay, slags) and solutions of acids, alkalis, and salines. Organic polluters have nitrogen, phosphorum, carbon, potassium and other substances in their structure. They are formed in reservoirs as a result of biological processes of living things and also get with rain waters, which wash off fertilisers from fields. A widespread organic polluter is petroleum and its products. Organic polluters create an appropriate medium for the development of bacteria, viruses, fungi, and other microorganisms very dangerous for people.

The special kind of contamination is the thermal source of which are the thermal water emission from the power stations. Particularly dangerous are the radioactive substances that enter the reservoirs with precipitation.

Naturally, water self-refinement is large enough, but not unlimited. When the polluting of the reservoirs reaches a critical level, the water not only losing its biological properties but even getting unacceptable for household or even industrial needs. Polluting of water kills the flora and fauna of reservoirs.

Now, increasing quantity of polluters does not attract public concern so much as the properties of polluters (insoluble, sparingly soluble, toxic). Among such polluters, petroleum and radioactive waste must be emphasised. About 10,000,000 tons of petroleum enter oceans from various sources on the planet annually. The petroleum film isolates water from atmospheric air, reduces the intensity of water evaporation, and breaks the ecological balance in the hydrogen medium.

The consequences of local polluting of ocean waters in some cases are hard to foresee. In Japan, it is unknown before mass diseases are detected; the cause is found in the taking of fish with food poisoned with mercury ingredients from the sewage accumulated in Minamata Bay. 'The Minamata disease', as it's appeared, is transmitted from generation to generation.

There is a complex of measures to reduce the contamination of biosphere waters:

- working out technologies containing little or wasteless with the closed return cycles for intermediate purification or cooling water and waste utilisation;
- improvement of technologies for reducing sewage volume by burial of polluters concentrated solutions in terrestrial bowels;
- application of various methods for purifying water polluted by industrial and household waste;
- reduction of chemical fertilisation of the farming industry due to efficiency of biological and other agrotechnical measures to provide protection against plant infection and pests;
- improvement of tanker constructions of inland water transport and navy, technology for marine petroleum production for decreasing petroleum quantity which gets into the ocean; realization of measures on purification of surface of water areas of see and river ports from petroleum polluters.

The purification of sewage is the destruction or extraction of some substances, and decontamination is the extraction of morbid microorganisms out of waste water. For purification of wastewater, purifying structures are used. For purification of city and industrial wastewater, mechanical, biological and physical-chemical methods for refinement are used. The universal method for the extraction of organic substances is the biological method.

4.6.4. Protection and Rational Use of Ground and Bowels

Soil is a surface fertile part of the Earth's crust, which was formed by continuous influence of moisture, air, heat, vegetative, and animal organisms on the surface layer of the Earth. Fertility is the ability to supply plants with moisture and nutritious substances, which is the most important property of the soil.

Less than 1/3 of the Earth is dry land – continents, islands; 90% of this territory is the people living space, and 10% of it is ice.

The growing amount of population and technical progress increase the anthropogenous loading on the ground resources and require the magnification of food production. The decrease in agricultural areas caused by soil (erosion, salinization, ravaging, swamping, mudflow, landslides, avalanches and contamination) and direct reduction in space is recently observed.

The erosion arises under influence of water, wind and anthropogenous factors on the soil and under-layer. Protection against erosion includes the application of the whole complex of protective measures.

Salinisation is a process of accumulation of natrium, cadmium, and manganese saline in an the soil in unacceptable concentration. Especially widespread is the secondary salinisation, salt accumulation caused by incorrect watering and filtration of water.

Ravaging is the transformation of fertile ground into infertile desert.

Swamping is the excess moisture content in soil. It takes place close to channels and artificial reservoirs. The drainage is used to dry the ground.

Mudflow is the stream of stone, mud, which appear in the river bed after heavy flood. The flow speed reaches 10 m/s and more, and the volume of emissions, up to millions of cubic meters. Methods for mudflow struggle are: growing vegetative cover on the slopes; clearing off accumulation of loose rock; stabilization of mountain river bed with systems of dams.

The land slide is the shifting of mountain masses down the slope caused by their moistening, seismic waves, and human activity.

The avalanche is the take-off and fall of big masses of mountain rock on mountain slopes. Measures for struggling landslide and avalanche are the following: drainage structures, fixing of slopes with piles, planting of vegetation.

Contamination is the covering of a surface or penetration of the soil by industrial or economic activity waste. There is the so-called ‘industrial desert’ – land space where the ground is polluted with industrial waste due to people activity. Industrial wastewater is expedient to be used or reprocessed. The industrial trend is wasteless and low-use technologies.

Tearing away is the transfer of agricultural areas or wood for cities, industry, highways, pipelines, and other needs construction.

Fertile soils that, due to economic activity, have destroyed vegetation, changed land relief are named affected.

Bowels are the upper accessible part of the lithosphere. Bowels are used for extracting minerals, storing rare and gaseous minerals, building up structures and transport communications, and burial of sewage and waste water.

The mineral refers to nonrenewable resources, but its extraction reaches large numbers (more than 200,000,000,000 tons of mountain rock, over 30,000,000,000 tons annually). Thus, there is a progressing exhaustion of mineral reserves and also their structural modifications.

4.6.5. Anthropogenic Impact on the Environment in Form of Energy Contamination

4.6.5.1. Thermal Containment

Energy contaminators of environment are considered such types of energy of anthropogenic origin, which are either absolutely not inherent for nature, or their intensities considerably exceed background (natural) magnitudes and harmfully act on people, vegetative and animal organisms and can disturb normal functioning of various ecological systems.

The influence of energy contaminators on the biosphere. They are thermal, radioactive (ionising), electromagnetic, and acoustic contaminators (noise, vibration). Each of these types has its own properties, parameters, and risk rate for a person and other living organisms.

The thermal contamination of the environment is related to the working of heat power aggregates and technological heat exchange arrangements. The equipment of thermal power stations, various thermal engines, including motors, refer to the first group. In these aggregates, heat transforms into mechanical or electrical energy. The second group includes various heating, drying, melting, evaporation, and sintering of various materials during their technological processing. Here are also devices for heating of dwellings and other objects.

4.6.5.2. Acoustic Containment

The main sources of noise in cities and other settlements are motor transport, rail and air transport and industrial plants. Motor vehicles create a noise level from 82 to 95 dBA on the streets. The street noise level is determined by intensity, speed, and character of traffic, and also depends on the construction factors (structure of the streets, height and density of buildings), road cover, and green plantings. On the territory of industrial cities cars make a significant level of noise, which spreading over the territory close to roads gets into dwellings. The following methods for reduction of noise on environment are recommended: decreasing the speed of traffic speed and its restriction for some types of cars on certain roads in a certain time; motor transport development; improvement of buildings and construction of noise absorbing screens along high-ways.

The railway transport creates a significant noise level: the electrotrain – 93 dBA, passenger train – 91 dBA, freight train – 92 dBA on distance of 7,5 m from the moving train. Noise levels in open subway lines reaches 70…80 dBA. The most noisy among all types of the city transport is the tram. The moving tram creates noise loading (10 dBA higher than car wheels) when the engine is on and doors are operating. Reduction of tram noise level is possible to improve the condition of the tram line, and also to modify the construction of the car.

The air transport creates sounds equivalent to levels of 80 dBA, and the maximum level reaches 108 dBA. For noise minimising special piloting on take-off and landing, more steep trajectories, low power setting, rational organisation of air movement (take-off and landing strip not crossing localities), rational planning, etc. are used.

Normalisation of noise for city building is carried out in correspondence with the standards, for example, for apartments and rooms, the standard makes 30 dBA, class rooms – 40 dBA. These standards are indicated for night time (from 11 p.m. to 7 a.m.), and in day time standards are increased for 10 dBA.

City-planning measures on noise reduction include: increasing of distance between protected object and source of a noise; using of acoustic screens – slopes, walls, screen-structures; rational placing noisy and protected objects; using earth relief, deepening of highways; using free building construction (places where people stay temporarily: shops, dining rooms, ateliers serve as screen-building situated in front of the streets and apartment houses are placed behind them); trees planting.

4.6.5.3. Electromagnetic Containment

The electromagnetic radiation of long-wave, middle-wave, short-wave and ultra-high diapason is widely used in wireless communication and also in high-frequency heating arrangement. Television uses ultra-short and decimeter waves, radar location – centimeter. In electrical networks of high voltage (over 1000 V) the electromagnetic fields of audio frequencies (50 Hz) are used. The electromagnetic radiation of anthropogenic origin can be considered as one of the energy contaminators, as they negatively influence the organism of people and other living organisms and detrimentally affect ecological system.

During exposure of the person, the significant part of electromagnetic radiation is absorbed by the organism. Absorbed energy turns into thermal, which induce intensive heating of tissue and liquid. The greatest danger it has for internal organs which have slight circulation of blood and other liquids and because of what heat hardly transfers from them. That can bring about irreversible consequences (modification of cell structure, tissue deadening, extravasation, and other). The influence of electromagnetic fields on endocrine, nervous and cardiovascular systems, reproductive function, morphological structure of blood, and exchange of substances.

The anthropogenic sources of electromagnetic radiation are divided into three groups:

1. point (radio-station, television centre);
2. joint (plants, radar-tracking stations);
3. linear (electricity transmission, contact networks of electrical transport).

The level of radiation intensity from these sources has now increased now because of growing of their amount and power; in some regions it exceeds the average natural level ‘natural background’ in hundred times.

One of the most powerful sources of electromagnetic radiation is also an electricity transmission line. Measures to reduce the influence of electromagnetic fields include construction along the special protection zone of the electricity transmission line with the following breadth: for a voltage of 1150 kV and higher, outside the localities it is 300 m to each side of the line axis; for 500 kV – 150 m outside the localities and 50 m – in boundaries of localities; for 22 kV – accordingly 10 and 7 m.

Except protection zone construction, special modes for agricultural and forestry works (short working day, minimum use of machines and mechanisms) are provided in zones of electromagnetic influence.

The main sources of high-frequency energy on people living in a medium are radio and television centers and radar tracking stations. Electromagnetic fields intensity measuring should be carried out periodically both on territory of radio stations, and in living zones, which are close to transmitting antennas. When the limits of acceptable level are exceeded it is necessary to realise complex of protective measures: shielding of apartment houses, changing of antenna directivity, reducing of the transmitter power. If these measures are not sufficient, there is a necessity to move radio station out of the borders of the locality or to remote living buildings from a zone of electromagnetic fields influence. Together with the mentioned above measures the shielding of territories by buildings with large contents of ferro-concrete constructions (radiation intensity is reduced in 1,5-2 times); multi-row green planting (having breadth 15-20 m radiation intensity is reduced for 10-15%) are applied.

4.6.5.4. Ionizing Containment

The human being has always lived and evolved in the world filled with radioactivity and ionization. The biosphere of the Earth has more than 60 natural radionuclides, primary and cosmic. Primary radionuclides are isotopes of elements with long half-life and decay product of long-living isotopes of uranium and thorium; cosmic are some which appear after interaction of space radiation with substance of atmosphere or with solid substance of the Earth. Every second, the human body passes through tiny particles. The ground, walls of houses, air, food, and the person itself are radioactive. Therefore, it is possible to assert that the natural background doze which influences the mankind for thousands of years is not dangerous because mankind got accustomed to such exposure during natural selection.

Research in the field of atomic nucleus and nuclear energy create artificial sources of ionising radiation. At the first stage of nuclear energy the problem of radiation safety is only to staff that worked with nuclear arrangements and radioactive substances, in modern conditions, when nuclear power's got fast development, it is necessary to take into account global scattering of artificial radioactive substances and the increase in the rate of natural radionuclides circulation which predetermines an additional exposure on any living organism. The increasing of the radiation factor on a global scale has set a problem on development of principles for public health services with account of the direct influence of ionising radiation on objects of a natural medium.

Radioactive contamination of the environment is caused by two types of radiation, corpuscular and electromagnetic. Corpuscular radiation includes flows of α- and β- particles and neutrons, electromagnetic one is X-rays ($\lambda = 10^{-9}...10^{-12}$ m) and γ-radiation ($\lambda < 10^{-12}$ m). Corpuscular and electromagnetic radiation with an indicated range of wavelength is able to split electrically neutral molecules, forming charged ions during interaction with substance. That is why the cumulative title of these types of radiation is ionising.

Each of the types of radiation has various properties and characteristics, the most important of them are penetrating and ionising abilities.

The source of ionising radiation can be closed when radioactive substances cannot penetrate the environment from installation, and open when such possibility exists.

The exposure of an organism can be external and internal. External exposure is when the source of it can be outside of an organism, and internal – it is inside. Radioactive substances can get inside an organism with the air through respiration, as radioactive dust, with water, food, smoke. The internal sources are more dangerous because their influence on the organism is constant, which results in accumulation of ionising atoms and molecules.

The ionisation of an organism is followed by complicated physical-chemical and biological processes, breaking of molecular bones, modification of molecules structure, killing cells, violation of normal physiological processes, and exchange of substances are possible to refer to. In addition, the structure and functions of blood are infringed, protective responses of an organism are reduced, the malignant swellings arise and develop. These and other symptoms characterize the so-called radiation sickness which is fatal.

The special danger for the biological world is in the fact that modifications occurring in an organism of people and animals under the influence of radioactivity concern only to them, but also the next generation which may have inborn defects.

Radioactivity causes changes in all living things. Virus and bacterium that are under future exposure can form new mutations of morbid microbes and cause unknown epidemics.

In accordance to the standard, there are three categories of people being under exposure set: A category is staff that constantly or temporarily works directly with sources of ionising radiation; the category B – people who do not work directly with radiation sources, but in living conditions or working can be under the influences of radioactive substances, which are used in appropriate technologies and are exposed to the environment with waste; category C – the rest of the population of the country.

Taking into account the sensitivity of separate organs of the person to ionising radiation, they are divided into three groups (in order of decreasing of influence):

I, whole body, red marrow, genitals;

II – muscles, liver, kidneys, lungs, alimentary canal, eyeball;

III – skin, bones.

The use of atomic energy is not connected with the threat of an erasure of life on the Earth, but violation of standards and rules of radiation safety puts people under direct danger of health from radioactive substances. Therefore, when projecting and constructing of power plants, it is necessary to pay close attention to this problem. The main problem here is the problem of neutralisation of nuclear industry waste.

Many countries practise the burial of radioactive waste at the bottom of the ocean. So into the Atlantic and Pacific oceans hundreds of thousands of containers with high radioactive waste were thrown. The containers were rejected in deep water areas with small circulation and low biological activity. However, as research showed, in many areas intensity of circulation and biological activity had increased.

Solid radioactive waste (polluted materials, workcloth, etc.) is placed into concrete trenches and filled with concrete.

4.7. Nitrates and Human Health Effects

Nitrates are saline nitrogen acid the most widespread substance in nature. Nitrates take place in the ground, water, they are the chemical component of plants, products of the exchange in organism of humans and animals. People experience the influence of nitrates during living all the time. However, in case loading of these substances on an organism is too heavy, they can have a negative effect.

The loading on the organism of the person has increased recently. This problem has arisen due to overuse of chemical supplements in agriculture, the application of mineral fertilizers containing nitrogen (potassium niter KNO_3, natrium niter $NaNO_3$, and ammonia niter NH_4NO_3) to increase agricultural harvest.

The problem of nitrates has two aspects, which are interconnected but have some features. It is the aspect of nitrates in potable water and the aspect of nitrates containing them in foodstuffs.

Such important components as protein, fat, carbohydrate, vitamins, and other, and also various chemical substances: pesticides, toxic elements, nitrates, and others take place in foodstuffs. The contents of chemical substances in a food can vary in wide range: from the safe concentration for people, to the level that represents actual danger for health. Nitrates serve as the obligatory part of foodstuffs, but their amount should be kept within acceptable limits.

More than 20 factors are known to increase nitrates accumulation in vegetative food. They concern to: light deficit, heat and cold in plants vegetation period, drought and constant overly moistening, large and small amount of such elements as nitrogen, potassium, phosphorum in a ground, biological activity of a ground, ground acidity, ground disease, etc. But the primary factor remains the nonrational application of nitrogen fertilisers, violation of agrotechnic processing agricultural cultures.

Intoxication by nitrates is characterised by heavy passing and can cause death. Nitrates' toxic action consists of hypoxia (oxygen starvation of tissues). Clinical indications of nitrate poisoning occur in 1…1,5 hours after entering an organism with potable water. At the first period, there is cyanosis of the lips, mucous envelopes, nails, face. Then an irritating affecting of the mucous envelope is exhibited with sickness, pain in the stomach area, salivary emissions, and vomiting. In case nitrates get into organism with food, the latent period of disease is longer, from 4 till 6 hours.

When there is suspicion of poisoning by nitrates and nitrites, the patient is cured of stomach, later on he takes activated carbon suspension (2 spoons per glass of water), and after that a salt laxative mixture.

The hygienic regulation of acceptable concentration for nitrates in separate foodstuffs is carried out taking into account the concrete climatic and economic regions. Here, it is necessary to take into account the acceptable daily dose of nitrates, the daily use of food, background nitrates' level in foodstuffs. The acceptable daily dose of nitrates for a person is 5 mg for 1 kg of body weight.

For checking out parameters of acceptable nitrates content in separate food the counting by the following formula is carried out:

$$DDD > \sum_i \frac{D_k \cdot N_i \cdot C_{rf} \cdot C_f}{C_{be}} \qquad (4.1)$$

where DDD – acceptable daily dose of nitrates, mg; D_k – acceptable daily dose of nitrates for food items, including potable water, mg per kg or mg/l; N_i – average daily use, kg per l; C_{rf} – coefficient of change in nitrate concentration in ready-cooked food, C_{rf} = 0.5…1.0; C_f – coefficient of foodstuffs, C_f = 0.6-0.9; C_{be} – coefficient of biological equivalence of nitrates 'food:water'; for potable water $C_{rf} = C_f = C_{be} = 1.0$.

Nitrates can accumulate in increased amount not only in vegetative food but also in food of animal origin and first of all in milk.

As practice testifies, contents of nitrates in vegetative food quite often exceed the acceptable level. This forms the basis for determination of ways for their correct use. The amount of nitrates in plants depends on their biological features. Vegetables contain the highest quantity of nitrates in greens (parsley, dill, salad, etc.), edible roots (garden radish, beet, carrots). The nitrate content accumulated in tomatoes and potatoes is relatively mild. Cucumbers and cabbages are found between these two vegetable groups. The early vegetables contain more nitrates than the latter ones. As a matter of fact nitrates' concentration of nitrates in hothouse vegetables is greater than in the vegetables growing in open ground. Quite a small quantity of nitrates is accumulated in fruit and berries. Research shows that contents of nitrates in vegetables is distributed irregularly. For example, the amount of nitrates in leaves of parsley, fennel is for 50-60% lower than in their stalks; amount of nitrates in upper part of carrot is for 80% lower than in internal. In cucumbers, radish, in contrast, the surface layer contains for 70% more nitrates more than internal.

Usual washing and mechanical clearing of food (potatoes, beet, carrot, cabbage, etc.) reduces the contents of nitrates in average by 10%. A significant reduction in nitrates is observed on steeping of the cleared food. After steeping of potatoes, carrot, beet during 1 hour, the level of nitrates decreases for 25-30%, greens (parsley, fennel, green onions) – for 20%. The reduction of nitrate content in food can be reached by cooking. While boiling they turn into broth, which decreases nitrates content: in potatoes – for 80%, carrots and cabbage – for 60…70%, beet – for 40…50%. Preserving decreases the content of nitrates in food. It is achieved by the transition of nitrates into pickle (in souring) or marinade (on pickling and preservation). Making juices and drying vegetables, on the contrary, increases the contents of nitrates.

The important element of maintaining the guaranteed quality for foodstuffs is controlling them, including parameters of nitrates contents and other chemical polluters in foodstuffs.

Table 4.1. indicates acceptable levels of nitrate content in some vegetables.

Table 4.1. Acceptable levels of nitrate content in some vegetables [44]

Vegetable	Acceptable levels of nitrates contents in foodstuffs, mg/kg	
	Open ground	Protected ground
Eggplants	300	-
Beet	1400	-
Melon	90	-
Squash	400	-
Water-melons	60	-
Cabbage late	400	-
Cabbage early	800	-
Potatoes late	120	-
Potatoes early	240	-
Carrots late	300	-
Carrots early	600	-
Vegetables leaves and salad	1500	3000
Cucumbers	200	400
Pepper	200	-
Garden radish	1200	-
Tomatoes	100	200
Onions	400	800
Large onions	90	-

The control of foodstuffs quality is carried out by:

- manufacturer;
- special official establishments – sanitary-epidemic stations;
- public organisations.

For detection of nitrates there is of whole arsenal a research tests:

- photometric methods are based on the transformation of nitrates into nitrites with the following synthesis of dyes (solution coloring) with nitrites. The intensive the coloring of a researched solution is, the more concentration of nitrates is in it;
- chromographic methods: method of gas chromographing, gas-liquid chromographing, and ionic chromographing. Last, we have the most perspective for arbitration researches which require high fidelity;

Electrochemical, volt-ampere-metre, and potentiometer with application of ion-selective electrode methods for nitrates detection.

Planning foodtuff quality tests on parameters of chemical danger, the following classification of normal controlling is used:

- once for one year;
- once for one quarter;
- once for one month;
- once for ten days;
- in each food lot.

4.8. Safety in Emergency Situations

Natural disasters, industrial accidents, and transport catastrophes, using weapons in case of war create situations dangerous for life and health of significant part of population groups. All disasters are integrated by the concept of emergency situation. Generally emergency situations (ES) mean an external unexpected, suddenly originating circumstance, which is characterized by disturbing of constant process and makes significant negative influence on people life activity, economical, social, or natural sphere.

Safety in emergency situations is possible to consider as a discipline having roots in antiquity and connected with problems of saving people that turned out to be in a zone of disaster, protecting them from negative factors of an external medium and giving medical aid to the victims.

In all the periods of the Earth existence there were natural cataclysms of great destructive force which are named natural disasters (eruption of volcano, earthquake, flood, drought, etc.) arisen. They have taken place in all the epochs of the history of people, arise presently, and will be in the future. Sad statistics of multiple victims of the emergency natural phenomena, their often appearing made people investigate their reasons to work out possibilities of saving measures.

Intensive development in the XIX century of chemistry, growing chemical industry, using of chemical substances in every industry, military industry, and then in agriculture and household activities created premises for accidents in chemical works, chemical polluting of surroundings, and their negative influence on health of the people. At the beginning of the XX century chemical weapon was created. This method of mass erasure was applied in the First World War, over 1,300,000 people had been hit, and many of them had perished. Approximately from the middle of the XX century because of the intensive growth of chemical productions, population of developed countries faced the threat of chemical polluting of surroundings, and accidents in the chemical industry, in places of preservation of chemicals, during their transportation became so often that consequences of their influence became dangerous for millions of people. An example can be the accident at the chemical factory in India in 1984. In the accident more than 2000 men perished, tens of thousands people were hit, many of them had heavy injuries.

The national economy of developed countries has a large quantity of dangerous objects. The zone of these objects is occupied by more than 22,000,000 people. Chemical accidents are the actual threat to the people health. Polluting the surroundings (air, ground, waters) with chemicals makes many cities and regions unacceptable for living. The ecological situation becomes a national tragedy.

In the XX century, owing to successful researches in the field of physics and chemistry, many technologies based on chemical and nuclear processes were developed. The creation of large power-technological complexes and manufacturing that are dangerous for health and periodic accidents are causes of negative influence on the surroundings, plants, animals, and people. The population of industrially developed countries has turned out to be unprepared to the influence of chemical and radiation factors. The toxic load on the person has grown hundreds times. The Chernobyl disaster has strengthened a situation.

Recent research has proved serious changes in various ecological systems. There was a defined reduction in some plants and species of wild animals. In Ukraine on the territory of Kanevsky reserve the mass loss of young animals of red mouse and mole happened, the gray rat passed from wood to open flatness. Data obtained by complex radiological expedition (1990) in 30 km zone Chernobyl power station testified that some plants have multiple modifications observed: resizing and changing shape of foliage, appearing sweep-shaped sprouts; small animals have violations of reproduction function as increasing of embryo losses on various stages of their development, modification of the formula and biological condition of blood, deviation in cell structure of a liver and spleen. All of it is the consequence of qualitative modifications of surroundings. By the data of I.J. Vartanyan (1993) among the population of the most polluted cities of Russia and Ukraine there was for the first time fixed degeneration of neurogenome being evolutionary of very stable structure, it controls brain activity and intelligence of the person. Every year in Ukraine, 40,000 women do not have full term pregnancy, for 1000 newborns there are 20 freaks, in polluted cities (Zaporozhye, Crivoi Rog and other), the frequency of natural abortions is 5 times higher than in Simferopol, and each second newborn has a deviation in health which arises due to ecosystems' violation. All of it is the new problem for medical science and practise and for safety. At near future their amount will increase.

On 11 March 2011, a magnitude 9.0 earthquake struck off the coast of Japan, followed by a tsunami that slammed the eastern coast, destroying communities and taking the lives of tens of thousands of people. The event led to the biggest nuclear disaster since Chernobyl in 1986. It also exposed serious failures in the Japanese system to ensure the safety of nuclear reactors.

A study by scientists from the Woods Hole Oceanographic Society called the Fukushima disaster 'the largest accidental release of radiation into the ocean in history'. In April 2011, oceanic levels of caesium-137 measured off the coast of the Fukushima Daiichi plant were 50 million times higher than before the disaster. In Japan, contaminated rice, beef, fruits, vegetables, milk and baby formula were found, causing trouble among residents and taking a huge toll on the Japanese economy. In January 2012, the Ministry of Economy, Trade, and Industry (METI) admitted that radioactive gravel had been used to construct new homes and condominiums, and to repair roads and other infrastructure damaged by the earthquake. No regulations had been established to monitor radiation in stone and gravel.

Homes, schools, and municipal areas need to undergo extensive decontamination, including soil removal. About 29 m cubic metres of radioactive soil will need to be removed from Fukushima Prefecture alone. Removal is extremely difficult, and the government is still trying to determine where that radioactive soil will be stored. Waste disposal is a growing and ongoing concern.

The large problem in the second half of the XX century for many countries is transport catastrophes (auto-, air-, railway-crushes, marine and inland water transport accidents). Railway catastrophes in recent years (Arzamas, Ufa, Bologoye and other) have taken hundreds of lives. The list of air crushes around the world for the last year counted dozens. Autocatastrophes in the last years became of extreme character.

On the eve of the twentieth century mankind faces a large-scale social and cultural metamorphosis, changing values' hierarchy, acceleration of life rate. This created abnormal conditions for the person and had a pernicious effect on mental activity and actually turned ordinary daily conditions into disastrous conditions.

Analysis and correct evaluation of processes passing in nature and society testify to the growing place of safety in an emergency situation in the general system of knowledge and practical activity of people.

4.9. Causes of an Emergency Situation, its Origin, Stages of Development and Hit Site

The emergency situations appear as a result of the following:

- rapid natural processes caused by gravity, earth circulation, or temperature difference;
- effect of external natural factors, which result in aging or corrosion of construction materials and structures and decreasing of physical-mechanical parameters;
- engineering-industrial defects of structures (designer error; low quality of materials; violation of the rules of safety precautions for repairing and other works);
- influence of technological processes on materials of structures (overloading; high temperatures, vibration, aggressive medium);
- breaking of safety regulations of construction and technological processes, which induce kettle explosion, chemical substances spreading, etc.;
- military activity of all kinds.

Irrespective to the origin and type of emergency situation, development has four inherent stages (phases): origin, initiation, culmination, and fading (liquidation of consequences).

At the origin stage the conditions, premise for future ES get formed: unfavourable natural processes are activated; the engineering-industrial defects of structures are accumulated, multiple technical breakdowns appear; equipment malfunctions.

Definition of duration of origin stage is possible approximately only by means of regular statistics of failures, breakdowns, 'local' failures, observations of seismic, meteorological, mudflow struggle and other stations.

In the initiation stage of ES the most essential influence belongs to the human factor. Statistics testify that more than 60% of accidents arise due to staff errors.

At the culmination stage, the release of energy or substance, which has an unfavourable effect on people and the environment, occurs, at that moment the extreme situation appears. The characteristic of an emergency event is the chain character of passing, when destructive action of the initiating event increases many times owing to engaging into the involvement of powerful, toxic or biologically active components in the process. It is the chain process of destroying energy and substances that are released.

The fading stage covers time from interception of the source of danger – localisation of ES, to complete liquidation of its consequences, including all the chain of secondary, tertiary, and other consequences. The duration of this stage can be a year, and sometime a decade.

The knowledge of ES development chain in concrete conditions enables one to reduce the risk for such situation originating – to ensure readiness for emergency circumstances.

The territory in which the dangerous and harmful factors of ES act, with people, animals, structures, communications located in is called a hit site. It is simple and complicated.

The simple hit site occurs under the influence of one hit factor, for example, ruining from explosion, fire, only chemical or bacteriological contamination.

The complicated hit site arises due to the force of several hit factors. For example, the explosion at the chemical plant entails ruin, fire, chemical contamination of surroundings; earthquake and hurricane ruining structures can induce floods, fire from damage of an electrical network, etc.

The shape of hit sites depends on the nature of a source of the dangerous factors and can be round on an earthquake, explosion; band on a hurricane, flood, mudflow; irregular on fire, tsunami and other.

Consequences can be various, they depend on type, character, and scale of ES distribution.

The main consequences of ES are: death, disease of people, ruin, radioactive polluting, chemical, and bacteriological contamination. People who turned out to be in extreme conditions of ES get under the effect of a psychotraumatic circumstance, which induces violation of mental activity, the so-called reactive condition. The reactive action of extreme conditions is made not only by direct danger for the life of the person but also is connected with expectation of its realisation outside the hit site.

If the radiuses of dangerous and harmful factors action can be defined beforehand by calculation methods, on contrary the radius of psychological action actually can vary. In some causes it can be many times larger than other hit factor radiuses.

4.10. Classification and General Characteristics of Emergency Situations

Each ES has the physical essence, origin causes, destroying forces, development character, and features of action on humans and surroundings. Therefore, the classification structure of ES is based on the character of its genesis (cause of origin), velocity of development (velocity of danger distribution), scale of distribution of the hit factors with the regard for consequences, and also on the quantity of victims.

According to the cause of origin, ESs are divided into natural disaster, man-caused catastrophes, anthropogenic and ecological catastrophes, social – political conflicts.

Natural disaster is a dangerous natural phenomenon or process which has an extreme character and results in disturbing of daily life of the people, and also erasure of material resources. It includes earthquakes, floods, tsunamis, hurricanes, wood and peat fires and other. The drought, strong frost, long rain, epidemic, spreading of wreckers of wood and agriculture refer to natural disasters as well.

Natural catastrophes are classified into 3 groups:

- tectonic catastrophe (earthquake, eruption of volcano);
- topological catastrophe (flood, snow avalanche);
- meteorological catastrophe (hurricane, typhoon, frost, etc.).

Natural disasters cause the national economy to collapse, the elimination of material resources and, what is the most essential, victims of people, destroying their homes and property. In addition, they can become the reason for mass infection diseases. Most people suffer from floods (40%), hurricanes (20%), earthquakes, and droughts (15%). Near 10% are the rest of natural disaster types.

Here, the characteristic for some natural catastrophes is given.

The earthquake is the force shacking of the earth's crust induced by tectonic or volcanic cause that results in ruin of structures, fires, and people victims.

The main characteristics of the earthquake are size of hit site, magnitude, intensity of the energy on the earth surface. The magnitude of hit site can be of 10…30 km, sometimes it is much more.

Magnitude characterises the general energy of an earthquake and represents a common logarithm of the ratio of the maximum amplitude of the ground oscillation measured in the investigated place by a seismograph in microns to maximum amplitude of the ground oscillation defined at a distance of 100 km from the epicentre.

The magnitude (M) by the Richter scale is measured from 0 to 9 (last number corresponds to the most powerful earthquake).

The intensity of energy on the surface of the ground is measured in numbers. It depends on hit site size, magnitude, distance from epicentre, and geological structure of the ground. For earthquake energy intensity measurement in our country, 12-number Richter scale is accepted.

Table 4.2. Earthquake characteristics [23]

Magnitude by Richter scale	Average amount of earthquakes in the world for 1 year	Duration of earthquake, sec	Radius of the region hit by strong earthquake, km
8,0-8,9	1	30-90	80-160
7,0-7,9	15	20-50	50-120
6,0-6,9	140	10-30	20-80
5,0-5,9	900	2-15	5-30
4,0-4,9	8000	0-5	0-15

Earthquakes cause great losses of material and kill thousands people. For example, on 21 June 21,1990 during an earthquake having intensity of 8 numbers by the Richter scale at northern Ural in the province of Shlyan more than

50,000 people perished and about 1,000,000 people were injured and left out of living places.

Table 4.3. The largest earthquakes of the XX century [21]

Year	Place	Amount of victims, thousand people
1920	Ganyasu (China)	180
1923	Fokto (Japan)	over 100
1960	Agadir (Morocco)	12
1970	Chimbote (Peru)	66
1976	Tanshan (China)	243
1978	Iran	15
1988	Armenia	25
1990	Northern Iran	

Protection from earthquakes involves beforehand the detection of dangerous seismic zones in various regions of country, that is, seismic zoning. On maps of seismic zones where earthquakes of intensity greater than 7-8 numbers by Richter scale are possible are marked. In such regions, they carry out various protective measures, and chemical factories and nuclear power stations are not admitted to build in.

Flood is an overwhelming water impact on the area after increasing the water level in the river and lake caused by various reasons (rain, ice jam on the rivers, dam destruction, and others). Floods result in material losses and human victims.

At the beginning of July, 1990 heavy showers in Zabaykallia caused the flood which destroyed 400 bridges and caused the losses of 400,000,000 in national currency. Thousands of people remained without a home or perished.

Floods can cause fires as the result of short-circuit of power cable and also destruction of pipes, electrical, television, and telegraphic networks.

The main direction in flood fight is decreasing of maximum water gain in a river by the redistribution of the flow in time (preservation of plants near water, planting of forest shelter belts, etc.). For protection from flood the system is used.

Land-slide is shifting of mountain masses down the slope, which appears because of equilibrium breaking caused by many reasons (ground undermining, unreasonable economic activity, etc.).

Land slides can take place in all hills with slope 200 and more in any season. They differ both in speed of mass moving (slow, middle, and fast), and in scale. The slow slide speed makes tens centimeters per year, middle – some meters per hour or 24 hours, fast – tens kilometres per hour and even more. Only fast slides can cause of catastrophes with people victims. For example, in 1911 in the Pamirs, the powerful earthquake ($I = 7.4$) induced a large land slide. Near 2,500,000,000 m^3 of loose masses were moved down. The village Usoi with 54 residents was dumped. The land slide has parted off the valley of the Murgay and created the dump lake that has flooded the village of Saraz. The height of that natural dam reached 300 m, the depth of the lake was 284 m, and the length was 53 km.

Precaution measures are transformation of ground relief, fixing of a slope by piles, construction of supports.

Snow avalanches are also called land slides and appear as sliding displacements. Gravity causes displacement of snow masses down the slope. Snow avalanche is a compound of snow crystals and air. Large avalanches arise on 25-600 slopes. For example, on 13 July 1990 in the Pamirs the earthquake and snow avalanche demolished the camp of the climbers, which was located at a height of 5300 m, 40 men perished.

The protection from avalanches can be passive and active. In passive protection, protecting shields are applied. In active protection, avalanche-dangerous slopes are shot.

Mudflow is a flood with a very large concentration of mineral particles, stones, fragments of mountain rock (which makes from 10-15 up to 75% of total flow volume), which occurs in pools of small mountain rivers and is caused by rain, sometimes by intensive snow thawing. Danger of mudflow consists not only of its destroying force, but also in suddenness of its origin. Mudflow can be of the mud structure (mixture of water and melkozem), mud-stone structure (mixture of water, rubble, gravel, small stone), or water-stone structure (mixture of water and large stone). The mudflow speed reaches 2,5-4,0 m/s, and sometimes up to 8-10 m/s. The consequences are sometimes disastrous. On 8 July 1921 Alma-Ata was hit by the mass of the ground, stone, snow, sand accelerated by the water flow. That flow destroyed structures, people, animals. The buildings were taken off the foundation and together with people taken by rough flow.

One mudflow was caused by the showers in the pool of the Mala Almaatinka. The total volume of mud-stone masses reached nearly 2,000,000 m3. The flow intersected the city by a 200-meter band.

The methods for mudflow control are various. These are the structures of various dams, cascades of jams, supports, ditches, etc.

The hurricane is a wind having force of 12 numbers by the Bofft scale, that is, the wind blowing over 32,6 m/s (117,3 km/h). Hurricanes are also tropical cyclones that arise in the Pacific ocean near Central America; on the Far East and the Indian Ocean, hurricanes are named as typhoons. In hurricanes, the velocity of the air reaches more than 50 m/s. They are followed by heavy showers.

In December 1944 near the Philippines the ships of the 3rd US Navy turned out to be near the centre of the typhoon. Three destroyers drowned, other 28 ships received damage, 146 planes, and 19 hydroplanes were broken and got out of the board, more than 800 people perished.

Hurricanes and storm wind (20.8 up to 32.6 m/s by the Bofft scale) in winter can raise a lot of snow in the air making a snowstorm. Due to the strong winds and large waves in East Pakistan, approximately 10,000,000 people suffered and approximately 500,000 perished on November 13, 1970.

Modern methods of weather forecast allow a couple of hours or even a day before to warn people about the coming up. The most reliable protection from hurricanes is using of protective structures (subway, cellars of houses, underground transitions, etc. can be applied as).

Man-caused catastrophe is a sudden breakdown of machines, mechanisms, and aggregates during their operation, followed by serious failure of technological process, explosion, fire, radioactive, chemical and biological polluting of large territories, people victims.

Failures in industrial objects, construction, and also in railways, air, autotransport, pipeline which cause fire, destroying civil and industrial structures, danger of radiation, chemical and bacteriological polluting of surroundings and also other consequences represent danger for people and the environment.

The character of man-caused catastrophe consequences depends on the type of an accident, its scales, and features of the place where it occurred.

Man-caused catastrophe can be consequences of the external natural factors action, including natural disasters, engineering-industrial structures, breaking of technological processes, breaking of safety regulations for transport and machine operation, etc. But the most often reason is the failure of technological processes and occupational safety.

Anthropogenic catastrophes are qualitative changes in the biosphere caused by an action of anthropogenic factors which have occurred during people economic activity and have a harmful influence on people, animals and plants, and their surroundings.

Degradation of the environment is a consequence of urbanisation, extension of economic activity, and wrong treatment to nature.

Emergency situations of ecological character include intensive degradation of the ground and its polluting with heavy metals (cadmium, mercury, lead, chromium), contamination of the atmosphere by harmful chemical substances, noise, electromagnetic fields, and ionising radiation, contamination by acid rains, elimination of the ozone layer; smog, contamination of water.

Social-political conflicts are very critical forms of solution of the disagreement between the countries using modern methods for attack (military-political conflicts), and also international crisis followed by violence.

According to velocity of danger distribution ES are classified as sudden (earthquakes, explosions, transport accidents), fast (fire, hydrodynamic breakdowns with forming of break wave), moderate (floods, accidents followed with radioactive substances ejection), smooth, with slow distribution of danger (drought, epidemics, ground and water contamination by harmful chemical substances).

According to complex indications, ES are divided into five types: place, local, regional, national, and global. The ES consequence spreads in the boundaries of an object of national economy and can be liquidated by its own forces and resources.

The local ES scales in the boundaries of the locality and can be liquidated by the forces and resources of the district.

Regional ES consequences cover space in the boundaries of a number of districts or economic regions and can be liquidated by forces and resources of the country.

The national ES has consequences covering several economic regions, but does not exceed the boundaries of the country. The liquidation of such ESs is carried out by the forces and resources of the country, frequently with the help of other countries.

The global consequences of ES go beyond the boundaries of the country and spread to other countries. These consequences are liquidated as by forces of each country on the territory so by forces of the international union.

Depending on the number of victims, ES can be small (25-100 people hurt, 10…15 people hospitalised), middle (100-1000 people hurt, 50-200 people hospitalized), large (it is more 1000 people hurt, more 200 people hospitalized).

4.11. Fire as an Antropogenic Catastrophe. Organization of Fire Protection

4.11.1. Fires and Causes

Fire is an uncontrolled burning out of the special area that brings moral and material losses and sometimes people victims.

The Causes of Fire

- violation of fire prevention rules;
- careless behaviour with fire;
- electrical equipment malfunction;
- failure, catastrophe;
- Natural phenomena.

The process of burning is possible when the following is present:

- combustible;
- ignition source;
- oxidiser.

Combustible is a solid, liquid, or gaseous substance capable of oxidising with heat and light radiation.

Oxidisers are oxygen, chlorine, fluorine, sulphur, and other substances that are capable under heating or impact to decompose the extracting oxygen.

The ignition source has an influence on the combustible and oxidiser that can induce inflaming. Ignition sources are divided into open and hidden sources.

When any of the three factors are missing, burning does not appear.

Fire risk materials are materials and substances that, by their properties enable origin or development of fire.

The ignition is burning and appears under the influence of the ignition source.

Flash is fast burning of combustible mixture that is not followed by the formation of compressed gases.

Self-ignition is a phenomenon of the sharp magnification of the velocity of exothermal reaction that results in the appearance of burning of the substance.

Combustion is ignition followed by the appearance of a flame.

Self-combustion is self-ignition that is followed by flame.

Explosion is a fast substance transformation that is followed by extracting of energy and formation of front of compressed gases.

The combustion temperature is the lowest temperature of a substance under which the stable flame burning appears.

All materials and substances are divided into three combustibility groups:

1. incombustible is the substance that cannot burn in the air;
2. Hard-combustible is a substance capable of igniting in the air from the source of fire, but unable to keep burning after the fire source is taken off;
3. Combustible is a substance that can self-ignite and also ignite from the source of fire and continue burning without a fire source.

Fire resistance of building constructions is the characteristic to keep bearing and protection function on fire (measured in hours). Fire resistance of structures is determined by the ultimate fire resistance of main building structures. Combustible parts of buildings have no ultimate fire resistance.

Fire-explosive-risk work areas are divided into 5 categories:

A, B – fire and explosion risk area;

C – fire-risk area;

D – area where heated incombustible solid, liquid, or gaseous substances burnt on salvaging as fuel are used;

E – area having an incombustible substance in the cold state.

The building area or its part where explosive mixtures can appear or combustible materials are is named as fire-explosive risk zone.

The explosion risk zones are divided into 6 classes; fire risk zones are divided into four classes.

4.11.2. Fire-Prevention Organization in Industry

The safety ensuring of a plant or an establishment is assigned on their head or person engaged; their responsibility for fire-safe is stipulated by the law.

The head of the enterprise and the officials have such fire-safe obligations:

1. to develop complex measures on the maintenance of fire safety in the the enterprise, in establishment, and in the organisation;
2. according to the state normative certificates on fire safety to develop and approve positions, instructions, other normative documents, which act inside the enterprise; to realise monitoring of their fulfillment;

3. to organise training of workers on fire-safe;
4. keeping in serviceable condition means for fire-prevention and communication, fire-technique, equipment, to use them only as required;
5. to carry out service investigation of fire cases.

Common requirements for fire-safety:

- each worker should know the rules of behaviour on fire, ways of evacuation, how to use primary methods for fire extinguishing, and place they are stored;
- highly inflammable and combustible liquids are necessary for storing in specially assigned places separately from other materials;
- in case of fire workers should immediately inform fire-brigade by telephone number 101 and management of the enterprise, and immediately start liquidation of fire by all available means.

The complex of technical, operational, organisational, and regime measures on fire prevention is developed and carried out by state fire inspectors. Fire Inspection representatives have the right to check up the condition of fire prevention in buildings, structures, warehouses, require the appropriate documents and information, take persons under responsibility for breaking statements, rules, standards, instructions on fire protection, partially or completely suppress the work of the enterprise if there's fire danger.

Fire prevention is a complex of organisational and technical measures directed on the fire-safe maintenance, preventing of fire, and the conditioning for fast and effective fire extinguishing.

Fire-preventive measures can be constructive, informative, and regime.

The fire safe is condition of an object in which, with the definite probability of ignition and development of fire, the action of dangerous fire factors action on people is impossible and protection of material resources is ensured.

Fire safety is ensured by:

1. fire warning and prevention system;
2. fire protection system;
3. organisational – technical measures.

The maintenance of buildings and structures consists of fire-prevention breaks and barriers.

People evacuate in a fire.

The parameter of efficiency of evacuation is the time in which people can, if necessary, leave some room or building.

The safety of the evacuation is achieved when the duration of evacuation from separate room and building is less than the that is of critical fire duration dangerous to people.

The duration of critical fire is the time for reaching dangerous temperatures and decrease oxygen contents in the air.

Safety rules of people behaviour on fire in objects:

- in case of fire it is necessary immediately to call the fire brigade by telephone number 01 and inform management and personality of the enterprise;
- start liquidation of fire by own forces;
- to evacuate people and property. First of all, the most valuable and fire-risk materials should be evacuated;
- in case when extinguishing of fire by the own forces is impossible, it is necessary as soon as possible to leave the place through the main and emergency exits;

Leaving the location on fire it is necessary densely to shut the door to reduce oxygen incoming to the location.

The main danger for people dying from fire is smoke and hot air; therefore, in a room filled with smoke, it is necessary to breathe only through a wet dense fabric, remembering that the concentration of smoke is the lowest close to the floor.

4.12. Firefighting

The primary means for fire extinguishing are:

- embedding tool;
- fire extinguishers;
- manual fire equipment.

All are placed on the special board. The board is set so that the distance to the most remote building would not exceed 100 m, and to warehouses with flammable materials 50 m, or set accounting one board per 5000 m^2.

The fire extinguishing means are painted in signal red, and the inscriptions on the them and on boards are made in contrast white color.

The types of fire extinguishers are described below.

Water makes the basic effect of extinguishing that is, cooling of burning subjects down to a temperature lower than the combustion temperature. Water extinguishing flaws are: water freezing at negative temperatures; water does not extinguish combustible liquid with boiling temperature below 80 deg C; causes substantial damages for equipment and buildings; person extinguishing electrical equipment can be shocked; water badly moistens some filamentary and solid substances, therefore on their extinguishing water is not effective.

The foam can be chemical and air-mechanical. The chemical foam consists of carbon dioxidal, air-mechanical contains air ones. The foam extinguishing effect is cooling of the upper layer and isolation of burning subjects from the atmospheric air. The foam is not applied for extinguishing of electrical equipment under voltage, and with such active substances as potassium, natrium, and carbon bisulfide it reacts with.

Carbon dioxide (CO_2) is used, generally for extinguishing electrical equipment. It is not applicable to extinguish ethyl alcohol, it is dissolved in, and it is also combustible in celluloid, making it combustible without air. The extinguishment of carbon dioxide in closed rooms increases concentration of dangerous CO_2 dangerous for life.

The powder cloud creates protection from heat radiation; therefore, fire can be extinguished without special protective cloth. When the powder enters the heated subjects there's saline decomposition and extraction of incombustible gases that enhance extinguishing effect of the powder. However, in closed rooms on powder extinguishing high dust content in the air appears, the powders also have weak cooling effect that makes it possible repeated inflaming.

4.13. Fire Alarm and Communication System

For communication on fire, the telephone, radio, wireless telephone, devices of automatic and manual-automatic communication are applied. For warning people in rooms the special communication system, internal wireless network and also beeps can be used.

Automatic signaling systems have the following components: transducers which are installed in building or on territory of an objects and are for making a signal on fire; detection station to receive signals from transducers; communication lines, which connect transducers with detectors; power supply.

By principle of operation, the transducers are divided into thermal, smoke, light, combined.

The thermal transducers respond to increase of environmental temperature and in turn are divided into maximum ones to turn on when temperature is increased to a critical level; differential, turn on when environmental temperature increases with the certain velocity; maximum, differential.

Smoke transducers are divided into ionisation and photoelectric. Smoke transducers cannot be set in rooms with an air temperature below – 30 deg C and above 60 deg C, a relative humidity greater than 80%, and also in very dusty rooms and areas where acid vapours can be.

The light transducers respond to ultraviolet or infra-red radiation.

Combined transducers are based on the principles of operation of both thermal and smock transducers.

The signals from transducers come to the following:

- detection stations of fire signaling system;
- automatic means of fire extinguishing.

4.14. First Aid Emergency

First aid is the assistance given to anyone suffering a sudden illness or injury, with care provided to preserve life, prevent the condition from worsening, and/or promote recovery. It includes the initial intervention in a serious condition before professional medical help is available, such as performing CPR while waiting for an ambulance, as well as the complete treatment of minor conditions, such as applying a plaster to a cut. First aid is generally performed by the layperson, with many people trained in providing basic levels of first aid and others willing to do so from acquired knowledge.

There are many situations that may require first aid, and many countries have legislation, regulation, or guidance which specifies a minimum level of first aid provision in certain circumstances. This can include specific training or equipment to be available on the workplace (such as an automated external defibrillator), the provision of specialist first aid cover at public gatherings, or mandatory first aid training within schools. First aid, however, does not necessarily require any particular equipment or prior knowledge and can involve improvisation with materials available at the time, often by untrained persons.

When transporting a person it is necessary to treat him very carefully, not to let his body move. It is important to find someone to help you as soon as possible and transfer him on stretcher made of any available material. Lifting and putting him on a stretcher should be coordinated with partners.

If there is a suspicion for spinal and also lower jaw fracture, the person should be laid face down. Transporting of such person, however, is carried out on a stretcher either on an even support or any even place in a car. It is necessary to go carefully to avoid shaking.

4.15. First Aid for Injuries

Wounds are known as penetrating and non-penetrating. Penetrating wounds are the most dangerous, as they can hit internal organs and bones.

Penetrating wounds can induce internal bleeding. Giving first aid on wounds it is necessary to know the following rules:

- do not wash out a wound with water or use ointments, as this can remove dirt from the surface of the skin that can fester;
- do not wipe a contamination from a wound;
- do not remove blood wound clots that can induce bleeding;
- before first aid wash the hands up.

For first aid the individual packages are used to make a bandage for a wound, and if an individual package is unavailable, it is necessary to use a pure fabric and drop iodine solution on it as well as the spot around the wound. Do not spill iodine on the wound or fabric on it, as this can cause a burn.

First aid in bleeding. Bleeding is the most common complication of heavy injury. The cardiovascular system of an adult person contains 5-5.5 litters of blood. For 1 hour, heart transfers about 350 litters. That’s why when bleeding is intensive a person can have a significant blood loss very quickly, which results in death.

Bleeding can be arterial and venous. Arterial bleeding is extremely hard to stop and is the most dangerous. The indication of arterial bleeding is a bright red blood flow force, and indication of venous is a deep-cherry color.

Bleeding should be stopped, whatever intensity it has. If bleeding is not intensive, it is enough to make a tight bandage and work the wound out with iodine solution.

If bleeding is intensive, the other methods are applied. In some causes bleeding can be stopped by bending the extremity in the joints. They plug in a hollow place of joint flexion, that is, above the wound, with a tampon from any fabric. Then the joint is bent. When it is done, that is from the artery blood coming to the wound is pressed.

This method cannot be applied for fracture on the wounded extremity, therefore they use a special rubber tourniquet for bandaging. A tourniquet is put over the cloth, the pulse does not have to be felt. The tourniquet can be kept in the warm season for not longer than 2 hours and in cold – 1 hour. After that it is necessary to remove it for 10 minutes to recover blood circulation. The first aid on intensive bleeding venous is necessary to press by fingers.

Bleeding in internal organs is very dangerous. When that happens, the face turns white, and loss of consciousness is observed. In this case, the place of the injury should be applied with ice or cold water. If there is suspicion of abdominal cavity bleeding, do not drink anything.

In nose bleeding, it is necessary to sit a person down and slightly incline backwards his head, put on his nose bridge and neck a cold bandage.

First aid for fractures, dislocations, and bruises. Bone fracture, joint dislocation, and ligament sprain is followed by strong pain, which sharply strengthens when an attempt to change positions of the damaged part of body is taken. Therefore, first of all, it is necessary to let the extremity take the most comfortable position.

If the fracture is open, contamination can get into a wound. The wound should be bandaged.

If the spine fracture occurred, it is necessary very carefully to put some board under the back or to turn a person face down. Body inflection is suppressed, as it can damage the spinal cord.

Falling and the impacts frequently are causes of serious skull and concussion. The indication of a skull injury is ear bleeding and vomiting. The indication of concussion is headache, sickness, vomiting, loss of consciousness. If there is no loss of consciousness, 'concussion of the brain' is not medically diagnosed.

A person should be placed on his back, then it is necessary to bandage the head and put cold lotion on the head. Before the doctors come, a person should have full rest given.

The fracture and dislocation of the clavicle is followed by sharp pain, which strengthens on shoulder joint. It is necessary to plug an under-shoulder hollow with a tampon from a soft fabric or cotton wool and fix the arm bent to right angle to the body.

In extremity injuries, regardless of whether a fracture or the dislocation occurred, the hurt body part should be placed so that it would be in full rest. It is necessary to bandage the arm (leg) a splint or stick to fix the wound.

First aid for burns and frostbite. The burns are thermal (fire, steam, boiling water), chemical (acid), electrical (electric current, electric arc).

Three degrees of burns are known:

I degree – reddening;

II degree – reddening, bladder containing liquid;

III degree – deadening and tearing away of a tissue.

It is prohibited to remove damaged wear that stuck to the skin of the burned parts of the (sterile) body, and the bandage must be put over the cloth. Nothing is allowed to be wiped from a wound, because skin can be injured. On chemical burns, a wound should be washed out with plenty of water.

Frostbite also refers to thermal injuries too. On frostbite, blood vessels get damaged first of all and blood circulation is infringed. To recover blood circulation, open body parts are warmed up by rubbing, beginning on the frost and then in a warm room. Snow is not allowed to rub, because it will damage the skin.

Rubbing is carried out with cotton wool penetrated with spirit or vodka until the skin is reddening and then it‘s bandaged. If the bladders appeared do not rub, just make a bandage and take a person to the hospital.

The first aid for unconsciousness, sun and heat strokes and poisonings with gases.

Unconsciousness has the following indications: giddiness, sickness, darkening of the eyes, weakness. A person should be laid so that his head is lower the body to ensure blood flow to the brain. Give to drink water and smell liquid ammoniaspirit. Cold lotions should not be applied to the head.

Sun and heat stroke are overheating of the human organism and are followed by disorder of functioning of all the organs. When body temperature rises to 41 deg C despite medical efforts 50% of people die.

A person loses consciousness, there is no sweating, the skin becomes dry, and frequently there is bleeding from the nose, sickness, and vomiting. It is necessary to lay a person in the cool place so that the head would be higher than the body, give him a chance to smell liquid ammoniaspirit, and apply the cold lotion to his head. In case of stopping breathing, it is necessary to do artificial respiration and external massage of the heart.

The problem of preventive poisoning with gases has become very real in consequence of accumulation in an environment about 6,000,000 of various toxic substances, and about 60,000 of them are used in household activities.

The most widespread gases with which it is possible to poison are carbon monoxide, acetone, chlorine, and other.

Carbon monoxide is extracted from the combustion of fuel.

Poisoning has three degrees:

- the degree of I occurs when 20-30% of oxygen is substituted by carbon dioxide. Symptoms are headache, giddiness, face reddening;
- the II degree occurs when 30-35% of oxygen is substituted by carbon dioxide. Symptoms are loss of consciousness, violation of sight, and the person cannot leave the room by himself;
- the degree III occurs in presence in the air of carbon oxide, which substitutes 35% of oxygen. On it the person loses consciousness and dies.

The first aid on poisoning with gases is to take in the next steps: take a person immediately out of polluted area, take his cloth off, put him on even surface, warmly to cover, give him to smell liquid ammoniaspirit and drink milk.

First aid is very urgent to give to drowning. There are two types of drowning: the ‘blue’ type, when water enters and fills the lungs, and ‘pale’ type, when there is no water in lungs. The blue type occurs more frequently when the person doesn’t dive underwater but struggles for life and swallows water during it. When water is in the lungs (lungs inflate), there is foam going through the mouth and nose.

For blue type, it is necessary at first to remove water from the respiratory tract and lungs. A drowned person is placed over the knee, the rescuer face down. The rescuer opens with one hand a drowned mouth and with the other presses repeatedly and periodically on his back. After the drain of the water is finished it is necessary to lay a person on the back and make artificial respiration and external heart massage.

The pale type occurs in cases where people do not try to struggle for life and deep under water at once. Frequently it happens in an unconscious state. The person chokes from oxygen absence. In this case, it is necessary at once to begin reanimation measures – artificial respiration and external massage of the heart. When a drowned person starts to breathe, it is necessary to make him smell liquid ammoniaspirit.

5. ENVIRONMENTAL SECURITY

5.1. General Concepts of Environmental Safety

Environmental security is a state and conditions of the environment in which ecological balance is provided and protection of the environment is guaranteed: biosphere, atmosphere, hydrosphere, lithosphere, cosmosphere, species composition of fauna and flora, natural resources, preservation of health and life activity of people. It is a set of actions, states and processes, directly or indirectly not leading to vital losses (or threats of such losses) to the natural environment, individual people, and mankind; a complex of states, phenomena, and actions, providing ecological balance on the Earth and in any of its regions at a level to which mankind is physically, socioeconomic, technologically, and politically ready (can adapt without serious losses).

Environmental safety is defined in relation to the territories of the state, region, administrative regions and districts, settlements (cities and villages), or national economic objects – oil and gas industrial areas, industrial hubs, plants, factories, and other objects of industry, transport, energy, chemistry, mining, communications, etc.

For a long time, there was a conviction: the development of the world economy would be stable and continuous, and natural resources would be inexhaustible. Environmental problems were seen as technical problems that could also be solved by technical means. Technological optimism gave rise to illusions about the limitless possibilities of economic growth. And man's rapid technological offensive on nature, spontaneous, without taking into account the possible consequences, became the cause of today's environmental problems.

Thus, global environmental security (GES) today is characterised by the following characteristics:

- scarcity and degradation of natural resources or environmentally dangerous situations exacerbate conflicts and tensions within and between states;
- cooperation on the environment is a potential stabilising factor in inter-state relations that exacerbates tensions related to resource sharing;
- processes of strengthening dialogue and increasing mutual trust, frankness in the ecosphere develop slower than new conflicts are generated;
- the state of ecological security threatens socioeconomic stability (demographic trends, mass migration, reduction of welfare, instability, and destruction of social institutions, etc.).

Environmental security is based on the following:

- the recognition that humanity is an integral part of nature, totally dependent on its environment;
- recognition of the limited natural resource (ecological) potential of the Earth and its separate regions, the need for its qualitative and quantitative inventory;
- impossibility of artificial expansion of natural resource (ecological) potential in excess of natural system limitations;
- the determination of maximum allowable extraction of natural resources and modification of ecosystems as the environment of life;
- necessity of development of preventive ecological bans long before economical depletion of natural resources or their indirect destruction;
- the obligation to create a socioeconomic mechanism of homeostasis in the system 'man-nature' of the type 'goods-money-nature' (similar to the mechanism 'goods-money-goods');
- the urgent and obligatory need to regulate the number of people and their pressure on the natural environment at the local, regional, and global levels;
- acceptability of only 'ecologically compatible' technologies and equipment in all sectors of economic activity;
- transition to resource-saving technologies and miniaturisation of products, to environmentally friendly and safe economic methods;
- recognition of the law of optimality, and in economic management – the principle of reasonable sufficiency in the use of ways of obtaining the benefits of life in the spatial and temporal specific framework (restrictions on the factors of environmental, social, and economic risk);
- understanding that without an adequate living environment (integrity of ecosystems) it is impossible to preserve anything living, including its species (including humans) and natural systems of lower hierarchy level.

Environmental security consists of:

- environmental auditing;
- monitoring;
- forecasting the development of the ecological situation;
- environmental management.

The implementation of these priority directions of environmental policy should be based on the appropriate methodological basis, which requires certain adjustments in the ideology of environmental security management. Regional environmental programs that aim to solve the most acute environmental problems should become an important form of environmental policy. At present, society has a real opportunity to reverse negative trends and implement a radical deepening of market reforms, including considering the environmental factor. This implies the implementation of a policy of targeted assistance to the development of efficient domestic industries, the formation of national ecocapital, and active support for the creation of a modern competitive eco-friendly economy. Its formation first of all, activation of the role of the state in this direction, using the whole arsenal of market tools with the simultaneous active implementation of institutional reforms aimed at increasing the efficiency and competitiveness of domestic enterprises. It is necessary to establish an effective system of control over the activities of natural monopolies, to develop mechanisms to adapt international requirements for improving the environment, and translate them into national environmental standards.

Environmental safety in the context of toxicant risk is a set of measures carried out by the state and aimed at balancing the development of economic, social, and cultural needs of society and the state of safe use of toxicological factors of environmental impact under conditions of guaranteed prevention of emergencies, accidents, and disasters with growth of anthropogenic pressure on the environment and threats to human life and health:

- the priority of evolutionary development of existing methods over the 'revolutionary-violent' leap to ultra-modern technologies;
- human and environmental safety should be based on the consideration of system interrelationships of the branches of practical activity;
- freedom of information provides access for all parties to information about the project of technological solution for its implementation, to discuss the possibilities of its implementation and possible consequences;
- the principle of compromise must provide a balanced and alternative use of available resources;
- the principle of the inalienable right to human health and the environment;
- internationality of safety problems and principles is connected to the possibilities of international and state regulation of the use of modern technologies; every state and every person have the right to the same safety for themselves and for others;
- the principle of voluntariness in the freedom to risk one's life and health;
- the principle of the need to pay for the safety of man-made facilities.

An emergency situation (ES) is a situation caused by sudden natural disasters or man-made accidents and accompanied by great damage, acuteness of manifestation, significant deviation of environmental indicators from the norm: exceeding MPC of pollutants by hundreds, thousands or even tens of thousands of times.

Danger is a phenomenon, process, object, subject, properties, or their totality capable of creating adverse effects under certain conditions both for people and for the environment.

A distinction is made between real and potential hazards depending on their implementation.

A *real hazard* is the possibility of death, human illness, or damage to the environment due to a permanent or intermittent harmful factor. Such hazards include those already realised or occurring permanently or periodically. These are man-made accidents that have occurred in the past or natural disasters, as well as emissions into the atmosphere (water, soil) of pollutants as a result of human economic activity.

Potential hazard is caused by potentially possible emergencies, accidents, or disasters with the corresponding negative consequences. Such a hazard is only assumed.

Technogenic hazard is a set of factors associated with the operation of a technical facility, caused by certain initiating events, and capable of leading to negative impacts on people and the environment. Such events can be in the form of a technogenic accident, natural disaster, derailment, or emergency situation.

Analysis of real accidents, events, and factors and human practise already allows us to formulate a number of axioms about the potential hazards of technical systems:

Axiom 1: Any technical system is potentially dangerous. The potential danger lies in its latent, implicit nature and manifestation under certain conditions. No type of technical system provides absolute safety in its operation.

Axiom 2: Technogenic hazards exist if daily flows of substance, energy, and information in the technosphere exceed threshold values. On the contrary, compliance with the threshold values of flows creates safe conditions for human activity in the living space and eliminates the negative impact of the technosphere on the natural environment.

Axiom 3: Sources of technogenic hazards are elements of the technosphere. Hazards arise in the presence of defects and other malfunctions in technical systems when technical systems are used incorrectly. Technical malfunctions and violations of modes of use of technical systems lead, as a rule, to traumatising situations, and waste disposal (emissions into the atmosphere, discharges into the hydrosphere, solid substances coming to the earth surface, energy radiations and fields) is accompanied by formation of harmful impacts on people, natural environment and elements of technosphere.

Axiom 4: Technogenic hazards operate in space and time. Traumatic impacts act, as a rule, short-term and sudden in a limited space. They occur in accidents and catastrophes, explosions, and sudden destruction of buildings and structures. The zones of influence of such negative influences, as a rule, are limited, though their influence can spread over considerable territories, for example, in an accident at Chernobyl NPP. However, the impact can be prolonged or periodic. The size of the impact zones varies in a wide range: from the working and household zones to the size of the entire earth space. The latter includes the impact of emissions of greenhouse and ozone-depleting gases, the entry of radioactive substances into the atmosphere.

Axiom 5: Technogenic hazards have a negative impact on humans, the natural environment, and elements of the technosphere simultaneously. Man and his technosphere, being involved in material, energy and information exchange, form a constantly functioning system ‘man-technosphere’. At the same time, there is also a ‘technosphere-natural environment’ system. Technogenic hazards act selectively, they adversely affect all components of these systems simultaneously, if the latter fall within the zone of hazard impact.

Axiom 6: Technogenic hazards worsen human health, lead to injuries, property damage, and degradation of the natural environment.

A *technogenic accident* is a man-made hazardous event resulting from changes during the operation of a facility or natural factors that cause loss of life or endangers human life and health and the environment.

Accidents can have a transboundary impact, the harm caused to the population and the environment of one state as a result of an accident that occurred on the territory of another state.

Hazard identification is a quantitative and qualitative assessment of hazards by possible consequences. Hazard identification results are: a list of undesirable events, description of hazard sources, hazard factors, conditions of occurrence and development of undesirable events, preliminary hazard assessments.

According to the Methodology of potentially hazardous objects identification, the following hazard types are distinguished:

- bacteriological – caused by the presence of dangerous microorganisms (bacteria, viruses, spirochetes, fungi, more simple);
- explosive – the presence of gaseous, liquid, and solid substances, materials, or their mixtures, as well as oxidants that can explode and burn under certain conditions;
- hydrodynamic – presence of hydraulic structures (dams, dikes, sluices) for accumulation and storage of large volumes of water and liquids;
- fire – presence of gaseous, liquid and solid substances, materials and their mixtures that can support combustion;
- radiation – presence of radiation substances and materials and other sources of ionising radiation;
- physical – presence of sources of electromagnetic, light, acoustic, or other fields of unfavourable range or power;
- dynamic – the danger associated with the presence of sources of high speeds, including variable (vibration);
- chemical – the presence of toxic, harmful, and potent poisonous substances, chemical plant protection agents, and mineral fertilisers;
- ecological – the possibility of adverse effects on the environment of anthropogenic and natural factors, as a result of which the adaptation of living systems to the usual conditions of existence is violated.

For hazard identification, technical means can be represented by three categories:

1. Comparative methods (regulatory inspections, safety audits, preliminary hazard analysis).
2. Basic methods (‘what if?’ analysis; operational risk study (ORS); analysis of failure states and their effects (FAS)).

3. Logic diagram methods (failure tree (FT) and event tree (ET) analysis; cause-effect analysis; human factor reliability analysis).

Regulatory checks are used to identify hazards and identify possible noncompliance with standard procedures. The list of checks is limited by the experience of the specialists performing them. The quality of the results of this procedure depends on the level of understanding and knowledge of the system or object and the physical processes that occur in their elements.

Based on the results of the audit, 'data'-type decisions are made on the agreement with standard procedures.

The safety audit is performed by a team of qualified specialists. A general safety assessment of the object is given, taking into account production and technical conditions, and organisational measures. All potentially hazardous production processes, equipment, and appropriate safety systems are implemented in detail. Interviews are held with personnel of all levels from operators and engineers to the administration. Data on all accidents, equipment failures, and emergency plans are studied. A final report is prepared based on the audit results.

Preliminary hazard analysis is based on a preliminary study of the list of hazards associated with the design of a facility, system, or installation with recommendations to reduce or, if possible, eliminate the hazard at a further design stage. The result of the analysis is qualitative in nature. Numerous evaluations are not included in the analysis.

Hazard and performance analysis (HPA) involves regular examination of the facility, including instrumentation of control and management systems to identify possible deviations from the standards. In addition to identifying hazards, this method is a safety management tool, as the necessary measures are identified to eliminate violations and deviations.

'What happens if?' analysis. The main purpose of the method is to consider the results of possible abnormal events that could have negative consequences and develop into an accident. Possible deviations from the design solutions in the design, equipment elements, and parameters of technological processes are studied in detail. In addition to identifying hazards, it is possible to develop proposals for risk reduction.

Analysis of types and consequences of failures (AON) provides analysis and structuring of the system by types of equipment failures with a description of how the equipment fails (for example, failures during opening or closing of stop valves, incomplete opening or closing of valves, flaps, flows in pipelines) and equipment elements, identification of failure effects (for example, the system response to failure).

The AON method requires knowledge of how the system as a whole functions and how the individual elements of the system function. The method gives only a qualitative result, which is a list of equipment elements with types of failures and their consequences.

Failure Tree Analysis (FTA). Combinations of equipment failures and human errors that can lead to an accident are identified. The analysis can be used during the system design phase to identify nonobvious types of failures as a result of interaction and superposition of equipment failures during operation. It can be applied during system testing with operator participation. In the presence of probabilistic characteristics of failures of equipment elements of a complex technical system, the method makes it possible to obtain quantitative estimates of the probability of a so-called severe accident with the destruction of protective shells and the release of hazardous substances into the environment.

There are no ideal systems for identifying threats. Therefore, it makes sense to use a complex of methods. The choice of identification method depends on the purpose for which the study is carried out.

The spatial spread of environmental hazards is characterized by the impact area, a territory within which due to the direct action of environmental hazards, there is a mass lesion of people and the environment.

Zone of affect – this territory, which may include several centres of affect under the action of factors of ecological hazard of different genesis.

Risk is the probability of a certain negative event which may occur at a certain time or under certain circumstances in relation to a certain contingent of people, country, city, etc.

The risk in relation to one person is called an *individual*, a group of people, *social*, in relation to the territory in which the negative factor operates, *territorial*.

Today, environmental risks can include:

- risk of waterlogging;
- economic risk of the region;
- hazard risks including three components: probability of realisation, amount of damage, uncertainty of loss, and probability of accidental process;
- risks of ecological insurance;
- engineering risks of the territory as a probability of occurrence and catastrophic activation of natural, natural-technogenic, and man-made relief processes, which complicate, make impossible or cause negative consequences for the health and safety of people;
- ecological risks of business activities, as well as environmental risks may include:
  a) risks of natural disasters and man-made accidents and disasters,
  b) economic risk of the region,
  c) risks of ecological insurance (product of expected case value by probability of ecological risk),
  d) risks of uncertain atmospheric air pollutants,
  e) risks of technogenic impact of two types: risks from a hazard source for a short period and a source of permanent hazard.

Risk must be designated by some key words that define the concept of risk: probability, environmental situation, environmental damage, environmental problems in the future, the level of the state of environmental security (human, society, the environment).

Since a hazard can be real and potential, according to this, the risk can also be defined as both real and potential.

Real risk is the probability of some negative event due to the presence of a real, continuous, or periodically acting harmful factor.

The potential risk is the probability of a potential accident or disaster with the corresponding negative consequences.

In this regard, we can distinguish the main types of environmental problems:

- environmental problem as a set of natural phenomena and their consequences that worsen the state of the biosphere;
- environmental problem as a set of types of environmental pressure of man-made or anthropogenic origin on the environment;
- environmental problem as a totality of environmental and economic issues related to the quality of the environment, considered as a priority;
- ecological problem as a set of measures for elimination or prevention of negative consequences from environmental pressure.

It is possible to classify risk according to where it occurs and who it concerns, as well as by the level and attributes of implementation.

Environmental risks can be classified according to the following:

- scale of problems (global, regional, etc.);
- the area of occurrence (resource, climatic, etc.);
- phenomena and processes (risk of fire, disease, engineering, accident, etc.);
- management and audit (quality risk, compliance risk, environmental cost risk, data likelihood, management risk, etc.);
- their significance, priority, and scale (zero, low, medium, significant).

Zero risk or background (average) risk is the risk of natural development of exogenous geological and other processes.

The first order risk is the risk of deviation of the state of the environment from the zero risk.

Second-order risk, the risk of deviation of the state of the environment from a given state.

Such concepts as risk analysis, acceptable risk, risk assessment have entered into the everyday life of experts.

Risk analysis is a systematic use of information about risk, comparison of risk with acceptable risk, justification of rational protective measures.

An acceptable risk is a risk that, in a specific situation, is considered acceptable up to the level acceptable in society based on economic and social factors.

Standard risk is a risk that does not exceed the maximum allowed level within the facility and/or outside the facility.

Standard risk combines technical, economic, and political aspects and represents a certain compromise between the level of safety and possibilities of its achievement.

The economic opportunities to improve the safety of technical systems are not limitless. As the cost of improving the equipment increases, the technical risk decreases, but the social risk increases.

The total risk has a minimum when there is a certain ratio between technical and social investments. This must be taken into account when determining the acceptable risk.

Risk assessment is a quantitative assessment of the impact of a hazard using available scientific information and scientifically sound forecasts to assess the danger of the impact of harmful environmental factors and conditions on human health (in particular, as the ratio of the number of hazards to the maximum possible frequency of their occurrence over a certain period of time).

Procedures for determining environmental risks are based on the principles of environmental monitoring, environmental impact assessment, environmental auditing, and environmental management and have a number of stages:

- ranking,
- defining the boundaries of the studies,
- data collection and processing,
- assessment of impacts (effective doses (exposure)),
- assessment of dose-effect relationships,
- risk characterisation,
- comparative analysis,
- presentation of the total risk for the complex of substances.

The assessment of the degree of risk can be carried out in different ways:

- engineering – based on the use of the theory of reliability of materials and provides for the determination of failure paths at facilities with the calculation of the probability of their occurrence; it can be determined both for normal conditions of accident-free operation and for the emergence of an emergency situation;
- expert – risk assessment is carried out with the participation of experts (specialists) in a particular field;
- statistical – allows one to carry out a risk assessment of danger with the help of information material (reports on dangerous situations which have already occurred);
- analogical – is based on the use and comparison of hazards and risk factors taking place in similar situations;
- sociological analysis carried out with the purpose of an expert assessment of possible risk in workers of certain professions, specialities, population groups.

Risk management is based on risk analysis and quantitative assessment.

Risk management is a process of decision making and implementation of measures that aim to anticipate possible risk.

The purpose of risk management is to anticipate (forecast) the risk in advance, identify factors affecting the situation, and use appropriate measures.

The management of catastrophic events and adverse effects of prolonged action has its own specifics. Since they can occur suddenly, it may seem impossible. However, one uses the accumulated knowledge of already existing hazards, peculiarities of territories, and hazardous objects.

The study of emergencies makes it possible to determine the factors that determine the scale of emergencies. For risk management, we can use:

- zoning of the territory according to danger (maps of seismicity or other adverse processes of natural or anthropogenic origin);
- organisation of economic development of territories taking into account potential risk (location of dangerous objects, nuclear power plants, hydraulic structures) to the least risk for people taking into account geological and meteorological conditions;
- regular monitoring of hazardous phenomena;
- informing the population about what should be done in case of an emergency;
- in case of a long-term emergency, monitoring the condition of the potentially hazardous object.

It is an interactive process with correctly defined periods and stages.

In the first period, there is the 'forming' of an ES (planning), in the second period it is its implementation (prevention, preparation for an ES, counteraction and elimination of consequences).

The first period includes the implementation of organizational and technical measures, shown as stages.

1. Determination and identification of hazards (situations) that can have undesirable consequences.
2. Analysis and assessment of risk. Optimization analysis 'harm-benefit' is applied, taking into account socio-economic factors.

As a result, three variants of decision-making are possible:

- risk can be completely tolerated (low and medium);
- acceptable partially (above average);
- unacceptable (high or very high).

In the last two cases, it is necessary to determine the degree of restrictions, prohibitions, it is necessary to introduce a regime to reduce, preserve and promote public health, it is necessary to introduce various compensations for risk, etc.

Two concepts of environmental risk reduction are possible. According to the first (currently prevailing), risk reduction should be carried out by reducing the hazardous phenomenon itself, including the technogenic load on the natural environment, by performing technical means and measures in terms of nature protection. The second concept proceeds from the fact that environmental risk can be reduced by optimizing socioeconomic conditions and thereby increasing the resilience of the population to this risk. At the same time, it is necessary to take into account that some phenomena and processes depend on the characteristics of the locality. For example, on radiation-contaminated territories, in general, protection of the population in case of a radiation accident is provided by direct and indirect countermeasures.

Direct countermeasures are aimed at reduction or prevention of collective doses of irradiation and almost always affect the vital activity of people and the sphere of social, economic and cultural functioning of a certain region (carried out directly during the factor's action).

Indirect ones are those that do not directly prevent collective or individual radiation doses but reduce or compensate the magnitude of health damage associated with accidental exposure (which is carried out both during the action of the factor and after its action).

The basis for deciding on the feasibility and implementation of countermeasures is as follows:

- for direct assessment and comparison of the total harm (economic, social, health) caused by it, with the health benefit due to the prevention of this countermeasure of the radiation dose;
- for indirect evaluation and comparison of the harm to health (expressed in economic units) caused by radiation and its attendant factors with the benefit received by the state from prevention of disease or return of health to the affected contingent of citizens.

A countermeasure is considered justified if the benefit of its application is greater than the total loss caused by its implementation.

Hazard monitoring and prediction consists of:

- observation, control, and prevention of hazardous processes and phenomena, man-made and social spheres that are the source of hazards;
- development dynamics in order to reduce the negative impact.

The environmental monitoring system should accumulate, systematise, and analyse information on:

- the state of the environment;
- sources and factors of impact on the environment;
- the level of stability of the natural environment to anthropogenic impact.

The monitoring system is implemented at several levels, i.e. the information necessary to make environmentally important decisions at different levels from local to global is accumulated. A particularly important link is the local monitoring system, since it includes the subject of economic activity. The use of local monitoring information makes it possible to create databases of ‘typical’ impacts (emissions, discharges, accumulations, pollution, etc.) and assess the potential danger of specific industries and industrial enterprises.

There are long-term and short-term forecasts.

Long-term forecasts are used in earthquake-prone areas, that is, where mudflows or landslides are possible, flooding, as well as to determine the possible limits of damage in case of man-made accidents.

Short-term forecasts tentatively determine the time of occurrence of a possible hazardous situation.

During the planning period, it is supposed to develop operational actions in the field and coordination at the strategic level of management. Making operational plans for man-made disasters covers both standard and nonstandard emergencies. In the first case, the deterministic nature of the sequence of events is taken into account, and clear instructions are developed in which the necessary management actions are described one by one. As for the nonemergency situations, in which the development of events has a probable nature, the situational type of management is used. It implies working out of different variants of decisions in connection with time, place, type, and other features of a technological catastrophe, irrespective of the probability of the beginning of this or that event.

The development and subsequent implementation of counteraction and elimination plans should be carried out by special personnel, selection, training and promotion of which is the second important function of the preparatory phase. Specially trained personnel are formed into task forces, each of which has responsibilities such as technical safety of the facility, personnel safety, population evacuation, emergency medical assistance, firefighting, debris removal, communication with the press, etc.

Another function of the emergency preparedness phase is to take organizational and technical measures to locate (limit) this situation and mitigate its consequences. These include the following:

- equipping facilities with early warning systems;
- equipping them with fire extinguishing means, individual and group protection from risk factors, evacuation, and medical care transport.

There can also be the construction of buildings and constructions.

In the second period, under the conditions of emergency response, there shall be:

1. Localisation of acts of technological disaster.
2. Actions to prevent secondary losses (e.g., fires, flooding of neighbouring facilities or settlements), and urgent restriction of the affected area (emergency cutting of glades, caving, plowing, etc.).
3. Sheltering personnel and population and provision of medical aid.
4. Elimination of consequences and carrying out restoration and repair works in order to achieve at least the minimum necessary resumption of operation of vital support systems (construction of temporary housing, clearing of debris, temporary communications).

The environmental crisis is a potential environmental hazard that has become a reality. This is a qualitative change in certain system parameters of the natural environment, its physical, chemical, and biological constants. It is a threatening aggravation of the ecological situation that can disturb the natural conditions of human activity. As a planetary process, the threat of ecological crisis involves all forms of life, not individual organisms, populations, or biogeocenoses.

In contrast to social crises, a crisis change in ecological conditions is fraught with the existence of humans as a species, all life on earth. Man, while achieving the goals he had hoped for, has received consequences that he did not expect and can often undo everything he has achieved. The threat of a global ecological catastrophe testifies to the exhaustive possibility of self-regulation of the biosphere under conditions of growth of intensity of human activity in nature. The function of regulator must now be performed by society itself as a direct subject of interaction between different levels of organisation of matter.

Ecological crisis is a situation arising in ecological systems (biogeocenoses) as a result of imbalance under the influence of natural phenomena (floods, volcanic eruptions, drought, earthquakes, etc.) or as a result of anthropogenic factors (pollution of atmosphere, hydrosphere, soils, destruction of natural phenomena) ecosystems, forest fires, regulation of rivers, deforestation carried out by man).

This is a tense relationship between man and nature, characterised by a mismatch of productive forces and production relations on the one hand and the resource-ecological capabilities of the biosphere on the other.

The ecological crisis can be prevented or overcome by appropriate nature conservation and environmental measures (rational use of natural resources, waste-free technologies, closed cycle of water use, creation of nature reserves, etc.).

Environmental crises are classified according to the following criteria:

- by causation;
- object certainty;
- Hierarchical status;
- the effect carried out.

According to the first criterion, causation, we can talk about environmental crises of natural and anthropogenic origin. Natural ecological crises represent those changes in ecological systems which are a consequence of natural biological processes, self-organisation of systems, such relations of systems as competition, etc. They can be a consequence of natural phenomena.

Ecological crises of anthropogenic origin are the result of the influence of human activity on nature. It is a consequence of the civilisation process.

The second way to typify ecological crises is when they are distinguished on the basis of object definiteness. That is, they are qualified on the basis of identifying exactly the object that is affected by the crisis. For example, these are those biological species that disappear as a result of an ecological crisis. Under the conditions of a global ecological crisis, humans have become such a species.

A third approach to defining types of ecological crises is their distribution with respect to which level of ecological systems of living organisation (from a simple ecosystem to the global biosphere) are affected by crisis phenomena. It is clear that systems of higher hierarchical status affect all living things, including humans, to a greater extent or even significantly.

The fourth possibility of qualifying and distributing ecological crises is by the effect of their impact on ecological systems, on humans. According to this feature, ecological crises manifest themselves as:

- local – their effect is limited to a certain region, certain communities;
- regional – occurring over large territories and affecting large ecological systems;
- Planetary – crisis processes cover most ecological systems of the Earth or the biosphere as a whole.

At the same time, with regard to the classification of ecological crises, including those of anthropogenic origin, the problem should not be considered conclusively solved. There are many approaches to it, but they lack certain unified criteria that allow us to objectively assess the state of ecosystems as a crisis and their impact on humans and society.

The biosphere under the influence of human activity loses its self-organising capabilities and indicates a movement toward such a state that may lead not only to the extinction of flora and fauna, mass elimination of species, but to the death of all life in general.

What is the difference between an ecological catastrophe and an ecological crisis?

A ***catastrophe*** is a disaster of natural or man-made nature, accompanied by especially great loss of life, damage to the environment, material, or other losses.

Environmental disaster is a change in the ecological equilibrium into a state of disappearance of the conditions of existence of a living organism, population, species, and biosphere.

According to the speed of development, disasters are divided into as follows:

- slow, caused by the accumulation of harmful substances in the human body due to their gradual entry into the environment;
- rapid, developing over a period of approximately six hours;

Instantaneous, when people die in a short period of time – up to one hour.

Depending on the number of dead, disasters are divided into the following.

- small, causing the deaths of no more than 10 people;
- large, large deaths of more than 10 people.

Catastrophes can be

- unintentional (accidental, spontaneous, which is what they are most often are);
- deliberate (an example is ecocide, i.e. the destruction of nature in order to deprive the enemy of freedom of movement, sheltering local sources of food, water, etc.).

By the nature of the manifestation of derailment can be obvious and hidden.

A sharp and growing aggravation of the contradictions between nature and society, leading to emergencies that threaten to destabilise or destroy natural and social systems, and as a consequence, require an immediate response from society. These situations may occur like an explosion caused by natural (earthquakes, prolonged heavy rains, etc.) and technological (energy and other) disasters, or in the form of a prolonged ecological crisis (tense state of relations between mankind and nature), characterised by a mismatch between the development of productive forces, industrial relations in human society and the environmental capabilities of the biosphere.

If these phenomena cover separate sites and regions, a local ecological catastrophe emerges. When it encompasses the entire Earth, then a global ecological catastrophe emerges.

Threatening ecological trends have contributed to the emergence of concepts such as ‘ecological disaster’, ‘zone of high ecological risk’, ‘zone (region) of ecological disaster’.

Ecological disaster is an abnormal ecological situation that has developed in the environment in a certain territory (water area) due to natural disasters and anthropogenic impact on the processes of nature, system, which led to definitive changes in the environment and disruption of normal conditions of life, namely, health and harm to national economy, disruption of the balance of nature and natural ecological systems, degradation of flora and fauna.

Environmental disasters include all destructive natural and natural-anthropogenic phenomena, namely earthquakes, floods, volcanic eruptions, droughts, mass reproduction of pests, threatening crops, and lack of insect pollinators.

Among environmental disasters, cyclones, especially tropical cyclones, are considered the most dangerous (according to the UN).

An ***ecological disaster zone*** is an area (water area) with profound irreversible (partially or completely) changes in the environment resulting from anthropogenic or natural disasters. Degradation and death of living beings, including humans, is observed in these areas. The processes that caused the disaster are irreversible. The system's ability to regenerate itself is impaired.

Conversely, a ***zone of ecological well-being*** is a region where all components of the biosphere (air, water, land) do not contain increased amounts of pollutants, increased levels of radioactivity are not recorded, vegetation cover and hydro-balance are not disturbed, there is no decrease in the number and diversity of species of living beings. There is no increase in population morbidity, and the birth rate, mortality, and life expectancy of the population remain unchanged. Unfortunately, there are very few such areas left. And for the most part it is the fault of man himself, his ever-increasing desire for consumerism, and ecological blunders. The unpredictability of harmful consequences is due, above all, as a rule, to society's misconception and lack of prior research, as to the well as underestimation of the force of the blows inflicted on the environment and living organisms in general by human economic activity (especially the development of technology).

Modernisation of the system of environmental security is a change in the environmental policy of the state, which will improve the quality of life and economic efficiency, green growth of the economy and energy, conservation and restoration of the environment. This process is a complex of technological, managerial, and economic improvements and innovations that can significantly improve the environmental parameters of the environment and reduce its negative impact on nature and population. Ecological modernisation should become a national innovation-active strategy that promotes mobilization and concentration of the available resources of the country to address the relevant tasks.

5.2. Environmental Security as a Component of the National Security of the Country

National security is a relatively new object of legal regulation. In the field of international relations, the inconsistency of ensuring with all completeness has arisen after the end of the Second World War. At that time, it was considered primarily as military security because the foreign policy of many states in relation to each other contributed to increased militarisation. Later, at the beginning of the 1970s of the last century, economic turmoil caused a change of priorities in the problem of national security. Society's economic vulnerability was brought to the forefront, not least of which was the dependence on natural resources. Scientific and technological progress, increasing the security of socioeconomic relations, led to the emergence of risks to human health and the environment. A third component of national security has emerged, environmental security.

The analysis of existing problems of ecological safety and researches on development and introduction of technical solutions on reduction of harmful influence on the person and environment allows to ascertain the following. A significant regional danger is caused by waste production and consumption. Research on their processing and utilisation in separate economic complexes has not been sufficiently developed. Under the conditions of insignificant volumes of waste use, the situation with their accumulation continues to become more complicated. In most cases, waste disposal sites (landfills) do not meet the established requirements, resulting in contamination of soil, surface, and ground water. Environmental hazards associated with landscape transformation are also formed. Persistent organic pollutants (POPs) pose a particular danger to humans and the environment. The main sources of POPs entering the environment are storage sites of banned and obsolete pesticides, companies producing organochlorine products, as well as incinerators and other facilities, where dioxins are produced.

The environmental situation related to the current state of water resources is quite complicated, as the quality of groundwater and surface water has deteriorated significantly in the last 10-15 years. A targeted study of these problems is only beginning. Different types of harmful physical impacts are major factors of ecological hazard formation. Studies, in particular, on mitigation of noise pollution and impact of technogenic earthquakes, as well as development and implementation of appropriate technical means are not sufficiently developed. Ecological safety is considered as a dynamic component of the regional system that provides its harmonious development under conditions of protection against real and potential anthropogenic and natural influences. The level of safety is mainly determined by the probability of hazard manifestation. This requires a comprehensive study of the conditions of formation of environmental hazards. Environmental hazards are a complex hierarchical structure.

The technological component of environmental hazards characterises the impact on people and the environment, associated with technical means and technologies of economic activity, and includes types determined by various factors. From the position of the system approach to environmental safety management, we consider the region as a set of interconnected and mutually influencing subsystems – natural and socioeconomic. The natural subsystem creates the background base for threat formation and is the environment for its spatial distribution. Socio-economic contains sources of environmental hazards (objects of economic complexes, communications, etc.). The latter have a corresponding effect on people, the natural environment, and technical systems.

5.3. Environmental Security in International Relations

Environmental security as an integral element of international relations has been considered since the second half of the twentieth century, when most leading countries of the world realised the need to make significant adjustments to the concept of national security, its guidelines, strategy, and means of security. The processes of globalisation, increasing disparities in economic development and resource provision between economically developed and underdeveloped countries, the growth of population and migration aggravate the threat to humanity in the long term due to the impulses of destructive conflicts of global scale in the form of:

- destruction of the ozone layer of the atmosphere: intensification of the greenhouse effect due to increased levels of methane emissions, aerosols, radioactive gases, 1.1-6.4°C increase in air temperature, etc.;
- manifestations of global climate change: melting of the Arctic glaciers, rise in sea level by 1 m, change in the frequency and intensity of precipitation, irreversible changes in eco- and biosystems, territorial changes in agricultural productivity, worsening of problems of water supply and water consumption in densely populated regions of the planet which may lead to catastrophic threats to life and health, worsening of power conflicts in 46 countries with a population of 2.7 billion people;
- pollution of the world's oceans through the dumping of toxic and radioactive substances, saturation of water with atmospheric carbon

dioxide, anthropogenic petroleum products, heavy metals and complex organic compounds;
- the growth of the world's population, projected at 9 billion by 2042, and the transformation of the determinants of migration flows (environmental migrants, environmental refugees);
- limited access to and disproportionate use of the world's resources. In the last decade, economically developed countries consumed about 70% of the world's energy and metals and 60% of its foodstuffs);
- growth in the volume of consumption and scarcity of resource and energy supply.

It is predicted that energy consumption will increase by 37-50% by 2030; in addition, world resources of oil to provide energy for civilisation will only be sufficient for 30-60 years, natural gas for 40-70 years, coal for 300-700 years and plutonium for fast neutron reactors for 1000 years.

GeB is an important issue for all the countries of the world in determining the survival strategies of the present generation, because the consequences of global warming are already turning unstable regions of the planet into zones of armed conflicts over natural resources (Mali, Chad, Algeria, Afghanistan, Bangladesh, Nepal and others) and water resources (China, India, Mexico, the Middle East, South America, Central Asia and other countries, where 430 million people already suffer from shortages of potable water).

The Environmental Performance Index (EPI) should be considered in the system of assessment of global environmental relations. This is a global study, the result of which is the creation of a ranking of the countries of the world on the indicator of the load on the environment and the rational use of natural resources.

The EPI has replaced The Environmental Sustainability Index since 2006, and its results are used to calculate the Human Development Index (Human Development 27 Index) as part of a special series of reports on human development. The index measures a country's achievements in terms of environmental conditions and natural resource management based on a number of indicators in 10 categories, reflecting various aspects of the state of the environment and the viability of its ecological systems, biodiversity conservation, combating climate change, public health, and practises. Economic activity and the degree of its burden on the environment, as well as the effectiveness of government environmental policy.

The 2020 index was calculated in the midst of the COVID-19 crisis, which created a series of challenges to health systems and disrupted economic activity around the world. The global pandemic made clear the deep interdependence of all countries and the importance of investing in sustainable development.

The formation of international environmental security should not be done at the expense of discrimination of individual regions and countries of the world, but should be implemented in accordance with generally recognised by the world community parity principles and principles, among which: superpriority, systematicity, commonality, integration, equality of actors, etc.

So, GeB today should be studied from the standpoint of globalisation processes, based on the formation and further development of a single global environmental and economic space by ensuring international environmental security based on the spread of new technologies, environmental innovation, participation in global agreements in the field of environmental protection, the formation of international market trading quotas.

The analysis of the processes taking place in the world allows us to talk about the prerequisites for the creation of the GeB system, which in turn requires the creation of specific legal obligations, recommendations for the improvement of institutional support.

The most generalised tasks for solving global environmental problems and ensuring GeB can be formulated as follows:

- study of global energy and biogeochemical cycles (industrial and biosphere processes), in particular the prospects and challenges of development of traditional and alternative energy, dynamics and forecast of the volume of emissions, discharges, disposal, and neutralisation of pollutants and waste;
- development and implementation of observation and monitoring systems at a global level: development of new observation systems, including space-based, exchange of satellite data and creation of common databases;
- analysis of global changes in biodiversity, including the search for ways to preserve it, identification of new species;
- development of the theoretical and methodological bases of ecological changes based on the synergetic combination of achievements in different fields of knowledge;
- work on justification, development and support of international efforts, creation and support of the work of international programmes, financial and scientific support of regional interstate projects, etc.

The limitation of natural resources leads to contradictions and conflicts that hinder socioeconomic growth. Today, environmental conflicts can be defined as confrontations at the interstate level caused by incompatible interests of the parties, as well as their struggle for ownership, use, or control of natural environment resources and services.

The number and scale of environmental conflicts are predicted to increase, as evidenced by a World Bank study that estimated global economic losses from natural disasters and catastrophes at $3.8 trillion for the period from 1980-2012.

Also, the World Bank's research revealed an increasing trend in the size of the average loss: in the 1980s, it was about $50 billion, and in the modern period it is about $200 billion a year. And losses from storms, floods, and droughts alone amount to about $2.5 trillion, two-thirds of the total damage.

In the regional distribution, as noted by the World Bank, the most affected were developing countries, where damage from natural disasters during the period

2001-2006 amounted to 1% of GDP. For comparison, developed countries over the same period for the same reason lost 0.1% of GDP, that is, ten times less. However, this is likely to be due only to higher GDP figures in developed countries.

The World Bank calls for the development of measures to prevent the risks associated with extreme weather deterioration.

Going forward, the priorities for environmental security in the global economic space remain:

- strengthening international cooperation on the sustainable use of natural resources;
- protection of flora, fauna and habitats;
- reduction of air pollutant emissions, such as hydrocarbons and those resulting in photochemical oxidants.

The most developed forms of international cooperation based on common safety criteria and universally recognised universal approaches are needed to effectively overcome environmental problems.

Given the global nature of environmental problems, the establishment and implementation of a national strategy for environmental security is impossible without taking into account international experience. At the same time, attempts to overcome global environmental crises have formed the approaches of the world community, in which the implementation of any specialised programme is activated with the participation of national governments.

In particular, it is extremely urgent to disclose at the international level its position on the issues of rehabilitation and adaptation of the affected Chernobyl territories on the basis of biological, medical, sociopsychological data of the relevant departments and ministries in order to further coordinate the international community efforts in addressing the ecological prospects of these lands.

The original ecological interdependence of the states is the starting point for the actualization of environmental protection problems in international relations. The latter can be understood in two ways:

- on the one hand – as direct interdependence, when one state can directly harm the environment of another state, in particular due to the thinning of the ozone layer;
- on the other hand, as indirect interdependence, when environmental damage in one state (for example, soil erosion) does not affect the environmental direction of another state, but causes harm in other areas, in particular in the social, when social destabilisation in regions suffering from soil erosion causes migration processes, which already directly affect the interests of other states.

This peculiar interrelationship and its impact on institutions and processes within the international ecological system are a driving force for the latest trends that follow.

1. Globalization of environmental conservation.

The global nature of environmental problems requires the development and implementation of a coherent international policy. To prevent an ecological catastrophe on a global scale, mankind already today must comply with agreed measures to preserve the stability of the biosphere: to form on the planet a single eco-safe economic and economic space, which will be the basis of sustainable and balanced socioeconomic development of all countries of the world. Environmental protectionism, to which countries, whose economies are developing, often turn, has become an integral part of the globalisation process. Environmental protectionism is adhered to by states banning or restricting the production, sale, and use of environmentally dangerous products and the importation of technologies and goods that are harmful to the environment and pose a threat to public health. Positive trends in existing global environmental problems contribute to the activation of existing, as well as the emergence of the newest environmental movements, currents, etc. Among them:

- ecological imperialism, – the transfer to territories and regions of organisms that are not peculiar (and often harmful) to local flora and fauna;
- ecoimperialism – as a process of blocking by the developed countries of the world the local subjects of power (with the involvement of environmental NGOs) in their right to manage natural resources on their own under the pretext of protecting the environment;
- eco-terrorism, – defined as the use of criminal threats or violence against innocent victims or their property by nature-orientated organizations for political reasons, often including symbolic actions;
- environmental racism, – a form of racial discrimination where low-income or minority communities are placed in close proximity to environmentally dangerous or degraded environments contaminated by toxic waste, without access to clean drinking water, etc. Globally, environmental racism exists between groups in the developed world and developing countries, as well as between different races and ethnicities on different continents: global corporations often produce hazardous chemicals that are banned in developed countries, exporting them for recycling or disposal to countries that are developing or to countries with weak environmental laws;
- Ecological sabotage (Ecotage) – direct action by extreme environmentalist groups (eg the ‘Earth First’ group). It is often seen as part of acts of civil disobedience or even ecoterrorism;
- Ecocide – any damage or destruction of the natural landscape and destruction or loss of ecosystems in a particular area to the point where the basic survival of the population of those areas is threatened. A distinction is made between natural (when a living organism kills enough individuals in an ecosystem to disrupt the reproduction of a species) and anthropogenic ecocide (occurs when large amounts of pollutants enter an ecosystem);

- Ecological fascism (Ecofascism) – as a radical trend in environmental protection, a trend related to neofascism. This term is often used as a political epithet to discredit the environmental policies of opponents;
- Environmental justice; – the concept originates from the United States and has two different interpretations: as a social movement whose focus is on the equitable distribution of environmental benefits and losses, and as an interdisciplinary body of social science literature that includes (but is not limited to) theories of environmental development, justice, environmental law and governance, environmental policy and planning, sustainability, and political ecology.

2. Priority of ecological security.

In recent years, the vast majority of scientists have pointed to the low degree of priority given to issues related to environmental security, especially its financing, in relation to other components of the national policy of the state. However, the degree of aggravation of environmental problems in the world, as well as a significant difference in the mechanisms of implementation of environmental policy provisions in adjacent territories (in border areas) and its consequences, require special attention on environmental issues. More and more often in programmes, strategies of national development and plans sound environmental safety, environmental development, environmental responsibility, improvement of quality of life and health of people through adjustment and formation of legal framework in the field of nature management, environmental protection and environmental safety.

An active role in achieving a high level of safety is assigned to environmental responsibility of business, public activity of the population, and the processes of monitoring and control of the state of the environment.

3. Growing institutionalisation of environmental safety.

The growing institutionalisation of environmental security and the interdependence of states manifest themselves both in the creation of new security regulatory structures and in their transcendence of the established system of autonomous states. Today there is a growing pluralisation of actors in international environmental policy, where classical state diplomacy is less and less important and more and more important are representatives of nongovernmental organisations (environmental clubs, TNCs, social and political parties, etc.). There is also a growing interdependence between the individual regulatory spheres of world politics, primarily between global environmental policy and economic policy. If these trends continue, they will become a prerequisite for changing the model of the system of states (environmental organisations, economic actors, academia) in the development and implementation of international environmental standards. A key trend of the last decades is the growing institutionalisation of interstate policy in the field of environmental protection. Today, within the framework of the so-called ‘world environmental order’, the behavior of states on the international arena is regulated by more than 1,000 bilateral and multilateral environmental treaties. In fact, every government is now subject to a huge number of international rules and regulations, ranging from protection of bats to restrictions on atmospheric emissions. A classic example is the common environmental legislation of the member states of the European Union, where directives are binding. However, this regulatory framework should not be overestimated. The vast majority of agreements provide only mild sanctions for their violation, contain difficult-to-check obligations, and prescribe standards whose observance does not require much effort.

Many international conventions also function without strict sanctions, including through non-legal mechanisms. An important factor in the effectiveness of the global environmental order is the international environmental associations, which operate globally and can to some extent compensate for soft interstate sanctions regimes. Changes in the configuration of interests within states are also important, which can contribute to the positive dynamics of the international environmental regime. The environmental conventions also provide a solid institutional and organisational platform on the basis of which governments can agree on further measures to implement existing norms and regulations. This is often done through the signing of protocols, such as the Protocol on Biosafety to the Convention on Biological Diversity or the Kyoto Protocol to the Framework Convention on Climate Change.

4. The pluralisation of international relations in the field of environmental protection.

There is a growing role for transnational private actors, primarily large environmental associations. The prohibition of whaling or the cessation of dumping near the sea has been made possible not least by these nonstate actors; states emerge in some institutionalisation processes as the executive bodies of the campaigns of private entities that set the agenda for domestic and foreign policies. In addition, they monitor the mutual obligations of states, inform governments and the public about the course of international negotiations, provide qualified expertise and recommendations that not only facilitate, but also influence the search for acceptable solutions within states.

A separate place in the pluralisation of actors in international environmental policy is reserved for transnational corporations. An example is the global ecolabeling programmes jointly implemented by the World Wildlife Fund and the major fishing industries. In these forms of cooperation, government agencies often play the role of extras or spectators, while environmental movements themselves define environmental goals and make decisions on their implementation. The successes of such alliances are especially noticeable in areas where the public sector, dependent on the economic interests of certain lobbying groups, cannot solve certain environmental problems.

5. Increasing the role of ecological informatization.

The national strategies of states will have no meaningful weight if they do not rely in their main theses on the opinions, recommendations, assessments, and forecasts of scientific experts. Global environmental policy requires a broad base of information and science, which, given the growing complexity of the problems, can no longer be provided by political decision makers alone. A real breakthrough in engaging the scientific community in solving environmental problems was the creation of the 1988 Interstate Committee on Climate Change (IRCC) within the framework of the United Nations, where some 3,000 international experts from around the world still work today. Similar forums have been organised on other topical issues of international environmental policy, such as ensuring biodiversity, reducing harmful emissions, reducing the ozone layer, etc. Such broad institutionalised expert networks have become important independent structures of global environmental policy, which through their own scientific interpretation of topical environmental problems have been able to influence political decision-making processes in the field of environmental protection. For all the euphoria of international relations in the field of ecology, in this issue, as in many other problems that affect the sphere of environmental protection, there is a conflict between developed and developing countries, the so-called 'North-South' confrontation.

An example of this imbalance is the definition of the climate problem in the early IRSS reports, which were written almost entirely by scientists from the north. They defined two classes of greenhouse gases: natural and anthropogenic. In particular, anthropogenic factors included rice plant emissions and methane production in the stomachs of cattle and goats. Therefore, food cultivation was equated with increased energy consumption in industrialised countries, making developing countries significant polluters. This approach has been severely criticized by South African countries, which have demanded that emissions from domestic animals and industrial crops be defined as 'natural' or that anthropogenic emissions be differentiated into those arising from luxury interests and those arising from the necessities of life. In some places, the ecological confrontation between the north and the south has led to real scientific conflicts, such as the debate between American and Indian research institutes over which countries are the largest greenhouse gas emitters. These and other problems have necessitated the introduction of a more flexible approach to the formation of international expert commissions, particularly in the direction of greater participation by scientists from developing countries, as well as independent experts from environmental organisations.

6. Development of eco-business and eco-entrepreneurship.

Development of ecobusiness and eco-entrepreneurship, ecologization of production as proactive economic activities taking into account environmental requirements, aimed at avoiding and/or reducing the negative impact on the environment, as well as improving environmental performance in order to profit or other benefits. On the territory of regions of the country, eco-business is represented by the enterprises:

- providing pollution prevention (the use of special equipment in production, the use of environmentally friendly fuel for vehicles, monitoring devices, environmental expertise services);
- with resource-saving technologies (recycling, alternative energy, production of goods marked as environmentally safe);
- implementing measures for environmental improvement (creation of ecologically ordered areas in the city, design for institutions and industrial enterprises);
- institutions that fund environmental education.

Modern forms of globalisation of environmental threats lead to increasing international recognition of the global ecological interdependence of all states of the world and the search for new effective mechanisms of cooperation in overcoming these problems. The ability of non-state actors to support both nationally and internationally and to draw the world's attention to global environmental problems has greatly increased. However, despite the rather heavy moral authority of the global environmental movement, it is still too early to talk about the introduction into the consciousness of the international community of the absolute necessity of an urgent solution to the problems of environmental degradation. With the exception of a core of active supporters of environmental policy in a number of developed countries (primarily Scandinavia), most governments are not yet ready or capable of addressing environmental problems, and their exaggerated promises of high standards of safety and environmental protection generate a mood of distrust among much of the public. and, consequently, indifference toward environmental responsibilities. So, there are serious grounds for weakening state legitimacy.

Sustainable socioeconomic development of any country means such functioning of its economic complex, under which it is possible to simultaneously provide the growing material and spiritual needs of the population, ensure rational and environmentally safe economic management and highly efficient balanced use of nature, create favourable conditions for human health, conservation and reproduction of the environment and natural resource potential of public production.

Ecologically balanced socioeconomic development involves technical reequipment of production based on the introduction of innovative projects, energy-efficient and resource-saving technologies, low-waste, waste-free, and environmentally safe technological processes. By reducing environmental pollution through the introduction of innovative resource-saving technologies and increasing the knowledge-intensiveness of production, it is possible to improve public health, reduce the number of occupational diseases and occupational injuries, improve working conditions, reduce the share of heavy labour in production processes, and increase skilled labour.

Modern socio-ecoeconomic development is characterised by a radical increase in the volume of production and consumption, new niches of economic activity, and more economically efficient use of production systems, and the expansion of the volume and quantity of material and energy resources. Scientific and technological progress with extensive use of the latest technologies dominates among the factors of production efficiency increase, which allowed the significantly increase of labour productivity, capital productivity, and volumes of competitive products output. At the same time, technological progress cannot be considered only on the basis of simplistic approaches, when socioeconomic models have signs of an idealized society in which the complex relationship of the latter, production and production mechanisms, and the ecological state are solved automatically. Actually, technological progress is also a source of significant complications, primarily balancing the interests of technogenic-reproductive systems and the preservation of established standards of existence, traditional cultural values, the environment. The beginning of the third millennium is defined by a number of complex problems that are unparalleled in nature and significance according to the functional load in the history of mankind and the development of productive forces.

Environmental safety is one of the priority principles in sustainable development of all countries of the world, which implies the introduction of such a model, under which it is possible to meet the vital needs of both modern and future generations. Human-environment relations become more complicated when the anthropogenic load on a certain territory or a certain ecosystem (defined through the anthropogenic influence and population density) exceeds their ecological capacity for self-reproduction, reproduction. The latter are conditioned mainly by the peculiarities of the natural resource potential and the general stability of natural complexes to anthropogenic actions. Deepening ecological crisis and instability of socioeconomic development of society led to the need to create a global legal act of international environmental security – the Environmental Constitution of the Earth as the basic law of survival of civilisation and sustainable development, guaranteeing to each state and the world community as a whole environmental and economic security, and separate natural conditions for its life, including the future.

An important indicator of the security of sustainable development is the Environmental Sustainability Index (ESI), formed from 21 environmental indicators, which, in turn, are calculated using 76 sets of environmental data on the state of natural resources in the state, the level of environmental pollution from different periods, state efforts in the field of environmental management, the country's ability to improve environmental performance, etc.

The reason for the 23% change in the ESI index is the GDP per capita, which is an important factor, but not the only determinant of environmental policy.

Of course, technogenic and environmental problems have arisen not only in the second half of the twentieth century but also in previous periods of society's development. But it was at the present stage that the interaction of society and nature took threatening forms, and humanity for the first time encountered the phenomenon of global problems, which must be considered from the ecological point of view. At the turn of the millennium, a significant resource deficit emerged – not a material, energy, or food resource, but an environmental resource. The insufficient so-called ‘economic capacity’ of the biosphere has been recognised. And we are talking about both the uneven manifestations of the problem and the different nature of the perception of threats of the ecological plan. For example, there are several countries that have already destroyed the natural environment and are degrading (‘weak’ countries of Africa and Asia) or have partially destroyed the surrounding and global ecosystems and consumed the natural systems and the preserved ecological space of other countries (‘strong’ countries of the West, Germany, Great Britain, France, Italy). Finally, some states have preserved large undisturbed areas of the environment due to their large territories and deep understanding of environmental policy. For example, Canada, Australia. And the first of them achieved this without much difficulty, given the size of the territory and some industrial undeveloped regions, the others, in addition to the above, actively pursue resource-saving and environmental protection policies.

The dangers associated with humanity's inability to overcome the uncontrolled manifestations of technogenic development have been exacerbated. Consequently, the tasks of socioeconomic rise of individual countries are determined not by a linear interpretation of progress and progressive increase in the gross indicators of production and consumption (which may lead to regression and degradation of ecosystems, real deterioration of living conditions), but by the objectives of preservation, even conservation of certain parameters of social life. It is necessary to move away from the outdated identification of the concepts of optimality and maximisation of consumption, which was simplistically viewed as an exclusive function of human well-being. This principled approach is called sustainable development, the concept of such development being a necessary component of state regulation and the basis for the coordination of international action on a regional and global scale.

5.4. Main Regularities in the Formation of Regional Environmental Hazards

The main regularities of the formation of the regional ecological hazard are determined by the following categories:

- regionalisation (each region is distinguished by its only inherent priorities and hierarchy of structures of ecological hazard, determining the specifics of its analysis and possible development);

- spatial and temporal structuring – a set of ecologically dangerous objects of any genesis, which as a result of interaction and mutual influence create situations dangerous for the life of biota, cause a threat to the functioning of technical structures, facilities;
- positivity of sources of danger (not only the spatial location of sources of danger with respect to objects, impacts, but also the characteristics of the environment in which the danger spreads);
- heterogeneity and diversity of hazard sources (sources' power, ingredient composition, geometric parameters, and toxicity are taken into account);
- neighborhood of hazards; the mutual location and combination of the various components of the hazard;
- Profiling of regions with respect to the conditions of formation of environmental hazards.

The most significant property that determines the specificity of environmental safety management is regionalisation. It consists of the definition of territories (regions) with a characteristic concentration and dominance of certain types and classes of hazard within them. Signs of regionalisation are the presence of different components of environmental hazards, their specific combination, etc. Among the main principles of regionalisation, they should be defined:

- the territorial integrity of the region;
- concentration of characteristic sources of hazard and predominant localisation of its manifestations within the region;
- Commonness of the processes of hazard formation.

The system structural paradigm of spatial structuring of environmental hazards is based on the differentiation of regions by the degree of concentration of hazards of different genesis.

Based on the analysis and synthesis of the actual material, the following regularities of the formation of environmental hazards are identified:

- the degree of hazard is largely determined by the unfavourable positionality of its sources in relation to objects and structures of different purposes;
- the neighbourhood of hazards of different genesis can be dangerous, neutral, and favourable. Dangerous neighbourhood can significantly increase the negative impact on people and the environment;
- profiling of regions is determined by the presence of dominant in the intensity of the possible impact of environmentally hazardous economic activities;
- the dynamics of hazard functioning assumes the following stages: origin, development, weakening, and disappearance. The last two stages correspond to the constructive development of regions, which requires effective management of environmental safety.

5.5. The Main Methods of Quantitative and Qualitative Assessment of the Level of Industrial and Environmental Hazards

Industrial (technogenic) safety: safety of production, transport facilities (agroindustrial complex, industrial, and military facilities (MIC)), i.e., their accident-free functioning in the absence of harmful effects on the environment.

The ***industrial environment*** is the space in which human production activities are carried out. In it, as part of the technosphere, negative factors are formed that differ significantly from the natural ones. They form elements of the production environment:

- objects of labour;
- means of labour;
- products of labor (semi-finished and finished products);
- energy;
- natural and climatic factors;
- plants and animals;
- personnel.

Most emergencies are of an organisational and psychological nature.

Human behaviour in emergency situations has several forms:

- hypermobilization, where – a person mobilises forces and senses at a certain danger;
- loss of orientation; – incorrect evaluation of information, distortion of the control process, and evaluation of the causes of errors;
- violation of the correlation between primary and secondary actions.

To access an emergency situation, clear actions aimed at reducing or eliminating the main danger are necessary, but when encountering difficulties, a person's attention to the main tasks decreases and he begins to deal with the minutiae.

Ecological safety in the narrow sense implies the safety of natural objects (sea, coast), objects of the natural reserve fund (NRF), and recreational resources.

There are a number of methodological approaches to hazard assessment. The assessment is carried out with the purpose of:

- management (transforming the states of the object in the necessary direction);
- prediction of the situation;
- development of general scientific ideas;
- determination of the suitability of territorial formations for human habitation and the existence of certain species of living organisms, the implementation of a particular type of economic activity.

In the process of analysis, it is necessary to take into account the peculiarities of situations, i.e.:

- it is important to know not only the situation, but also the trends of its change;
- peculiarities of processes and phenomena determining the technogenic hazard (constant, periodic, episodic);
- the response is not a mirror reflexion of the impact, as the system has the properties of elasticity, inertia (delayed response to the impact);
- there is often a superposition of the action of different factors;
- the manifestation of the danger can be a consequence of processes that occurred earlier.

Considering the many ways of assessment, we can distinguish three main approaches to assessment.

1) assessment of the subject's condition;
2) assessment of the condition of the subject's environment;
3) Assessment of the risk of an environmental threat.

In the first case, we are talking about the state of man, society, society, plants, including crops, animals, biocenoses, and landscapes. Their condition is compared with the ‘norms’ which are determined theoretically or by analogy (the condition of the subject under conditions of an insignificant technogenic load is compared).

It is reasonable to introduce the concept of a background state. This is such a state of the natural environment of a particular territory that occurred in the absence of anthropogenic impact on it (with conditionally removed anthropogenic loads). It is established according to the results of observations in the objects located in the territories under consideration. Although this method does not always give the desired result, there may be pollution of the natural environment as a result of migration of pollutants from neighbouring industrial areas. In such cases, the background condition is established retrospectively (according to documentary data, scientific publications, etc.), by calculation.

The degree of deviation from the norm determines the degree of environmental hazard. If the condition corresponds to the norm, then we can talk about environmental safety.

Some scientists believe that the content of harmful substances at a concentration below the MPC corresponds to the norm, that is, harmless.

The disadvantages of this approach are that the state of any subject is formed over a long period of time, and the subject is influenced by various factors, resulting in difficulty in identifying one or more factors that act negatively.

In the second case, the state of the environment is evaluated. But since there is no rigid functional relationship between the state of the environment and the state of the subject, that is, subjects respond to the influence of the environment with a certain delay, depending on the properties of inertia, buffering, relative independence, and may be different for different subjects. The most significant changes in natural landscapes occur in industrial areas. The latter to a greater extent lose the ability to self-regulate and require significant energy inputs to perform their functions.

Urban development deviates from natural landscapes to a lesser extent, because there are green spaces and less pollution within them.

The first and second approaches complement each other. Risk assessment of environmental hazards is performed more often for events that have a rare and likely nonperiodic recurrence (has a predictive nature). An important element in risk assessment can be the establishment of functional relationships of certain parameters. For example, the potential environmental risk can be expressed as a function of the following parameters (factors):

- type of land use;
- Technology of management;
- dangerous technological processes and phenomena;
- population density;
- landscape stability potential:

$$R = 1/(1 - X)^{\alpha} \tag{5.1}$$

where *RTE* is the value of environmental risk; X is the corresponding anthropogenic load on the ecosystem ($0 < X < 1$); α is the index of the favorability of a given type of ecosystems to a certain type of anthropogenic load (the stability value), $\alpha \geq 1$.

The environmental risk potential (E) of the territories is determined as follows:

$$E = T/C + H \tag{5.2}$$

where T is the potential for the anthropogenic load on the environment; C is the potential for the sustainability of the natural environment to the anthropogenic load; H is the potential for adverse natural-anthropogenic processes.

At the same time, the potential for sustainability C is expressed by the sum of the following values:

- meteorological potential of the atmosphere,
- potential for sustainability of natural waters and soils,
- biotic potential.

The higher the risk, the greater the degree of anthropogenic load and the influence of natural-anthropogenic processes on the formation of danger and the lower the level of environmental sustainability.

The risk factor is the risk attributable to a single dose. Establishment of its numerical values requires special studies in experiments on animals and statistical processing of observations on people.

In some cases, it is convenient to assess environmental (man-made) risk in absolute terms (in monetary form):

$$R = P \cdot Z \qquad (5.3)$$

where P is the probability of environmental (manismade) hazard; Z – the total value of the expected damage from the probable manifestations of this threat.

This damage has several components, economic, social, environmental, moral, etc. (measured in monetary form).

5.6. Standardization and Regulation in the Field of Environmental Safety

In order to prevent negative impact on the environment and preserve ecological balance, the legislation provides for special rules regulating many aspects of carrying out economic activities. In particular, it is supposed to establish environmental standards and norms in order to provide a set of obligatory norms, rules and requirements for environmental protection, use of natural resources and ensuring environmental safety.

State standards in the field of environmental protection are mandatory and define concepts and terms, the regime of use and protection of natural resources, methods of environmental control, requirements for the prevention of environmental pollution, and other aspects related to environmental protection and use of natural resources.

Standardisation plays a significant role in ensuring the production of competitive and high quality products, contributes to environmental protection, the economical use of natural and other resources as the basis for sustainable development of the national economy.

A set of so-called environmental standards can be considered an important element of environmental security. They are designed to determine the limits of the impact of human activity on the environment so that the quality of the latter would be favourable for human life and health. Norms in the field of environmental protection define its acceptable state and acceptable levels of negative impact on it. In fact, such standards are a legal way to determine the maximum possible negative impact on nature, in which the environment does not lose the possibility of self-recovery and does not harm human life and health.

The establishment of environmental standards is a forced measure of legal regulation of the environment. They are criteria for the evaluation of the legitimacy of the behaviour of subjects of environmental legal relations and determine the degree of effectiveness of environmental legal norms. Among ecological norms are distinguished:

a) standards for maximum permissible concentrations and levels of pollutants in the environment and levels of harmful physical and biological impacts on it;

b) standards for maximum permissible emissions and discharges of polluting chemical substances into the environment;
c) standards for the use of natural resources.

Maximum permissible concentrations (MPC) establish the maximum possible amount of harmful substances in water, air, soil, and food, at which the elements of the environment will retain their useful properties and will not harm human life and health. In addition to MPC also determine the maximum permissible levels (MPL) of acoustic, electromagnetic, ionising, and other types of impact of physical and biological factors on the state of the environment. The maximum permissible concentrations are designed to ensure the quality of the environment. The safety of atmospheric air regulates MPC for 256 chemical compounds in their isolated effect and characterises the combined effect of 43 mixtures. The sanitation and hygienic regulation of chemical substances in soil is complicated by the fact that these substances affect the human body not directly but indirectly, through the media in contact with it (air, water, vegetation). Therefore, to determine the permissible value of chemical substances in the soil, indicators of harmfulness as the migration of chemicals from the soil to plants and to the atmospheric air and groundwater are additionally used. In contrast to MPC, maximum permissible emissions (MPE) and discharges (MPD) limit the harmful impact on the environment of economic entities. They set the maximum permissible mass of a substance that can be discharged into the environment per unit of time from a particular facility. The maximum permissible discharges limit the pollution of water bodies, and the maximum permissible emissions limit the pollution of atmospheric air.

Environmental rationing is based on three indicators:

- medical (the maximum level of threat to human health, its genetic programme);
- technological (the ability of the economy to ensure the fulfilment of certain limits of impact on people and the environment);
- scientific and technical (the ability of scientific and technical means to control compliance with the limits of exposure to all its parameters).

It is true that the actual application of environmental standards proves their inability to fully form a safe environment. First, it is impossible to establish standards for all harmful substances and their compounds. The consequences of the impact on human life and health of harmful substances within the norms are not fully studied. Usually, they do not take into account the specifics of the region and do not analyse the impact of complex compounds that exist in nature and society.

A new direction of integrated sanitary and hygienic standardisation is the development of a system of indicators that determine the overall characteristic of the purity of water, air and soil. They are formed by means of a list of indicators with established limits, or total relative indicators (quality indices). Such indicators are still in the experimental stage, but are sometimes already used by designers.

In addition to environmental regulations and standards, the environmental requirements established by law for certain types of activities are also important to ensure environmental safety. They provide a certain set of environmental standards and regulations, rules for the use of equipment and machinery, and establish other restrictions on the implementation of harmful activities. There are environmental requirements for location, design, construction, reconstruction, commissioning, and operation of enterprises, structures, and other facilities. They are also defined for the location and development of settlements, the application of plant protection products, mineral fertilisers, oil and oil products, toxic chemicals, and other preparations.

There are requirements for environmental protection from uncontrolled and harmful biological effects, acoustic, electromagnetic, ionising, and other harmful effects of physical factors, such as radioactive pollution, as well as waste pollution.

The legislation contains environmental safety requirements for transport and other mobile vehicles and installations. They are widely used in scientific research, implementation of discoveries, inventions, application of new equipment, imported equipment, technologies and systems, defense facilities and military activities.

The legal regulation of each of these activities is carried out by a number of special normative legal acts detailing general environmental requirements and ensuring compliance with environmental safety in those or other areas of economic activity.

Analyzing the existing normative legal provisions on environmental emergencies, it is possible to formulate the following signs of areas of environmental emergencies:

- the presence of damage to the environment, changes in its qualitative state, violations of environmental safety, in particular, a significant exceeding of established environmental standards;
- changes in the environment, which, in turn, entail a negative impact on people, their health, causing, or a real threat of harm to humans;
- such consequences are caused by human activities or the influence of natural forces of nature;
- declaring the respective territory as an area of ecological emergency according to the established procedure;
- establishment of a special regime for this territory.

Classification of zones of ecological emergencies is possible on the basis of different criteria, in particular, according to the example of general classification of emergencies, depending on the causes of events that may cause occurrence of ecological emergencies, it is possible to allocate:

a) environmental emergencies of a man-made nature (transport, industrial accidents, fires, etc.);

b) environmental emergencies of a natural character (natural forces, such as earthquakes and floods);

c) environmental emergencies of sociopolitical nature (terrorist acts);
d) ecological emergencies of military nature.

5.7. Environmental Safety Requirements for the Planning and Development of Areas

The planning of territories at the local level is carried out through the development and approval of master settlement plans and is ensured by the relevant local councils and executive bodies. Development of territories shall be carried out by placing and construction of new facilities, reconstruction, restoration, overhaul, streamlining of existing urban planning facilities, expansion, and technical re-equipment of enterprises. All objects of development shall be placed taking into account the requirements for environmental protection, urban planning, and sanitary-hygienic norms.

In addition, measures for sanitary cleaning, decontamination, and disposal of domestic and industrial waste must be developed. Furthermore, the norms of permissible emissions and discharges of substances and microorganisms, restoration of the natural environment, land reclamation, landscaping, and other environmental safety measures must be complied with. In particular, when selecting land for a new settlement or its redevelopment, an assessment of conditions of hygienic importance is required, that is,

- analysis of natural-climatic conditions with a comprehensive assessment of solar radiation, humidity, temperature, and wind conditions throughout the area to be developed;
- assessment of the potential capacity for self-purification of the natural environment's potential capacity for self-purification;
- analysis of compliance of the environmental quality (air, water, soil) with hygienic standards;
- ensuring radiation safety of the territory for the population;
- possibility of centralised water supply, sewerage, efficient treatment and neutralization of industrial, household, and special waste;
- peculiarities of engineering preparation of the territory and organisation of landscaping, etc.

In addition, settlements should be located in areas that meet basic hygiene requirements, with quiet, low-country terrain, with slopes sufficient for natural runoff of atmospheric precipitation (1-6%).

The main hygienic principle of the planning organisation of the territory of new settlements or those subject to reconstruction consists of functional zoning, which involves the rational mutual placement of all elements of the settlement and provides favorable living, working, and recreation conditions for the population.

The territory of the settlement, taking into account the preferential functional use, is divided into agricultural, industrial, landscape, and recreational areas.

Agricultural territory is designed to accommodate the housing stock, public buildings and structures, institutions of social, cultural, and domestic purposes, intra-village street and road and transport network, green spaces and places of public use. Here, separate utilities and industrial facilities may also be located, construction of which is allowed near the residential development.

Industrial enterprises and related facilities, complexes of scientific institutions with pilot production facilities, utility and warehouse facilities (bases, warehouses, garages, car parks, etc.), enterprises for the production and processing of agricultural products shall be located on the industrial territory. Here, sanitary protection zones of industrial enterprises, objects of external transport, roads of suburban and suburban communication are also created.

Landscape and recreational territory are formed by suburban forests, forest parks, forest shelter belts, water reservoirs, recreation, and resort areas. Lands of agricultural use and other land, together with parks, gardens, squares, and boulevards of the rural territory, form a system of landscaping and recreational areas also belong to this territory. In these areas are allocated zones of different functional purposes – residential development, public centres, industrial, scientific, scientific production, municipal and warehouse, external transport, mass recreation, resort (in the presence of medical resources), etc.

In order to control the condition of the sanitary and environmental regime of cities and major industrial centres and other settlements, there are maximum permissible concentration standards (MPC) of harmful substances in the air, water bodies, and soils, the excess of which is dangerous for people. Protective, protective, and sanitary protection zones are created around industrial enterprises and facilities with technological processes accompanied by emissions of harmful substances into the environment in order to ensure living conditions and environmental safety of people. And in the neighbourhoods and neighbourhoods of urban and rural settlements, territories (green areas) are arranged, including forest parks and other zones with a limited regime of natural resource use.

During the improvement, territories are necessarily allocated for the placement of green spaces, necessary to create aesthetics of settlements, the possibility of recreation, and recreation of the population. They are the object of independent legal regulation. They include tree, shrub, flower, and herb vegetation of natural and artificial origin in a particular area of the settlement.

A distinction is made between green areas for general and limited use and for special purposes. Green areas for general use are located on the territory of city and regional parks, specialised parks, parks of culture and recreation, the territories of zoos and botanical gardens, city gardens and gardens of residential areas, squares, boulevards, forest parks, etc. These areas are characterised by free access of citizens to recreation.

Green areas of limited use sprout on the territories of public and residential buildings, schools, children's institutions, higher and secondary specialised educational institutions, healthcare facilities, industrial enterprises and warehouse areas, sanatoriums, cultural, educational and sports facilities.

For special purpose green spaces, they are located along main thoroughfares and streets, in areas of sanitary protection zones around industrial plants, high-voltage power lines, etc. This also includes forest reclamation, water protection, wind protection, anti-erosion, plantings of nurseries, flower farms, and roadside plantings within populated areas.

Sanitary and urban planning rules and regulations for the construction and reconstruction of cities require the design, construction, and expansion of cities to provide for the maximum preservation and use of existing green spaces. They define the optimal size of the green areas per inhabitant and require that general or specialised urban and regional parks, squares, and gardens must be developed.

5.8. Environmental Safety Requirements for Food and Agricultural Products

Among the protective measures of agricultural lands, there is obligatory monitoring of fertility, implementation of natural-agricultural, ecological-economic, anti-erosion and other types of zoning (zoning) of lands.

In order to protect lands and reproduce soil fertility, norms shall be established for the maximum permissible pollution of soils, their qualitative condition, optimum ratio of land holdings, indicators of land degradation, and soil degradation.

The rules of safe handling of pesticides and agrochemicals have a special place in the system of environmental safety measures in agriculture.

Pesticides are toxic substances, their compounds or mixtures of substances of chemical or biological origin intended to kill, regulate, and stop the development of pests, the activity of which affects plants, animals, people and causes damage to material values, as well as rodents, weeds, woody, shrub vegetation, and weedy fish species.

Agrochemicals are organic, mineral and bacterial fertilisers, chemical ameliorants, plant growth regulators, and other substances used to increase soil fertility, crop yields, and improve the quality of crop production.

Despite the fact that these substances are designed to increase agriculture efficiency, they are still hazardous in nature, and therefore a violation of the rules of handling them can threaten the environmental safety of people. Therefore, legal entities and individuals must comply with the rules of transportation, storage, and use of plant protection agents, growth stimulants, mineral fertilisers, oil and oil products, toxic chemicals, and other preparations, in order to prevent contamination of the environment and foodstuffs by them or their constituents.

During the creation of new chemical preparations and substances of other potentially dangerous substances for the order established by the legislation the permissible levels of content of these substances in the environment and foodstuff, methods of determination of their residual quantity and utilisation after use shall be developed and approved in the order established by the legislation. The content of natural and artificial impurities that may adversely affect the environment or human health in such preparations, as the well as raw materials used for their production, shall not exceed the allowed levels established in accordance with the legislation.

Domestic and foreign pesticides and agrochemicals may be used only if they are biologically effective for their intended purpose, safe for human health and the environment, in compliance with the regulations of their use and in accordance with state standards, sanitary norms, or other regulatory documents.

Economic activities in the sphere of production of pesticides and agrochemicals, wholesale and retail trade are carried out exclusively on the basis of licence and in the manner prescribed by the legislation. Agricultural raw materials must meet the sanitary requirements on maximum limits of residues of pesticides and agrochemicals. The decision on the order of use of agricultural raw materials, which do not meet these requirements, is made by the state sanitary and the epidemiological service and state authorities for veterinary medicine. The same agricultural raw materials that cannot be used are subject to withdrawal, utilisation, and destruction.

A new direction of agricultural development is the use of new artificially created microorganisms and other biologically active substances, including genetically modified organisms. The danger of this activity lies in the lack of knowledge about the consequences of the introduction of such organisms into the environment, their impact on the existing flora, fauna, and human health.

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