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ENVIRONMENTAL SAFETY TECHNOLOGIES

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Навчальний посібник «Environmental safety technologies» є англомовним, адаптованим до сучасних міжнародних стандартів методичним виданням спрямованим на формування уявлень та засвоєння фундаментальних положень та методів захисту довкілля від шкідливих зовнішніх впливів різної природи. Запропонована комплексна, наукоємна класифікація, як самих збурених середовищ, так і типів ,ступенів та джерел забруднень, а також відповідних адекватних методів їх дезактивації та реабілітації.

Посібник може бути корисним бакалаврам, магістрам та аспірантам, які проходять підготовку за спеціальністю Технології захисту навколишнього середовища, а також викладачам та науковим співробітникам, наближуючи їх професійну базу до міжнародних вимог та полегшуючи сприйняття англомовної літератури. Посібник також може бути корисним методичним підґрунтям для англомовного навчального контингенту.

CONTENT

INTRODUCTION

This handbook aims to gradually and consistently formulate ideas about the specialty "Environmental Technology", which acquires in recent years its steady development. The need to include in the sciences on the protection of the environment technological part of the individual component comes from the requirements of time, which are formed thanks to the development of the latest technology. Rational and effective manipulation of the latter requires a thorough knowledge of the fundamental theoretical natural and engineering disciplines, which must be laid out consistently within the framework of the adapted program. In addition, after acquiring many years of experience in solving environmental problems, it became clear that their complexity and multipara meter require their systematic involvement in the application of the exact sciences, especially physics, chemistry, and biology. Of course, this program must be performed at a decent level of mathematical culture using efficient methods of theoretical and numerical simulation, which also requires not superficial, but rather, in-depth knowledge of the above sciences.

All of the foregoing creates such high requirements for the integration discipline "Environmental Technologies", that the content of our manual can be considered only the first step in the formation of system ideas about discipline, which is based on previous experience, and in separate parts - on separate opinion of the author.

In many cases, it is more about the resolution of tasks and coverage of the phenomenological component, than about the arguments. However, the correct resolution of the problem is no more than its possible (and, as a rule, approximate) reasoning. The manual, thus, contains elements of a systematic approach to the formation of knowledge of discipline and coverage of its main provisions (which certainly bear the reflection of the author's physics point of view on the specialty).

The material of the manual is designed in such a way that for its assimilation only conceptual representations from the courses of exact disciplines and the general ecology are necessary. In practice, thus, the assimilation of materials does not require prior special training. The material of the manual is offered to students, masters, postgraduate students, teachers working in the field of conservation, protection and environmental protection sciences , to protect the population from the harmful effects of hazardous natural and artificial factors (radiation exposure, radionuclide pollution, environmentally harmful impurities from the chemical and others industries of production, etc.). List of literary sources, allows deepening the knowledge gained from separate sections of discipline.

CHAPTER 1. PHYSICAL BASES AND METHODS OF DESCRIPTION OF NATURAL ECOSYSTEMS, THERMODYNAMIC PROPERTIES AND METHODS OF DIAGNOSTICATION OF THEIR POLLUTION

1. Characteristics of sources of environmental pollution and basic methods of its protection

Pollution of the environment can be called a change in the quality of the environment, which can lead to negative consequences. It is believed that equally harmful substances have the same negative consequences regardless of their origin.

Classification of types of sources of pollution of the environment [1, 2]:

1. Mechanical pollution is the pollution of the environment by agents that perform only a mechanical action without the chemical-physical consequences (for example, debris).

2. Chemical pollution is a change in the chemical properties of the environment, which adversely affects ecosystems and technological devices.2. Physical pollution is a change in the physical parameters of the medium: temperature-energy, wave, radiation, etc.

3. Thermal pollution is the increase in the temperature of the environment, mainly due to industrial pollution of heated air, gases and water that are destroyed, may occur as a secondary result of changes in the chemical composition of the environment.

4. Light pollution is a violation of natural illumination of the area as a result of artificial light sources; can lead to anomalies in the life of animals and plants.

5. Noise pollution is the increase of noise intensity above the natural level; in a person leads to increase of fatigue, decrease of mental activity, and at achievement 90-100 dB - to a consistent loss of hearing.

6. Electromagnetic pollution is the change in the electromagnetic properties of the medium (from power lines, radio and television, the work of some industrial plants) leads to global and local geographic anomalies and changes in fine biological structures.

7. Radiation pollution is the excess of the natural level of content in the environment of radioactive substances.

8. Biological contamination is the introduction into the ecosystem and technological devices of species of animals and plants that are alien to these societies and devices.

9. Biotic contamination is the distribution of certain, generally unwanted from the point of view of humans, nutrients in areas where they have not been observed before.

10. Microbiological contamination is the emergence of an extremely large number of microorganisms associated with their massive proliferation on anthropogenic substrates or in environments that have changed during human activities; the acquisition of a previously safe form of microorganisms of pathogenic properties or the ability to suppress other organisms in communities.

All listed sources of pollutants are interconnected, and each of them can be an impetus for the emergence of other types of pollutants. In particular, chemical pollution of the atmosphere can contribute to increased viral activity, and consequently, biological contamination [1-5].

1.1. Indexes of quality of environment

There is overhead and lower critical limits of parameters of environment, the achievement of that can result in irretrievable violations in the biological system and in her separate links. Some substances (for example, most heavy metals) in fars are strong poisons, and in small doses they are needed, as reduction to their content in the organism of man below from a critical size causes heavy functional disorders. To the health of humanity harmful, both superfluously noise loading and absence of sounds; the same can be said about the electromagnetic fields, radioactive background, temperature loading, optical phenomena and other physical, and also biological, informative and other parameters [1, 3].

A law rations contamination of environment as varieties of unfavorable actions, coming from supposition about existence of possible norms of the harmful operating on nature, that guarantee ecological safety of population, maintenance of gene pool, provide the rational use and recreation of natural resources in the conditions of steady development of economic activity. A law rations contamination of environment as varieties of unfavorable actions, coming from supposition about existence of possible norms of the harmful operating on nature, that guarantee ecological safety of population, maintenance of gene pool, provide the rational use and recreation of natural resources in the conditions of steady development of economic activity.

Norms in area of guard of environment - the set norms of quality of environment and norms of the possible operating on her, at the observance of that the proof functioning of the natural ecological systems is provided and kept biological variety [1, 3, 4].

Norms of quality of environment are norms that is set in accordance with physical, chemical, biological and other indexes for the estimation of the state of environment and at the observance of that a favourable environment is provided.

For an estimation contaminations of environment are used such norms [5]: norms maximum possible concentrations MPC (ГДК) of chemicals, including radioactive, other substances and microorganisms; norms that is set in accordance with indexes maximum possible maintenance of chemicals, including radioactive, other substances and microorganisms in an environment and a failure to observe of that can result in contamination of environment, degradation of the natural ecological systems; norms of possible physical actions; norms that is set in accordance with the levels of possible action of physical factors on an environment and at the observance of that the norms of quality of environment are provided.

The criteria of quality of environment presently possible concentrations (ГДК) that are hygienical norms serve as maximum. There were scientifically reasonable and set hygienical norms more than for 400 substances and their combinations, thus all these substances are attributed to one of four classes of hazardous contaminating substances (most dangerous is a 1th class, the least dangerous - 4th). For most contaminents set two values ГДК : maximally valid for one occasion and average daily. Maximally valid for one occasion ГДК is constrained, mainly, with the possible reflex operating of substance on an organism. It is ГДК of admixture in mid air, registered with 20-minute усереднюванням; maximum possible frequency of appearance of concentration that exceeds maximally valid for one occasion ГДК must not exceed 2% of incurrence of measuring [1, 2, 5].

Average daily MPC (ГДК) is sent to warning chronically action of substance at the protracted inhalation.

MPC – maximum possible concentration of chemical substance in mid air working zone, a mg/ MPC must not cause disease or rejections in the state of health, educed by the modern methods of research, in the process of work or in remote life of present and further generations spans during everyday (except week ends) job within the limits of 8 hours or other duration, but no more than 41 hour for a week, during all working experience [5].

MPC_{ad} (ГДКсс) – maximum possible average daily concentration of chemical substance of in mid air settlements, мг/м. MPC_{ad} must not influence on a man at indefinitely long (years) inhalation. It is a basic norm of estimation of the state of atmospheric air from the sanitary-hygenic point of view.

MPC_{mv} (ГДКмр) – maximum possible maximal valid for one occasion concentration of chemical substance of in mid air settlements, мг/м. MPC_{mv} must not cause reflex (including subsensory) reactions in the organism of man at inhalation during 30 min This index is set for substances that have a specific action (for example, by a strong smell) and can be examined as a norm, if his value below than MPC_{ad}.

Quality of natural water depends on composition and amount of cut-in and hanging up substances, microorganisms, aquatic lives, and also from a temperature, acidity and other physical and chemical indexes. Thus, the estimation of quality of water can be folded on physical, chemical, bacteriological and hydrobiological indexes. Standards and norms of quality of water are different for the water objects of the sanitary-domestic and рибогосподарського setting. MPC of harmful substances in natural waters were set more than for 800 chemical substances. These substances are subdivided into three groups on the limiting index of harmfulness, the рибогосподарський index of harmfulness is especially distinguished [1, 2].

One of factors that determine quality of natural environment are maximum possible extrass MPE (ГДВ) - scientific and technical norm, set on condition that content of contaminents in the ground layer of atmosphere from a source or their totality, taking into account the prospect of development of industrial enterprises, would not exceed the norms of ecological safety of atmospheric air, : maximum possible concentrations of contaminents in atmospheric air for people and objects of natural environment [1, 2].

Essence of MPE ГДВ consists in setting of norms of contamination, as at the existent methods of reduction of wastes of production it is practically impossible fully to avoid penetration in the atmosphere of harmful substances. At the same time it is possible to decrease industrial contaminations to the set limit or weaken their action to the levels certain to MPC ГДК. For the exposure of connection between MPE ГДВ and MPC ГДК investigate conformities to law of distribution of mixture from their sources to the zone the actions predefined by turbulent diffusion in an atmosphere [3, 4].

1.2. Sources of atmospheric pollution

The environment's optimal conditions for life and work are in certain, relatively narrow limits. Increasing or decreasing these limits means a qualitative change in the living conditions of mankind. Industrial production and other types of economic activity of people are accompanied by pollution of air of premises and atmospheric air and various substances polluting the environment. Hazardous substances fall into the premises as a result of the life of humans and animals [1, 2].

The air enters aerosol particles (dust, smoke, fog), gases, vapors, as well as microorganisms and radioactive substances. Air quality deteriorates also due to the presence of unpleasant odors in the air. The main sources of pollution of the external air environment are:

- industrial enterprises;
- heat generating devices;
- transport.

Entry into the air of industrial premises and emissions to the atmosphere of vapors, gases, aerosols and other harmful substances is a direct result of the imperfection of technological and transport equipment, in the first place, its leakproofness, as well as the lack or lack of efficiency of dust collecting and localizing devices and systems [1, 2].

Air pollution as a result of falling into it of various kinds of harmful substances has a number of adverse effects.

Sanitary and hygienic effects. Since air is a medium in which a person lives throughout his life and on which his health, well-being and ability to work depends, the presence in the air environment of even small concentrations of harmful substances may badly affect a person, lead to irreversible consequences and even death [1].

Environmental consequences. Air is the most important element of the environment, which is in continuous contact with all other elements of living and dead nature. The deterioration of air quality due to the presence of various pollutants in it leads to the death of forests, crops, herbage, animals, to the pollution of water bodies, as well as damage to cultural monuments, building structures, various buildings, etc. [1].

Economic Impact. Air pollution causes significant economic losses. Filled and gassed air in industrial premises leads to a decrease in labor productivity, loss of working time due to increased morbidity. In many industries, the presence of dust in the air enhances the quality of products, accelerates the wear of the equipment. In the process of production, extraction, transportation of many types of materials, raw materials, finished products, part of these substances passes into a dusty state and is lost, polluting the environment at the same time. Losses in production amount to 3 - 5%. Big losses due to pollution of the environment. Measures to reduce the effects of pollution cost too much [1].

There are the organized (through pipes, ventilation shafts and etc.) and unorganized sources of contamination (through lanterns and intervals in workshops, from the places of loading and unloading of transport, through sources in communications and other) on enterprises. The unorganized sources of contamination in opinion of specialists fold from 10 to 26 % from the general amount of sources of contamination, atmosphere. Reasons of considerable contaminations of atmosphere are: absence or uneffective localization of sources of gassing and dust; insufficient impermeability, structural lacks of productive equipment, him technical disrepair; wrong conduct of technological processes [6, 7].

1.3. Characteristics of dust-gas sources of air pollution

Air quality is the impact on the body and equipment, as well as the technological processes that are caused by the presence of hanging particles in it, mainly dust. Dust of technological origin is characterized by a large variety in chemical composition, particle size, shape, density, particle character. Thus, the dust significantly affects the human body and the environment [1, 8].

Dust causes damage to the body, as a result of mechanical effects (damage to the respiratory system), chemical (poisoning with toxic particles of dust), bacteriological (with dust in the body penetrate harmful microorganisms).

According to hygienists, dust particles of 5 microns or less can penetrate deeply into the lungs, up to the alveoli. Dust size 5-10 microns mostly falls into the upper respiratory tract, almost not penetrating into the lungs. Dust adversely affects the organs of breathing, vision, skin [9, 10].

The most serious consequences are the systematic inhalation of dust containing free silicon dioxide SiO2. As a result, there is such a disease - silicosis. This is one of the forms of pulmonary diseases associated with inhalation of polluted air - pneumoconiosis. Effects of dust on the organs of vision cause conjunctivitis, on the skin - dermatitis [9].

Organic dust, for example, flour dust, can be an enabling environment for the development of microorganisms. Dust particles can be the nucleus of condensation for liquid vapor. Together with dust, substances that cause intense corrosion of metals can penetrate into the room. Together with air, dust can form an explosive mixture [10].

Carbon monoxide (CO). It is a gas that has no color or odor. This is a highly toxic substance. It is formed as a result of incomplete combustion of carbon. Isolation of CO occurs in foundry, thermal, blacksmith shops, boiler houses, especially those working on coal fuels, CO is contained in exhaust gases of motor vehicles, tractors. Through the lungs, CO penetrates into the bloodstream.It comes into contact with hemoglobin and forms carboximoglobin. In this case, supply to the body of oxygen is disturbed.

Cyanides. Cyanides include: cyanist (strong) acid (HCN) and its salts (KCN, NaCN, CH3CN). HCN is a liquid that does not have a color but has a smell of bitter almonds. Cyanides of sodium and potassium - colorless crystals that smell weakly with hydrocyanic acid. Cinnic acid can enter the body through the mucous membrane of the respiratory tract and not in a significant amount through the skin. Cyanides that have got into the body, violate blood circulation and supply of the body with oxygen [2].

Hydrogen sulfide (H_2S). It is a colorless gas with a smell of rotten eggs. Occurs when processing or using sulfur barium, sodium sulfide, antimony in the leather industry, artificial silk factories. It enters the body through the lungs, in small quantities through the skin and is very toxic. Affects the central nervous system [1].

Sulfur dioxide (Sulfur dioxide S02) is a colorless gas with a sharp smell. Occurs when burning fuel containing sulfur. Very common substance. In the human body it gets through the respiratory tract.

Strongly irritates the mucous membrane of the eyes, upper respiratory tract. At high concentrations there can be more serious consequences, even loss of consciousness, pulmonary edema [1].

Nitrogen oxides are a mixture of nitrogen compounds at their different ratios. Very common harmful substances are released during the production of nitric acid. Get into the body through the respiratory tract. At high concentrations of the mixture in the air comes the phenomenon of strangulation.

Carbohydrates of the aromatic series. The production is widely used in benzene, toluene, xylene. They are obtained during the distillation of coal at coke plants. In normal conditions, they are in liquid state. Get into the body through the respiratory tract and skin. The most dangerous is benzene. Aromatic carbohydrates act on the hematopoiesis and the central nervous system [1].

Metals. Today, along with well-known metals (lead, mercury, zinc, manganese, chromium, nickel), are increasingly used to produce alloys with special properties, as catalysts, for the manufacture of individual parts, liquid scattering metals (lithium, beryllium, vanadium, titanium, zirconium, tungsten, thallium, selenium, etc.). As harmful substances, metals can be in the form of aerosols of disintegration and condensation, and also in the form of vapors.

Lead (Pb). Heavy metal. Lead and its compounds are released into the air at industries where lead melt. Lead is released into the human body to a greater extent through the respiratory tract, as well as through the gastrointestinal tract. Lead disrupts the functioning of the circulatory system, the central nervous system, metabolic processes in the body. Can accumulate in different organs (bones, brain, liver, muscle). The removal of lead from the body occurs during a long period.

Mercury (Hg). Liquid metal. In industries, mercury is used in its pure form and in the form of its compounds (chlorine, cyanide, sulfuric and nitric oxides, etc.). Almost all of them are poisonous. Mercury is used in the production of measuring instruments (thermometers, barometers), mercury rectifiers, and the extraction of gold from ore. In the human body under conditions of production mercury gets through the respiratory tract. When you get into the body, mercury affects primarily the nervous system and the gastrointestinal tract, the kidneys. Mercury can accumulate in the body, mainly in the liver and kidneys. Fine-dispersed mercury can fall into pores of materials (gypsum, wood, etc.) and for a very long time allocate a pair of mercury.

Manganese (Mp). Silver metal with a red hue. Distributed compounds of manganese: manganese oxide, manganese dioxide, chloride manganese. With manganese you can meet in the metallurgical industry. Manganese and its compounds get into the body through the gastrointestinal tract in the form of dust. They affect the central nervous system.

Zinc (Zn). The harmful substance is zinc oxide - it is a white, loose powder. Zinc oxide can be obtained by oxidation of zinc when heated above the melting point. When heated zinc, its vapor forms, which are connected to oxygen and form zinc oxide (ZnO). Zinc oxide in the form of dust enters the body through the respiratory tract. The effect of zinc oxide on the body is a fever. Zinc is mainly deposited in the liver and pancreas.

Chromium (Cr). Chrome is a solid, brilliant metal. Chromium compounds are used: chromium oxide, chromium dioxide, chrome alum, potassium and sodium. Chromium and its compounds are used in metallurgy, chemical, leather, textile, and others. industries. They get through the respiratory tract in the form of dust, fog vapors, through the gastrointestinal tract, absorption through the skin in the form of solutions. May be deposited in the liver, kidneys, endocrine system, lungs, hair, etc. Chromium and its compounds affect the mucous membrane of the respiratory system, the gastrointestinal tract, causing ulcers on the skin. As allergens, they cause bronchial asthma disease.

Nickel (Ni) is a silvery white metal with a brown tint. It is used in the production of nickel-chrome steel alloys made of copper and iron, as a catalyst, in the nickel plating of metal parts in galvanic production. In the body gets through the respiratory tract in the form of dust. Nickel and its compounds affect the respiratory system, the skin.

Carcinogenic substances. A number of substances used in industry can cause malignant tumors in different parts of the body. These substances include: chrome, arsenic, nickel, asbestos, beryllium, soot, resin, mineral oils and a number of others. These tumors can occur even after a significant period after the termination of work with the relevant substances. The most harmful are unpleasant odors, sources of which are gases and aerosol particles, which are in small quantities in the air environment. Odor negatively affects the human body, causing increased fatigue, nervous excitement or, conversely, depression. Unpleasant smells have to be encountered in the locations of chemical plants[1].

In recent decades, a new kind of air pollutant has appeared - these are radioactive substances. The development of nuclear energy and the industry for the extraction and processing of nuclear energy carriers, associated with the release of radionuclides into the environment. These substances are very diverse in terms of the intensity of exposure to the human body and animals, the environment, as well as the time of its existence. Microorganisms are also in the air - they are bacteria and viruses [2, 6].

1.4. Basic properties of aerosols

The aerosol is a disperse system in which the dispersed medium is gas, namely air, and the disperse phase is solid or liquid particles. Usually it is a particle size of 100-200 microns, and according to some ideas - 500 microns [5].

There are dispersion and condensation aerosols. Dispersion aerosols are formed by crushing solids and liquids. Condensation aerosols are formed by condensation of saturated vapors, as well as as a result of gas reactions. Sprays include dust, fog and smoke [1].

Dust is a disperse aerosol with solid particles, regardless of dispersion. The dust is usually called the set of settled particles [5].

Under the mist understand the gaseous medium with liquid particles, both condensation and dispersion, regardless of their dispersion [5].

Smoke is called condensation aerosols with a solid disperse phase [5].

It is sometimes difficult to draw a clear line between different types of aerosols. This is explained by the fact that aerosol systems consist of particles of different origin. In addition, the continuous interaction of these particles, the addition of small particles to larger ones. The aerosol system is not in a constant state. As a result of the interaction of particles there is an increase in them, the destruction of conglomerates, precipitation of particles [1].

In technology and in everyday life, we constantly have to deal with substances that are in a crushed condition. The main focus is on the consideration of dust, because in most cases the air has to clear from this type of aerosol. Most of the purification systems are designed to capture dust [1, 2].

Distinguish the dust of natural and industrial origin. Natural origin is formed as a result of processes that are not directly related to the production process, although in many cases there is an interconnection between this type of dust formation and human economic activity [1, 2].

The dust of natural origin is dust that forms as a result of soil erosion (this process, of course, affects human activity), as well as dust that occurs during weathering of rocks, dust of cosmic origin, etc. Natural origin is also organic powders [1].

With a dust of natural origin it is necessary to meet when solving the problem of air purification before it gets to ventilation rooms. Industrial dust occurs during the production process. Almost every type of production, each material or kind of raw material is characterized by a certain type of dust [2].

Many technological processes are aimed at obtaining various materials that consist of small particles. The totality of these particles will be correctly called sawing material. The appropriate dust is usually called very shallow particles of these materials, which are carried by airflows [1, 2].

Most of the dust occurs as a result of processes related to the processing of materials, their sorting and transportation.

In turn, organic dust is flora and fauna. Inorganic dust is divided into mineral and metal.

Much of industrial dust - mixed, consists of particles of inorganic and organic, or, being organic, includes particles of mineral and metal dust. For example, cereal dust, in addition to the particles formed during the grinding of grain, also has mineral particles that fall into the mass of grain when grown and harvested. Dust, which is released when grinding metal parts, in addition to metal particles, has mineral particles formed by the interaction of the processed metal. This should be taken into account when choosing methods for cleaning and dust extraction [1, 2].

Dispersion is the degree of shredding of a substance. Under the disperse composition is the distribution of particles of aerosols in size. It shows the particles of which size is the aerosol, and the mass or number of particles of corresponding size [5].

The dispersion largely determines the properties of aerosols. As a result of shredding, some properties of a substance change and new ones are formed. This is mainly due to the fact that when the substance is dispersed, its total surface is multiplied repeatedly [1].

As a result of a sharp increase in the total surface of the substance, surface energy increases, which causes an increase in physical and chemical activity. The reaction of oxidation of these substances proceeds very quickly and intensively. For an increase in physical activity, for example, the fact that crushed matter dissolves many times faster than the initial material [1].

The dispersion composition characterizes the aerosol from different directions. In addition to physical and chemical properties, the disperse composition determines to a large extent the nature and conditions for the propagation of aerosols in the air environment. Fine dust precipitates considerably more slowly, and in particular fine-grained dust virtually does not precipitate. Thus, the diffusion of dust particles in the air is largely determined by the dispersion of dust. The most important issue of dust extraction - the choice of dust extraction equipment - is solved mainly on the basis of disperse composition of dust. The dispersion of aerosols is determined by laboratory studies using various methods [1-3].

The dispersion of dust is of primary importance for the development and improvement of dust collecting devices and systems, as well as for measures to reverse dust emissions and its propagation [4].

Density is the mass of a unit of volume, kg / m. Distinguish the true, imaginary and bulk density of dust particles. The true density is the mass of the unit volume of the substance from which the dust is formed. The apparent density is the mass per unit volume of particles, including the volume of closed pores. The apparent density of the monolithic particle is equal to the true density of this particle. Bulk density is the mass of the unit volume of caught dust freely poured into a container. In the volume that takes the dust, also includes the internal pores of the particles and the intermediate space between them [5].

Specific aerosol surface - the ratio of the surface of all particles to their mass or volume. The value of a specific surface allows us to judge the dispersion of dust [1, 5].

Ductile fracture. The tendency of particles to cling to each other is determined by autogenous properties, and in the technique of dust removal was called "fissure".

It is believed that for the wet dust the degree of its folding should be increased by one level. Folding increases with smaller particle size.

Dustiness of dust. Viscosity characterizes the mobility of dust particles one relative to one and their ability to move under the action of external force. The bulkiness depends on the size of the particles, their moisture and the order of sealing. Characteristics of bulking are used in determining the angle of inclination of the walls of bunkers and other devices associated with the accumulation and movement of dust and dust-like materials.

Hygroscopicity of dust is called its ability to absorb moisture from the air. The absorption of moisture affects dust properties such as electrical conductivity, fusibility, flaking, etc. The equilibrium between the relative humidity of the air and the moisture of the material is an isotherm of sorption. Using the isotherm of sorption, you can judge the behavior of dust in the apparatus, dust containers, pilosebars.

Wetting of dust. Wet dusting is based on wetting of dust with scattered water. Wetting of dust determines the possibility of its hydrodilution, wet dust treatment of industrial premises.

Electrical properties of dust. Electrical properties have a significant influence on the behavior of dust particles. Electrical forces largely determine the process of coagulation, the stability of dust aggregates, the explosion of dust, its effect on living organisms.The electrical properties of dust should be taken into account when dealing with issues related to the cleaning of gases (air) from dust, in the first place, with the work of electric filters. Data on the electrical properties of the collected dust can be used to optimize the work of the electrofilter, the efficiency and stability of which directly depends on these properties. The main electrical properties of dust - the specific electrical resistance and electric charge [1, 2].

Specific electrical resistance (PEO) characterizes the electrical conductivity of a dust layer.

PEO is equal to the resistance of electric current passing through a dust cube with a side equal to 1 m (Ohm). By the value of PEO, dust can be divided into three groups: well conducting <10 Ohm, with an average conductivity of 10 ohms, high conductivity> 10 Ohm. Electric dust resistance is due to surface and volume conductivity. The superficial layer of dust particles on its electrical properties differs from the main mass due to the adsorption of moisture and gases on the surface. Bulk (internal) conductivity is determined by the conductivity of the material of the particle. It increases with increasing temperature as a result of increased energy of electrons. At room temperature, the dust absorbs moisture from the air. Surface conductivity rises, resistance decreases. As the temperature rises, moisture evaporates and resistance increases. Then, with a further rise in temperature to 90 - 180 ° C, due to the thermal excitation of the electrons of the substance, there is a decrease in resistance.

Electric charge of dust. Dust, like any other aerosol particle, may have one or more electric charges or be neutral. The aerosol system may have particles that are charged positively, negatively, and neutrally. The ratio of these particles determines the total charge of the system.

Dust particles receive an electric charge both in the process of formation and after formation, being in an oblique state, as a result of an explosion, dispersion, mutual friction, friction about the air, and also as a result of adsorption of ions during ionization of the medium. The last method of electrification is essential for suspended particles. The electric state of the aerosol system does not remain constant over time. As a result of interaction with each other and with the environment, the suspended particles receive a charge, give it, neutralize.

The electrical properties of the dust have a certain effect on the resistance of the aerosol, as well as the nature of the action of dust particles on a living organism. It is also known that the momentum in the process of explosion may be the charge of static electricity. The interaction of two bodies, the size of which can be neglected, is described by the law of Coulomb. At high concentrations of particles in the environment Coulomb forces contribute to the processes of coagulation [1, 2].

Flammability and dust explosion. The ability to form explosive mixtures with air and the ability to ignite are the most important negative properties of many types of dust. Substances such as grain and sugar, although capable of combustion under certain conditions, are not explosive substances. Being brought to a dusty condition, they become not only fire hazardous, but also explosive. Many types of dust form explosive mixtures that can explode with air [1].

Coagulation of aerosols. Particles of aerosols with medium and good wettability, which do not react with wetting liquids, can form with them mixing mechanical mixtures, colloidal solutions and true solutions. True solutions are different from suspensions - colloids and mechanical mixtures of particle sizes, which dissolve matter when stirred. Liquid colloidal solutions include highly dispersed and coarse dispersed mixtures.

Coarse liquid colloids with a solid disperse part are called suspensions, with liquid emulsions [1, 2].

The common feature of true solutions is their stability. Colloidal solutions, both liquid and gaseous, are unstable, that is, they can not be stored for a long time in the initial state [3].

Aerosol is an unstable system. It is prone to constant change. Over time, in the aerosol there is an enlargement of the suspended particles.This process is called coagulation; it occurs as a result of the interaction of particles under the influence of various physical factors. The greatest role in coagulation belongs to molecular forces and forces of electric gravitation. Coagulation of particles weighed in gases significantly influences the effectiveness of dust collecting devices. From the point of view of vacuuming of air, coagulation is a very useful phenomenon, because due to the aggregation of dust particles, the efficiency of their capture increases. The coagulation will be more intense, the greater the probability of a collision of aerosol particles. This probability increases with the above factors. Small particles are more prone to coagulation than large ones. Coagulation also accelerates when the dust particles become concentrated in a gas medium [1-4].

Also, natural coagulation occurs when this process occurs under the influence of natural forces, that is, mainly due to Brownian motion and gravitational forces, and artificial coagulation, when this process is intensified, using additional factors, for example, turbulization of dusty flow, its artificial ionization and acoustic processing The process of coagulation as a result is accelerated many times, that is, the probability of collision and interaction of particles many times increases [1].

Thermal (Brownian) coagulation. At the heart of Brownian coagulation is Brownian (chaotic, disorderly) motion of very small particles - up to 0.1 μm.

Gradient coagulation. Gradient coagulation is due to the presence of a velocity gradient in the flood of polluted gases. The most typical example is the flow of gases near the solid wall of the canal. In accordance with the laws of hydraulics, the particle near the wall moves at a lower speed than a particle that is closer to the longitudinal axis of the channel. Contact of particles is possible, if the distance between them is less than the sum of their sizes. The action of gradient coagulation is limited mainly to the wall layer. Therefore, it plays an essential role in the considerable length of the channels and the large surface on which the contact takes place [1].

Turbulent coagulation. The vortical motion of the medium resulting from turbulence increases the probability of collision of particles, which increases the rate of coagulation. Turbulence of dust-gas streams is carried out to increase the dust particles and increase, due to this, the efficiency of cleaning. The vortical motion resulting from turbulence increases the probability of a collision, and consequently, the aggregation of particles.

Kinematic coagulation. The process of kinematic coagulation occurs when the relative motion of particles of different sizes under the influence of external forces - forces of gravity, centrifugal forces, etc. Different size particles move at different speeds. As a result, they collide and consolidate. Kinematic coagulation occurs also in the oncoming movement of scattered water and aerosol in wet dust collectors.

Electric coagulation. Interaction forces occur between charged and uncharged particles. This largely determines the behavior of particles. The particles come in contact, stick together, forming aggregates. Among the particles, the following electrical forces of interaction act: Coulomb gravity or repulsion that occurs between two charged particles that are at a certain distance from each other; the induction force between the charged particle and the neighboring unloaded; the force of interaction between a charged particle and other particles with the same sign; power of the external electric field (if it is). Electric coagulation is used in dust extraction technology.

Acoustic coagulation. The spontaneous flow passes through the acoustic field created by the source of sound and ultrasound. With certain parameters of the field and the characteristics of the dust-gas stream due to the fluctuation of the medium, the number of collisions between the dust particles increases significantly, which leads to their adhesion, that is, to the consolidation of the dust. Acoustic processing is carried out in order to increase the efficiency of dust extraction.

Specific characteristics of dust and dust contamination. All real gas emissions contain water in a state of overheated, saturated or wet steam. Molecules and aggregated particles of water are diffused into gases that go away during evaporation from liquid and solid surfaces, are gas streams when sprayed and sprayed with liquids, formed in the gas phase when chemical reactions occur (for example, when combusted with fuel), they enter the atmosphere together with air that is involved in the technological process.

Carriers of polluting compounds of most industrial emissions are air or flue gases. The elasticity of the saturated vapor and other parameters of air contaminated by no more than a few percent can be determined by the error of engineering calculations by the tables and diagrams of wet air. The humidity of the flue gases depends on the type, composition, and sometimes the method of combustion of the consumed fuel, on the humidity of the air entering the combustion zone and is determined by the calculation according to stoichiometric and balance equations [1-4, 10].

It is important to know not only their disperse, but also the chemical composition, for the right choice of methods for treating solid, and especially liquid, contaminants of gas emissions. In order to avoid negative consequences or unanticipated results of the disinfection method being developed, it is necessary to have information on the chemical composition of contaminants and the properties of the ingredients in the field of parameters, which corresponds to the conditions for their treatment [1, 2].

1.5. Hazardous gases and vapors

Gas pollutants, like aerosols, pollute the atmospheric air, significantly degrade its quality, and in some cases make it unsuitable for people to stay in it. It causes significant damage to the health of people living in areas that are exposed to harmful gases and vapors, it damages farming in the area, organizes people's rest, leads to damage to architectural structures, historical and cultural monuments, and so on. more [9, 10].

In order to avoid these serious consequences and maintain air quality, emissions to the atmosphere should be cleaned not only from aerosol pollutants, but also from harmful vapors and gases. With the development of technology and the improvement of technological processes, there are new types of substances emitted into the atmosphere. At the same time, there is a modernization of the existing and development of new types of technological equipment, which provides complete sealing, automation, remote control of devices. There is introduced a non-waste technology in which emissions are eliminated into the atmosphere, there are new methods of air purification from harmful gases and vapors, new technological equipment is being developed and used, which includes built-in aggregates for the removal and disposal of harmful substances [1, 9, 10].

During the cleaning of emissions from gaseous pollutants it is necessary to solve simultaneously a number of problems connected with the fact that in emissions that contain harmful vapors and gases, there are also aerosols - dust, soot, so they must be subjected to different methods of purification.

Methods of purification are used depending on the physical and chemical properties of the pollutant, its aggregate state, concentration in the environment that is purified [1-4].

A radical solution to protect the most important element of the environment - the air is to create and implement non-waste technological processes, ie those in which all waste products are not emitted into the environment, but used for useful purposes [1-3].

The most important measure to reduce emissions into the atmosphere is to improve the technological process in the direction of reducing waste, using them, the use of processes that are not related to the formation and release of harmful vapors and gases in the environment.

Another important measure is sealing equipment. Under sealing it is necessary to understand the impenetrability of external structures (walls) and other structures of vehicles and communications, in which liquids and gases are located or transmitted. With insufficient sealing of apparatus and communications, liquids and gases penetrate into the environment. The disadvantage of this is the loss of the product, raw material, material, and pollution of the environment, soil, atmosphere, reservoirs [1, 2].

1.6. Classification of water and properties of water disperse systems

In industry, water is used as raw material and energy source, as a refrigerant, solvent, extractant, for the transportation of raw materials and materials. The water used in the industry is divided into cooling, technological and energy. In industry, 65-80% of water is consumed to cool liquid and gaseous products in heat-exchange units. In these cases, water does not encounter material flows and is not polluted, but only heats up [6-8].

Technological water is subdivided into water, which is formed in a medium, flushing and reactive. The water formed in the environment is used to dissolve and form pulp, when enriching and processing ore, hydrotransportation of products and waste products; flushing - for flushing of gaseous (absorption), liquid (extraction) and solid products and products; reactive - in the composition of reagents, as well as in distillation and other processes. Process water is in direct contact with the environment. Energy water is consumed for steam and heating of equipment, premises, products [1, 2, 6-7].

To reduce the consumption of fresh water create reverse and closed water supply systems. In the case of reverse water supply, the necessary purification of sewage, cooling of return water, treatment and reuse of sewage water are provided.

The content of organic substances and compounds of nutrient elements (nitrogen, phosphorus), which is a nutrient medium for microorganisms, is limited in the reverse water to prevent the biological overgrowing of apparatuses and structures [1, 2].

Waste water is water that was in household, industrial or agricultural use, and also passed through the contaminated area [5].

Household and domestic water are drains of showers, laundries, dining rooms, toilets, floor washing, etc. [5].

Atmospheric waters are formed as a result of rainfalls and flood from the territories of enterprises. They are polluted with organic and mineral substances. Industrial waste water is a liquid waste that occurs when extraction and processing of organic and inorganic raw materials [5].

Sewage is contaminated with various substances [1, 2]: 1) biologically unstable organic compounds; 2) low-toxic inorganic salts; 3) petroleum products; 4) biogenic compounds; 5) substances with specific toxic properties, as well as heavy metals, biologically rigid organic synthetic compounds, which do not decompose.

Depending on the physical state of the phases, distinguish the following liquid inhomogeneous systems [1]: suspensions, emulsions, and foams.

The suspension consists of a liquid and suspended solid particles in it.

Depending on the size of the particles, there are rough suspensions with particles> 100 microns, thin (0.5.100 microns) and mud (0.1 ... 0.5 microns).

The intermediate position between the suspensions and true solutions is colloidal solutions with particle sizes smaller than 0.1 μm.

The emulsion consists of two liquids that are not mixed or partially mixed, one of which is distributed in the other in the form of liquid drops. The size of the particles of the disperse phase in emulsions fluctuates in rather broad limits

Foam is a system consisting of a liquid and gas bubbles distributed in it.

Inhomogeneous systems are characterized by a mass or volume ratio of phases and the size of particles of the dispersed phase. The dispersed phase, which consists of particles of varying size, is characterized by fractional or dispersed composition, that is, the percentage content of particles of different sizes. Sewage water is polydispersed heterogeneous (heterogeneous) aggressive-unstable systems. In the process of deposition, the size, density, shape of particles, as well as physical properties of system particles change [1, 2, 5].

Properties of sewage differs from the properties of clean water. They have a higher density and viscosity [1, 2].

1.7. Classification of industrial waste

The classification of industrial waste (PV) produced as a result of human production activity is required as a means of establishing certain links between them in order to determine the optimal ways to use or dispose of waste [6, 7].

Synthesis and analysis of literature data show that the classification of PV is based on the systematization of them by industry, processing capabilities, aggregate state, toxicity, and so on. In each particular case, the nature of the classification used is consistent with these aspects: compilation, purification, processing, burial of PV, rejection of their toxic effects, etc. Each industry has a classification of its own waste [8].

The classification of waste is possible on various indicators, but the most important of them is a measure of danger to human health. Hazardous waste, for example, is considered infectious, toxic and radioactive. Their collection and liquidation are regulated by special sanitary rules [1].

Classification and general safety requirements, all PVs are divided into four classes (Table 1):

Table 1

Class of danger	Characteristics of substances (waste)
1st	Extremely dangerous
2nd	Highly dangerous
3rd	Intent is dangerous
4th	Not very dangerous

For example, one can cite the hazard class of certain chemicals, which is determined by the calculation method:

- the presence of mercury, sulam, potassium chromic, antimony trichloride, benz (a) pyrene, arsenic oxide and other highly toxic substances, makes it possible to classify them as hazard classes;
- the presence of copper chloride, nickel chloride, antimony trioxide, lead nitrogen oxide and other, less toxic substances makes it possible to transfer these waste to the second class of hazard; availability;
- the presence of sulfuric copper, oxalic copper, nickel chloride, lead oxide, carbon tetrachloride and other substances in the waste allows them to be classified in the third grade of hazard;
- The presence of sulfuric manganese, phosphates, zinc sulphate, zinc chloride in the waste gives grounds to classify them as a fourth hazard class.

Belonging to the hazard class of others by the chemical composition of the waste can be determined by the calculation method for this chemical in the soil, using the mathematical formula, reference literature (physical and chemical constants, their toxicity and hygiene norms for chemicals in the soil).

1.8. Energy pollution of the environment

Industrial enterprises, energy facilities, communications and transport are the main sources of energy pollution of industrial regions, urban environments, buildings and natural zones. To energy sources of pollution include vibration and acoustic actions, electromagnetic fields and radiation, the effects of radionuclides and ionizing radiation [1, 6-8].

Vibrations, the source of which is technological equipment, rail transport, construction machinery and heavy vehicles, extend over the soil. The length of the zone of action of vibration is determined by the magnitude of their attenuation in the soil, which is 1 dB / m [1, 5].

Noise is created by means of transport, industrial and sanitary equipment. On the city highways and in the adjoining areas, the sound levels can reach 70 – 80 dBA.

The main sources of electromagnetic fields (EMF) of various frequencies are radio engineering objects, television radar stations, thermal workshops and sites. The effect of the EMF of the industrial frequency is connected with high-voltage transmission lines, sources of permanent magnetic fields used in industrial enterprises. Zones with elevated levels of EMF radiofrequencies have a radius of 100-150 m [1, 9, 11, 12].

The effect of ionizing radiation on a person can occur as a result of external and internal irradiation. Exterior irradiation causes sources of X-ray and γ-radiation, protons and neutrons. The internal irradiation is caused by α and β particles that enter the human body through the respiratory system [13].

In the study of radioactivity, it was found that the radiation of various particles and γ-radiation, as well as the conversion of one nucleus to another, occurs arbitrarily, but with the adherence to the rules of displacement [14-16]:

- at α-decay, the nucleus loses its positive charge and its mass decreases by four mass units, leaving the element shifted to the beginning of the periodic system;

- at β-decay, the element is shifted to one cell by the end of the periodic system.

β-radiation is a stream of helium nuclei, which are emitted during the decay of a radioactive substance or in nuclear reactions. Energy α- particles of the order of several MeV. In the air, these particles are absorbed by a layer in the thickness of 8 - 9 cm. Due to the large mass, these particles quickly lose their energy, so the permeable property of this type of radiation is low.

β- radiation is a stream of electrons that arise during a radioactive decay. The energy of these particles is several MeV. These particles have a much smaller mass, so they have a higher permeability property.

Neutron radiation converts its energy as a result of a collision with the nuclei of matter. In the case of inelastic interactions, secondary radiation may occur, which can have both charged particles and radiation [16].

X-rays arise when the particles act on the environment or when the electrodes of the anodes of the X-ray tubes are bombarded. X-ray radiation, as a rule, consists of a brake and characteristic. The braking radiation has a continuous spectrum, and the characteristic one is a discrete spectrum, which depends on the material of the anode. X-rays have a high permeability [14-16].

γ - radiation as X-ray has an electromagnetic nature and a large permeability. γ- radiation occurs as a result of natural radioactivity, as well as in artificial nuclear reactions with collisions of high-energy particles [16].

Ionizing radiation represents a great danger for living organisms of the biosphere, and especially for humans. With such kind of physical fields, special care should be exercised, because very often radioactivity, without color, smell, taste, acts insidiously on the human body with a possible lethal end. When considering the biological action of radioactivity distinguish external and internal radiation. External radiation is a case where the source of radiation is outside the body and radioactivity products do not fall into the middle of the body. The first signs of chronic lesion are dry skin, ulcers appear, hair loss [14-16].

The ingestion of radioactive products inside the body is very dangerous. In this case there is a defeat of many organs until the time when the radioactive substance does not disintegrate or leave the body as a result of physiological exchange [17-19].

Living organisms are constantly exposed to irradiation due to the natural background. Background radioactive radiation consists mainly of three components: the natural background caused by radionuclides of the biosphere, an artificial background caused by human activity, X-ray diagnostics [18, 19].

On the basis of regulatory requirements, establish the procedure for conducting work with sources of ionizing radiation and ensure the elimination of radioactive waste [20].

In order to ensure the radiation hazard, it is necessary to observe the general principles of protection [1, 2, 20]: not to exceed the maximum allowable dose; apply a distance protection method, sometimes; apply shields; use personal protective equipment and.in The choice of a protective screen should be made depending on the type of ionized radiation. To protect against α - the radiation used screens of glass thickness of several millimeters. To protect against β - radiation use materials with a small atomic mass, and more often combined. To protect against γ - radiation, materials with a high atomic mass and high density, as well as cheaper materials and alloys are used. Stationary screens are executed without concrete. When working with radionuclides, always use overalls.

1.9. Methods of environmental protection from industrial sources of pollution

Environmental protection is an integral part of the concept of sustainable human development, which involves the long and continuous development of a technological base that will ensure the future generations of life in a safe environment. The concept of sustainable development can not be realized unless specific programs of action on the cessation of environmental pollution will be developed, including organizational, technical and technological developments for the development of resource, energy saving and low-waste technologies, reduction of gas emissions and liquid discharges, processing and utilization of household waste, reduction of the energy impact on the environment, improvement and use of environmental protection means. The future of technological methods of protecting the natural environment as the most progressive and ecological. It is the embodiment at all stages of the production of non-waste technology that will completely eliminate the problem of anthropogenic pollution of the environment [21, 22].

Organizational and technical methods of environmental protection can be divided into active and passive methods. Active methods of environmental protection are technological solutions for creating resource-saving and low-waste technologies. Passive environmental protection methods are divided into two subgroups: 1) rational allocation of sources of pollution; 2) localization of sources of pollution. Rational placement involves the territorial rational allocation of economic objects, which reduces the burden on the environment, and localization is essentially a phlegmation of sources of pollution and a means to reduce their emissions. Localization is achieved using various technologies for environmental protection, technical systems and devices [1, 2, 21].

The basis of many technologies are physical and chemical transformations. In physical processes, only shape, size, aggregate state and other physical properties of substances change. Their structure and chemical composition are preserved. Physical processes dominate in the crushing, crushing of minerals, in various methods of metal treatment by pressure, during drying and in other similar cases [1, 21].

Chemical processes change the physical properties of the raw material and its chemical composition. With their help, they receive metals, alcohols, fertilizers, sugar, etc., which are not present in their raw form. Chemical processes are the basis of production in metallurgy, chemical industry, construction materials industry, pulp and paper industry, and many other sectors of the national economy [1].

Chemical phenomena in technological processes usually develop under the influence of external conditions (pressure, volume, temperature, etc.), in which the process is realized. In this case, non-stoichiometric transformations of certain substances into others, changes in their surface, interphase properties and a number of other phenomena of mixed (physical and chemical) character [1] occur.

The set of interconnected chemical and physical processes that occur in a natural substance, called the physicochemical. Physico-chemical processes are widely used in enrichment of minerals, metallurgy, technology of basic chemical production, organic synthesis, energy, and especially in environmental technologies [1, 2].

Specific group consists of biochemical processes - these are chemical transformations that occur with the participation of subjects of wildlife. Biochemical processes form the basis of the vital functions of all living organisms of the plant and animal world. A large part of the agricultural production and food industry, for example biotechnology, is built on their use. The product of biotechnological transformations occurring with the participation of microorganisms are substances of inanimate nature [1, 2].

Depending on the basic laws that characterize the course of protective processes, biochemical processes are divided into the following groups [1]:

- mechanical;
- hydromechanical;
- mass-exchange
- chemical;
- physical and chemical;
- thermal processes;
- biochemical;
- processes complicated by a chemical reaction.

To mechanical processes, the basis of which is the mechanical action on solid and amorphous materials, include grinding, sorting, pressing and mixing of bulk materials. The driving force of these processes is the forces of mechanical pressure or centrifugal force [1].

Hydromechanical processes based on hydrostatic or hydromechanical action on the environment and materials include mixing, settling (precipitation), filtering, centrifuging. The driving force behind these processes is hydrostatic pressure or centrifugal force.

By mass-exchange (diffusion) processes, in which the transfer of a substance from one phase to another through diffusion plays a large role, together with heat transfer, adsorption, desorption, extraction, rectification, drying and crystallization. The driving force behind these processes is the difference in the concentrations of the transitional substance in the interacting phases.

Chemical processes occurring with the change in physical properties and the chemical composition of the starting substances, are characterized by the transformation of some substances into others, by changing their surface and interphase properties. These processes include the processes of neutralization, oxidation and recovery. The driving force of chemical processes is the difference in chemical (thermodynamic) potentials.

Physico-chemical processes are characterized by an interconnected set of chemical and physical processes. Physical and chemical separation processes based on physicochemical transformations of substances include coagulation and flocculation, flotation, ion exchange, reverse osmosis and ultrafiltration, deodorization and degassing, electrochemical methods, in particular, electric gas purification. The driving force of these processes is the difference between physical and thermodynamic potentials, components that are separated at the boundary of phases [1, 2].

Heat processes, the basis of which is the change in the thermal state of the interacting environments, include heating, cooling, evaporation and condensation. The driving force behind these processes is the temperature difference (thermal potentials) of the interacting media.

Biochemical processes, which are based on catalytic enzymatic reactions of biochemical transformation of substances in the process of vital activity of microorganisms, are characterized by the course of biochemical reactions and the synthesis of substances at the level of living cells. The driving force of these processes is the energy level (potential) of living organisms.

The specified classification is not rigid and unchanged. In reality, many processes are complicated by the occurrence of adjacent-parallel processes. For example, mass exchange and chemical processes are often accompanied by thermal processes. Thus, rectification, drying and crystallization can be attributed to combined heat and mass transfer processes. The processes of absorption, adsorption are often accompanied by chemical transformations. Chemical processes of neutralization and oxidation can simultaneously be considered as mass exchange processes. Biochemical processes are accompanied simultaneously by heat and mass exchange, and physical and chemical processes - mass-exchange processes [1, 2, 21]

1.10. Methods of cleaning dust air emissions

Under the disinfection of gas pollutants understand the separation of gas or transformation into a harmless state of contaminating impurities [5].

Unlike gaseous dispersed contaminants are fixed in the atmosphere visually at small concentrations. Therefore, the absence of a loop of suspended particles and the transparency of contaminants are simple criteria for its purity [22].

The neutralization of pollutants involves either removing harmful impurities from the inert gas carrier, or turning them into harmless substances. Both principles can be implemented through various physical and chemical processes, for which certain conditions are needed. To remove aerosols (dust and fogs), dry, wet and electrical methods are used. The basis of dry methods are gravity, inertia, centrifugal precipitation mechanisms or filtration mechanisms. With the use of wet methods for cleaning gas emissions is carried out by close interaction between the liquid and dust gas on the surface of gas blisters, droplets or liquid film. Electric gas cleaning is based on ionization of gas molecules by electric discharge and electrification of particles suspended in gas [1].

When processing contaminants containing solid aerosol pollutants, low values are jumps (1 - 2% and less) can be achieved, usually only two-stage cleaning. For pre-cleaning, louvre grate and cyclonic apparatus (sometimes for a small amount of contamination - vapor deposition chambers) can be used, and for the final one - porous filters, electrofilters or wet dust extractors.

Liquid aerosols (fogs) can be adapted by changing the state parameters (cooling and increasing pressure) to further deposition, using generally wet processes for capture in wet scrubbers, porous and electrical filters, in absorber [1, 2].

Wet methods for cleaning solid and liquid aerosols have a significant drawback - the need to separate the trapped contaminant from the catching liquid. For this reason, wet methods should only be used in the absence of other methods of purification, giving preference to methods with a minimum flow of liquid [1-4].

It is impossible to specify the exact limits of the application of certain physical and chemical processes to any of the principles of neutralizing pollutants or to strictly correlate them with certain aggregate states of the latter. Thus, the gravitational and inertial deposition processes of the dispersed part of the contaminants can also be used to separate high-density gases, for example, heavy metal halides. At the same time, cooling and condensation processes, which are widely used to separate gases, are also used to consolidate submicron condensation aerosols.

The problems that arise in the design and design of treatment systems are closely related to the general laws and the specific laws of natural technologies. The capabilities of the mathematical apparatus are not sufficient for a comprehensive quantitative account of the characteristics of real processes. Many factors are interconnected, and the resulting dependencies are so complex that it is not always possible to find a logical explanation for the results. Therefore, even in calculations of simple cleaning devices - dusting chambers and louver lattices, one has to rely on experimental data and production experience [1-4, 21].

The most difficult to clean pollutants that represent a multiphase system. Since most modern cleaning machines are not suitable for simultaneous disinfection of dispersed and homogeneous contaminants, in the general case, such pollutants must undergo 4 stages of treatment: preliminary and fine purification from the aerosol, and then preliminary and final disposal of the gaseous pollutant.

In particular, if the gaseous pollutant is readily soluble in water, preliminary treatment of contaminants by wet methods can be organized, which will reduce the concentrations of dispersed and homogeneous pollutants [1, 2].

If elemental solids or liquid aerosols do not contain other elements other than carbon, hydrogen and oxygen (vegetable dust, wool fibers, fogs of mineral oils, etc.), then they can be disinfected in one stage - direct burning in boiler furnaces and furnaces [1].

1.11. Ways of cleaning gas emissions

Dispersal and gas pollution is often a consequence of production processes. They are mixed in communications with air, closely interact with the purifying apparatus and the atmosphere and cause great damage to the environment and to humans. Judging by the chemical composition of the real gases that are released into the air and the extent of environmental pollution, the development of the arrangement of dusters without gaseous pollutants is possible only for ventilation contaminations of mechanical workshops. Pollution of virtually all other industries requires the destruction of dispersed and gaseous pollutants, and sometimes this can be done in a single purifying device [6-8].

For the removal of pollutants on the principle of the elimination of toxic impurities, together with the physical well used and chemical processes. With the help of the latter, it is possible to change the physical properties of impurities (for example, converting initial gaseous pollutants into compounds with high boiling point) to a wide extent, in order to facilitate their further capture [1-3].

To implement the second principle of neutralization - the transformation of pollutants into harmless substances must combine chemical and physical processes. For this purpose, the processes of thermal destruction and thermal oxidation are most often used. They are used for all contaminated aggregate states, but limited by the composition of the treated substance. Only substances whose molecules consist of carbon, hydrogen, and oxygen atoms can undergo heat treatment for the purpose of neutralization. Otherwise, heat-shrinkage installations become sources of pollution of the atmosphere, and are often extremely dangerous [1, 2].

Classification of means for the destruction of gaseous pollutants is to divide the processes used. Basically for gas purification means of chemical technology are used. Therefore, the classification of the means of elimination of emissions practically coincides with the classification of processes and apparatus of the chemical industry, producing harmful substances as wastes of the main production [1, 2].

Adsorption, catalytic, thermal and condensation absorption methods are used to dispose of gases leaving gas and vaporous toxic substances. Absorption methods are based on the absorption of gases or the absorption of vapors by liquid absorbers. Adsorption methods are based on the absorption of impurities by solid porous bodies. Catalytic methods of purification are based on chemical transformations of toxic impurities on non-toxic ones, on the surface of solid catalysts. Thermal methods are based on the combustion of combustible harmful impurities. The basis of condensation methods is the phenomenon of reducing the pressure of saturated vapor of the solvent with a decrease in temperature [2].

The most universal means of purification from gaseous pollutants at present is adsorption, and the most universal adsorbent is activated carbon. With the help of adsorption it is possible to extract from the source of pollution any pollutant in a wide range of concentrations. However, highly concentrated contaminants (approximately with concentrations greater than 510 kg / m) are more conveniently subjected to pre-treatment (condensation, absorption) to reduce their concentrations. Preliminary treatment (drainage) of highly humidified gases is also required [1].

Unfortunately, as a universal remedy for cleaning pollutants, thermal damage is considered as it is not actually. In general, the scope of thermosensitivity is limited only by compounds in which molecules have no other elements other than carbon, hydrogen, and oxygen. Getting non-toxic reaction products of any other compounds with oxygen is fundamentally impossible.

For perspective methods of treating large volumes of pollution with low concentrations of organic gaseous pollutants, the scheme of thermosetting with the previous concentration of pollutants can be attributed to adsorption. Such a scheme can be technically and economically acceptable at an initial concentration of pollutants higher than 50 mg / m3.The heat released during combustion of pollutants can be easily disposed of.

Perspective ways of treatment of polluted gases, which are based on the transfer of vaporous pollutants into a condensed state and subsequent filtration of the formed aerosol, seem to be. If the contaminants have a low vapor pressure, condensation can be acceptable by increasing the pressure and reducing the temperature of the pollutants.

In practice, gas purification uses three main methods of cleaning the atmosphere from harmful vapor and gases: absorption of liquids, adsorption by solid sinks, catalytic purification methods.

It is probable that the possibility of further processing of waste by means of basic technology is very limited, as initially determined by the low quality of cleaning of pollutants. Such an approach to the problem requires a substantial revision. One of the most effective steps could be the inclusion of waste disposal operations in the main technological process, as the limiting quantity and quality of the products produced. The unlimited growth of the range and volume of production in the modern world of production leads to the complication and increase in the cost of waste treatment technologies. We can assume that already in the near future, the methods used today in small industries, where gas is separated by chromatography on molecular sieves, centrifugation of heavy components, thermodiffusion, neutralization of pollutants by plasma 2, will become quite cost-effective.

1.12. Classification of sewage treatment methods

To create closed water supply systems, industrial waste water is purified to the required quality by mechanical, chemical, physico-chemical, biological and thermal methods. The specified purification methods are divided into recovery and destructive. Recovery methods involve extraction from sewage and further processing of all valuable substances. In destructive methods, pollutants are destroyed by oxidation or reduction, and destruction products are removed from water in the form of gases or precipitation [6-8].

The main methods of purification of different nature are used both for purifying sewage from various impurities, and for cleaning from dissolved impurities. In turn, the first group of cleaning of heterogeneous systems is divided into methods of purification from coarse dispersed impurities, which include methods of defending, stratification and filtration, flotation, centrifugal deposition; and on methods of purification from finely dispersed impurities by coagulation, flocculation and electroflotation [1, 2].

In the first group can also include methods for eliminating and destroying impurities by injection into wells, burial and thermal destruction [1].

The second group includes methods of purifying water from mineral impurities by distillation, ion exchange, reverse osmosis, electrolysis; methods of purification from organic impurities, including regenerative methods of extraction, rectification, adsorption, reverse osmosis and ultrafiltration, and destructive methods: biochemical, liquid and vapor phase oxidation, radiation and electrochemical oxidation; as well as methods for purifying from dissolved gases, including methods of blowing, heating and reagent.

Mechanical methods for the removal of suspended particles from sewage are based on the laws of hydromechanical processes. Physico-chemical methods of wastewater treatment are used for the removal of finely divided solid and liquid suspended particles, soluble gases, mineral and organic substances from the sewage. The mechanisms of these methods is to use the laws of physico - chemical hydromechanics, physical and colloidal chemistry, electrochemistry, processes of chemical technology.

Chemical methods are used to remove soluble substances in closed water supply systems.

Biochemical methods are used for the purification of household and industrial waste water from dissolved organic and inorganic substances. The process of biochemical purification is based on the ability of microorganisms to use pollutants for their nutrition in the process of life [1, 2].

Thermal methods are used to dispose of wastewater containing mineral salts.

The choice of the method of purification is carried out taking into account sanitary and technological requirements for the quality of purified water, the amount of sewage, the availability of necessary energy and material resources, the effectiveness of the process of neutralization [1].

1.13. Methods of protecting the lithosphere

The protection of the lithosphere includes not only the disposal of waste by placing it on landfills and landfills, but also the processing of liquid and solid waste using a variety of methods [4].

Mechanical dewatering of sediments of industrial effluents can be carried out by extensive and intensive methods. Extensive methods are carried out in various types of sealants, intensive dehydration and condensation is carried out by means of filtration, centrifugation, hydrocycloning, and the like. In the practice of industrial wastewater treatment, chemical (reagent) processing methods are most commonly used [1].

When using the thermo-oxidation method, all organic substances that pollute waste water, are completely oxidized by air oxygen at high temperatures to non-toxic compounds. These methods include the method of rare-phase oxidation, the method of steam-phase catalytic oxidation and flame or "fire" method.

Relatively widespread in the area of treatment of urban sewage sludge was dried (drum driers, drying in counter jets) [1, 2].

Many solid waste recycling processes are based on the use of leaching (extraction), dissolution and crystallization of recycled materials.

In the practice of recovering solid waste from the industry, methods of enrichment of recycled materials are used: gravity, magnetic, electric, flotation, and special.

During the utilization and processing of solid waste, various methods of thermal treatment of initial solid materials and products are used: these are various techniques of pyrolysis, melting, firing and fire fighting (combustion) of many types of solid waste on an organic basis.

1.14. Methods of environmental protection from energy actions

The choice of methods of protection against energy actions depends on the type and form of energy expression [23].

When protecting against mechanical and acoustic mechanical vibrations, the main methods of reducing their level of action are reduction of energy parameters in the source, optimal orientation of the source of oscillations relative to the object of action, absorption of part of the generated energy of oscillations, decrease of the energy of oscillations in the way of their propagation from the source by isolation, shielding and damping, protection of distance and time, carrying out of organizational and technical and social rehabilitation measures [24, 25].

The choice of methods and means of protection against the action of electromagnetic fields and radiation is largely determined by the characteristics of the sources by frequency. Among the methods of protection against EMF in the environment is the protection of distance, shielding, partial absorption of radiation power, reducing the level of energy by scattering and removing part of the energy from its location to the environment [1, 24-27].

1.15. General principles of intensification of technological processes of environmental protection. Physical bases and methods of description of natural ecosystems, thermodynamic properties and methods of diagnostics of their pollutants.

The general principles of the intensification of technological processes of environmental protection are reduced to the use of kinetic and thermodynamic factors that effectively influence the speed of the process and the output of the products of interaction [1, 6-8].

The choice of factors influencing the kinetics of the process must depend on which region (kinetic, diffusion, transient) it proceeds and in what degree accelerates the limiting stage in these concrete conditions of its implementation [7].

Thus, for the intensification of processes in the kinetic mode it is advisable to change the temperature, pressure, concentration of reactants, use of catalysts, increase the surface of interacting substances [1, 2].

The increase in temperature leads to a significant increase in the constant of the reaction rate and is used as a powerful factor in the intensification of many processes [2].

An increase in the concentration of interacting components is achieved by enrichment of the initial products of the process. The same role is played by increasing the pressure of gaseous initial reaction products, the enrichment of blast furnace oxygen in the combustion processes. If at the same time the removal of products of interaction with the reaction zone is carried out simultaneously, then their concentration and, consequently, the rate of reverse processes decrease, which additionally increases the total speed of the process [1, 2].

A strong intensifying factor of heterogeneous reactions occurring in the kinetic region is the increase of the specific surface (dispersion) of the initial substances. The general reaction rate in this case is proportional to the surface area on which the interaction takes place [1].

The same goal is achieved by increasing the homogeneity of the distribution of substances, their homogenization, expanding the contact area of the interacting phases. Homogeneity is achieved by mechanical mixing, vibration, ultrasound, high-voltage discharges in a liquid medium.

The acceleration of reactions through the use of catalysts is widely used in the chemical industry and is due to a decrease in the activation energy. Processes in the diffusion region are intensified by mixing the interacting phases, by turbulating their flows, which contributes to the accelerated flow of the slowest in this case, diffusion stages.

This is achieved by reducing the viscosity and density of the medium in which diffusion is carried out. To intensify processes in the transition region, both kinetic and diffusion factors must be used [1, 2, 21].

Typically, kinetic stages limit processes at low temperatures, and diffusion - at high temperatures. In the latter case, the phase composition of the substance may change (for example, it melts or distills, sharply intensifying the diffusion rate and the process as a whole).

Thus, the temperature increase should be considered not only as a factor accelerating the process in the diffusion region, but also as a means for the flow of a heterogeneous system into a homogeneous, and solid phases in the liquid and gas phase, which must significantly increase the rate of transformation.

The output of finite products in technological processes in the limiting case, that is, in the position of chemical equilibrium, is determined by the equilibrium constant and the activity of the initial substances associated with their concentration. In turn, the equilibrium constant for a particular reaction depends only on temperature [21].

In accordance with the principle of Le Chatelier, the output of the reaction products in the endothermic processes will increase with increasing temperature, as well as with increasing pressure if the volume of gaseous reaction products is less than the volume of the initial, and with the increase of the concentration of one or more starting substances. In all cases, the time to reach the equilibrium state (the maximum yield of reaction products) is reduced with increasing temperature.

In industrial practice, in order to increase the speed of the process and the output of reaction products, several or most of the above-mentioned intensification factors are used simultaneously.

The intensification factors based on the use of highly dispersed bubble technologies, which increase the interphase interaction surfaces, increase the pressure of the blast and its oxygen enrichment, vacuum processes, the use of rich ore concentrates, and the methods of extracurricular melting of metals are also widely used.

CHAPTER 2. PROTECTION OF THE ATMOSPHERE

2.1. Air purification from aerosol impurities

The basis of the action of dust collecting and separation devices is the determined physical mechanism. The following methods of separating harmful particles in the air are used in these devices: deposition in a gravitational field, deposition under the influence of inertia forces, centrifugal field deposition, filtration, deposition in an electric field, wet gas purification [6-8].

Gravitational deposition. The aerosol particles are deposited from the stream of contaminated gas under the influence of gravity. To do this, it is necessary to create an appropriate mode of movement of contaminated gas in the apparatus, taking into account the size of the particles, their density, etc. [1, 7].

Inertial deposition. Inertial deposition is based on the fact that the particles of aerosol and medium have a significant difference in density, and therefore have different inertia. The aerosol particles, moving in inertia, are separated from the gas medium.

Deposition in a centrifugal field. Deposition occurs in the curvilinear motion, under the action of the centrifugal field of aerosol particles fall on the periphery of the apparatus, where the deposition occurs.

Filtering. The aerosol particles are delayed in narrow channels and pores when the aerosol stream passes through filtering materials [1, 2].

Deposition in the electric field. Passing an electric field, aerosol particles receive a charge. Moving to the electrodes of the opposite sign, they settle on them.

Damp cleaning. Warming the surface of elements of apparatus with water or other liquid leads to the delay of particles on this surface.

In practice, dust extraction and separation of aerosol particles are used and other methods: thermophorez, photophoresis, increase of particles in acoustic field, magnetic field action, biological purification, and others.

In dust collecting and separation devices, along with the main catching mechanism, other regularities are commonly used. Due to this, the overall and fractional efficiency of the device reaches a higher level.

2.1.1. Gravitational deposition of particles

The work of gravity dust collectors is based on the laws of gravitational deposition that is, dust particles are deposited under the action of gravity.

The phenomenon of deposition occurs also in apparatus, the action of which is mainly based on the use of other forces [1].

Consider straightforward uniform motion of a particle subject to Newton's law. Possible convective currents are not taken into account. When the particle moves, it meets the resistance of the medium, which can be determined by the formula:

$$F_C = \varsigma_\tau S_\tau \omega_\tau^2 \rho_0 / 2, \tag{2.1}$$

where S_τ - the projection of the cross section of the particle in the direction of its motion, m2; ρ_0 - the density of the medium; ω_τ - particle velocity; ς_τ - aerodynamic coefficient of particle resistance [1].

The particle coefficient ς_τ depends on the Reynolds number. For a circle-like particle

$$R_{e\tau} = \omega_\tau d_\tau \rho_0 / \mu_0, \tag{2.2}$$

where μ_0 is a dynamic viscosity of air (gas), d_τ is a particle diameter, m [1].

Taking the value ς_τ, for the case of a laminar motion in the region $\mathrm{R}_{e\tau} < 2$, $\varsigma_\tau = \dfrac{24}{R_{e\tau}}$, we substitute its value for Newton's formula (2.1)

$$F_C = \left(24 / R_{e\tau}\right)\left(\pi d_\tau^2 / 4\right)\left(\omega_\tau^2 \rho_0 / 2\right) = 24 \cdot \mu_0 \pi \cdot d_\tau^2 \omega_\tau^2 \rho_0 / \left(8 \omega_\tau d_\tau \rho_0\right) \tag{2.3}$$

and get it

$$F_C = 3\pi\mu_0 d_\tau \omega_\tau. \tag{2.4}$$

This formula expresses the Stokes law: the strength of the resistance tested by a solid in the form of a circle with slow motion in an unbound viscous medium is directly proportional to the velocity of the gradual movement, the diameter of the body, and the viscosity of the medium.

Dust particles of small size participate in the Brownian motion - chaotic displaced particles under the influence of molecules. The smaller the particle size, the greater the role played by the Brownian movement in its displacement.

In accordance with the Einstein equation, the mean square displacement of a particle $\sqrt{\left\langle \Delta x^2 \right\rangle}$ in time under Brownian motion is:

$$\sqrt{\left\langle \Delta x^2 \right\rangle} = \sqrt{2 D_\text{ч} t}, \tag{2.5}$$

where $D_\text{ч}$ - particle diffusion coefficient, which characterizes the intensity of the Brownian motion, m^2 / s.

The highly dispersed aerosol particles are practically not deposited, but due to the Brownian motion they can move in any direction.

If we consider the motion of a particle not in the form of a circle, then in the calculated formulas the value of ς_τ is multiplied by the dynamic form factor χ, instead of d_τ introducing an equivalent diameter:

$$\chi = d_E^3 / d_ч^3 \quad , \qquad (2.6)$$

where d_E - the equivalent diameter of a particle is equal to the diameter of a circle, the volume of which is equal to the volume of this particle.

In motion, a particle that stays under the action of gravity in a stationary medium, it is possible to distinguish three stages: the initial moment of the fall; movement with increasing speed until the forces of resistance and gravity are not balanced; uniform movement with constant speed. The first two stages have a short duration [1-4].

If the air velocity is equal to the velocity of precipitation and is directed against it, the rate of precipitation of the dust particles in the air is zero.

The velocity of air in a stream in which the particle is stationary (or forms oscillatory motions) is called the speed of propagation. Thus, the rate of settling dust particles in the stationary air is equal to the speed of its propagation.

The term "speed of propulsion" is important for systems and devices in which the displacement of a gaseous medium with particles suspended therein occurs [1].

2.1.2. Centrifugal precipitation of particles

This method of separating aerosol particles from air (gas) is much more effective than gravitational deposition, because the centrifugal force that occurs is much larger than the gravitational force. Centrifugal separation can be applied to smaller particles [1, 2].

The velocity of the centrifugal deposition of a circular particle can be determined by equating the centrifugal force $F_Ц$ that arises during the rotation of the dust gas stream, with the force of the medium resistance according to Stokes's law:

$$F_u = m_ч \omega_\omega^2 / r \quad , \qquad (2.7)$$

where $m_ч$ is a particle mass; ω_ω is a the rate of rotation of the flow around the stationary axis; r is a radius of rotation of the flow. Hence, the rate of settling of the particle in a centrifugal field, taking into account the resistance of the medium:

$$\omega_u = \tau_p (\omega_\omega^2 / r) \quad . \qquad (2.8)$$

The rate of deposition $\omega_ч$ under the influence of centrifugal force is greater than the rate of gravitational deposition, in $(\omega_\omega^2 / \mathrm{r}) g$ times.

Two principled design solutions can be used in centrifugal separation machines:

- The aerosol flow rotates in the stationary body of the apparatus;
- The flow moves in the rotary rotor.

The first solution is applied in cyclones, and the second - in rotary dust collectors.

The capture of aerosol particles in cyclone vehicles is based on the use of centrifugal forces. Under the influence of the centrifugal force that occurs when the rotational flow of the stream, the aerosol particles move radially to the walls of the cyclone. The suspended particles are separated from the air mainly in the transition of the flow into the output, which occurs in the conical part of the body. The stream, continuing to move in the body of the cyclone, turning 180 °, enters the exhaust pipe and, moving in it along a spiral, flows out of the cyclone. The particles that are separated from the stream enter through the lower exhaust vent into the hopper.

In the cyclone, two vortex currents are generated: the outer and the inner ones. The processes that take place in the cyclone are complex and dependent on many factors, so, in theoretical calculations, many assumptions have to be made and simplified [1-3].

2.1.3. Inertial deposition of particles

Aerosol particles that move in the stream under the influence of a large inertia do not follow the flow, but try to preserve the previous direction of motion, moving in which settle on the walls, partitions, nets, and others. elements of the apparatus.

When a solid body (or droplet) flows through a dusty stream, particles, due to their large inertia, continue to move across the curved lines of gas and settle on the surface of the body [1, 2].

The coefficient of efficiency of inertial deposition is determined by the particle particles that left the flow when changing their direction of motion as a result of the flow of various obstacles. If the motion of a particle is carried out in an area where the Stokes law is not applied, an amendment must be introduced that takes into account the relation of the true resistance strength to the stock resistance.

The Stokes criterion is the only criterion for inertial deposition. Provided that the Stokes criterion is zero (in particles with infinitesimal mass), the particle flows along the current line without touching the surface of the streamlined body. It is obvious that the same phenomenon will be observed even with sufficiently small values of the Stokes criterion [1, 2].

There is a definite minimum so-called critical value of Stokes, in which the inertia of the particle is sufficient to overcome the capture of its gas stream, and it reaches the surface of the body. The theory of inertial deposition considers the deposition of particles on the front (front) part of the streamlined body and does not take into account their deposition on the posterior surface of the body, which may occur due to turbulent fluctuations in the gas flow. This phenomenon is significant at small values of the Stokes criterion, that is, in the capture of submicron dust particles.

With the increase of the $R_{eч}$ criterion value in the transition to a turbulent flow on the surface of the streamlined body, a boundary layer whose thickness decreases as the criterion grows is formed. At values larger than the critical line, the flux bends more strongly (the potential flow) and flows around the body at a distance closer to it, resulting in a higher value of the Stokes criterion. This increase in efficiency will continue with a decrease in the thickness of the boundary (laminar) layer around the body, that is, with the increase in the criterion. Thus, with a potential flow, the efficiency of precipitation depends both on the Stokes criterion and on the criterion. The most complicated character acquires the boundary layer with a turbulent flow.

Therefore, it is better to consider only systems with the same value of a $R_{eч}$ criterion or system, in which the flow of the flow approaches the self-similar, and the criterion can not be taken into account in the calculations [1, 2].

2.1.4. Filter aerosols

For fine purification of gases from particles and drip liquid, a filtration process is used. The filtration process consists in passing the aerosol through the filtering partitions, which allow the passage of air, but delay aerosol particles [4].

The filter enters the contaminated gas, the particles of the mixture settle on the inlet of the fibrous partition (filter element) and stay in the pores between the fibers, forming a layer on the surface of the partition. Filtering a dust stream through a layer of porous material is a complex process, similar to the effect of a screen, an inertial collision, and a Brownian diffusion, a grapheme that acts by gravity and electric forces [1, 3].

When the particle approaches the fiber, there are several mechanisms that can lead to its capture, namely [1, 2]:

1) touching;
2) inertia capture;
3) diffusion;
4) electrostatic precipitation;
5) thermophore;
6) gravitational sedimentation;
7) sieve effect.

The deposition of particles on the surface of the pores of the filter element occurs as a result of the effect of the coupling effect, as well as diffusion, inertia and gravity mechanisms. Dust at the filtration is mainly delayed as a result of collision of particles with fibers and filaments of filtration material and sputtering particles to fiber [1].

Contact. This is a process in which a particle is carried along a line of gas current to a thread or fiber. If the particle moves near the obstacle at a distance less than its radius, then it touches the obstacle and admires.

Inertia. The process when the particle is on the flow line, whichever it passes bypassing the obstacle, without touching it, but under the action of inertia, the particle proceeds from the original line. As a result, she faces an obstacle. The larger the particle, the greater its inertia, the better conditions for capture. At normal flow rates in filters this mechanism was effective for particles with a diameter less than a micrometer.

Diffusion. The particle is so small that its trajectory becomes chaotic through the Brownian motion. Capture can occur if a random deviation leads to a particle to the fiber. This mechanism becomes most important when the particle size is less than 0.1 μm [1].

Electrostatic precipitations. The particle and the obstacle have charges of opposite signs, resulting in a particle attracted to the obstacle.

Thermoferesis. The particle shifts to an obstacle under the action of the temperature gradient [5].

Gravitational deposition. The particle shifts from the flow line, and passes past the obstacle to the very obstacle under the action of attraction between the particle and the fiber or under the influence of earthly gravity. This effect is very small.

Sieve effect. The piece is delayed because it is very large to pass through the time or channel.

Possibilities of deposition due to the effect of the screen, especially when the flow passes through a clean cloth, are limited, since in most cases the size of the particles is much smaller than the pore size.

The filtration process in the most common fibrous filters can be represented as the movement of a particle near an insulated cylinder (from a fibrous material), which is located across the flow.

Passing through the filtering partition, the gas flow is divided into thin jets, continuously disconnecting and connecting tributaries. The particles that have inertia, try to move straight and collide with the fibers and keep them. It is believed that the flow has a non-vortex motion, and particles are spherical, particles in collisions with cylindrical fibers on their surfaces are delayed by intermolecular interaction.

The distance between the cylindrical fibers is more significant compared to the size of the particles.

When the flow of flow through the filter material gas envelopes fibers, larger dust particles under the influence of inertia forces retain the previous straight-line direction of motion, and when confronted with the fibers, admire and stick to them. Such a mechanism is characteristic for capturing large particles and manifests itself more strongly with an increase in the rate of filtration.

When one particle is deposited on an isolated fiber, the touch, inertia and diffusion are probably the most important mechanisms. Gravity and thermophore is usually not essential, electric forces can play a minor and very important role. The screen effect in this process does not work.

In the case of fabric filters, a significant part of the capture process takes place in a layer of particles that settle on the frontal surface of the filter. Conventional mechanisms - touch, inertia and diffusion, act only for a small part of the entire filtration cycle. As soon as the filter is cleaned a new layer of sediment is formed, the effect of the screen becomes the dominant mechanism [1, 2].

The size of the particles is important when gripping and trapped particles due to the touch of the surface of the streamlined body. If we neglect the inertial effects and assume that the particle follows precisely in line with the flow lines, then the particle stays not only in the case when its trajectory will intersect with the surface of the body, but also in the case of intersection of the line of flow at a distance from the surface of the body, equal to its radius. Thus, the efficiency of the coupling is greater than zero, and when there is no inertial deposition.

It is necessary to take into account that several lines of fiber are located on the path of the polluted stream, which significantly increases the overall efficiency of the settling.

The electrostatic grapple mechanism is manifested when the fibers carry charges or are polarized by an external electric field.

The determined influence on the filtration process may have electric forces, especially when using dielectric filtering fibrous materials from a mixture of wool and synthetic materials, as well as dielectric bulk materials.

As the particles are deposited on the filter material, the pore size decreases and the layer of dust with the pores is formed considerably less than in the dusty filtering material. Its own working layer during filtration is a filtered material with settled dust particles on it. He determines the effectiveness of cleaning. When deposition of dust increases the hydraulic resistance, decreases the productivity of the filter. When reaching some value, the resistance of the dust is periodically destroyed.

This process is called regeneration of the filter.

The hydraulic resistance of a layer of dust that is deposited can be determined by the formula of the Kozeny-Karman (Pa):

$$\Delta P = k_C \mu_0 v_0 G(1 - m_П)/\left(d_Ч^2 m_П \rho_Ч\right) \tag{2.9}$$

where k_C is the coefficient to be taken for a dust with a particle diameter with a value $d_ч < 6$ μm; G is the mass of the dust contained in the pores of the filtered material is attributed to the unit area of the filter, kg/m^2; $m_П$ is the porosity of the dust layer is equal to $m_П = (\rho_Ч - \rho_Н)/\rho_Ч$, here $\rho_Ч$ is a particle density, kg/m^3; $\rho_Н$ is a density of the bulk layer, kg/m^3; $d_Ч$ is a diameter of dust particles, m.

In real conditions, the process of precipitation of dust particles in the filters is accompanied by the coagulation of particles and the corresponding change in permeability of the layer, as well as the effectiveness of the filter. Due to the complexity of the process in the filters it is virtually impossible to determine the influence of all factors on the filtering parameters.

2.1.5. Wet gas cleaning

The process of wet dust collection is based on the contact of a dusty gas stream with a liquid that captures particles and removes them from the device in the form of a slurry.

Technological analysis, which leads to the development of models of operation of gas-cleaning devices, is based on representations about the mechanisms of processes. Mechanisms of processes are the main variants of gas-liquid contacts, in which the removal of particles from the gas occurs. There are such mechanisms of processes [1, 2]:

1) capture of liquid droplets moving through gas;
2) capture by cylinders;
3) capture of liquid films;
4) capture in gas bubbles;
5) capture when a gas stream is struck about a liquid or a solid surface.

With each hardware mechanism, the particles are separated from the gas by one or more trapping mechanisms: gravity sedimentation, centrifugal precipitation, inertia and tangling, Brownian diffusion, thermophorez, diffusion, electrostatic precipitations. The rate of precipitation can be increased by increasing the particle size as a result of agglomeration and condensation growth [1-4].

When a gas-dust stream flows round the liquid droplet, the trajectories of the motion of gas and dust particles diverge due to different values of the inertia force acting on the gas and on particles of different masses. Large particles, to a lesser extent than gas, change their direction when approaching a drop and settle on it. The scheme is close to the process of inertial and filtration settling of particles on fibrous filter elements, which have a cylindrical shape. This is explained by the fact that in these cases, the two-phase flow is considered and the forces of inertia are considered.

The efficiency of the inertial deposition of dust particles on a liquid droplet depends on the Stokes criterion. The action of inertia forces actually manifests itself in relation to particles that have a diameter greater than.

In addition to inertial deposition, there is a diffusion deposition on droplets, under the action of electrostatic forces.

2.1.6. Deposition of particles in an electric field

The deposition in solid and liquid gases under the action of an electric field has advantages over other deposition methods. The action of an electric field on a charged particle is determined by the magnitude of its electric charge. In the case of electrodeposition of particles of small size, it is possible to obtain a significant electric charge and, due to this, there is a process of precipitation of very small particles that can not be carried out by gravity or centrifugal force.

The principle of electric air purification from particles consists of charged particles, followed by their removal from the environment under the action of an electric field.

The physical nature of the electroposition is that the gas stream is ionized in advance, with the particles that are in this gas becoming an electric charge. Charging of particles in a corona discharge field occurs under the action of an electric field and as a result of diffusion of ions. The maximum value of the particle charge in excess of 0.5 μm is proportional to the square of the diameter of the particle, and particles with a size smaller than 0.2 μm - the diameter of the particles [1].

Under normal conditions, most of the gas molecules are neutral, that is, it does not carry an electric charge; Due to the action of various physical factors in the gas, there is always a certain number of electric charge carriers. Such factors include: strong heating, radioactive radiation, friction, bombardment of gas by fast moving electrons or ions.

Ionization of gas occurs in two ways [1, 2]:

1) independently, with a sufficiently high difference in the potentials on the electrodes;

2) independently - as a result of radiation of radioactive substances, X-rays.

In the industry, the electrospinning of suspended particles from the gas is carried out in such a way that the gas flow is directed into the tubular positive electrodes that are grounded. Inside the tubular electrodes, thin wire or rod electrodes, which are cathodes, are stretched [21].

If a voltage is created in the electric field between the electrodes, then the charge carriers, ions and electrons, receive a significant acceleration, and when they collide with the molecules, ionization of the molecules takes place.

Ionization consists in the removal of one or more external electrons from the orbit of a neutral molecule. As a result, the transformation of a neutral molecule into a positive ion and free electrons occurs [21].

As a result of shock ionization, ions and free electrons under the influence of the field also accelerate and ionize new molecules. Thus, the process has an avalanche character. However, with the distance from the crowning electrode, the intensity of the electric field is already insufficient to maintain high velocities, and the shock ionization process is gradually dampening [21].

Carriers of electric charges, moving under the action of an electric field, as well as the result of the Brownian motion, collide with dust particles suspended in a gas stream passing through an electrofilter, and transmit them an electric charge.

During ionization, both positive and negative ions are formed: positive ions remain near the "crown" near the cathode, and negative are directed at a faster speed to the anode, encountering and charging in their path suspended in the particle gas.

Most of the suspended particles that pass in the interoelectrode space receive a charge opposite to the sign of the precipitating electrodes, moves to these electrodes and precipitates on them. Some part of the dust particles that are in the sphere of the crown action, receives a charge opposite to the sign of the crowning electrode, and deposits on this electrode.

If the potential difference (4 - 6) kV / cm is created on the electrodes, and to ensure the current density (0.05 - 0.5) mA / m of the length of the cathode, then the pollinated gas, when passing between electrodes, is almost completely free of suspended particles.

To characterize the electric field, the physical value is used - the intensity of the field E. The tension in any point of the electric field is called the force with which this field acts on a single positive charge placed at that point.

The corona discharge occurs when the field strength is determined. This value is called critical tension and for the negative polarity of the electrode can be determined by the imperial formula:

$$E_{кр} = 3,04\left(\beta + 0,0311 \cdot \sqrt{\beta / r}\right) \cdot 10^{6} \qquad (2.10)$$

where r is an electrode radius; β is the ratio of gas densities in working conditions to gas in standard conditions ($t = 20^{0}C$, $p = 1{,}013 \cdot 10^{5}\,Pa$):

$$\beta = \frac{B \pm p_r\left(273+20\right)}{1{,}013 \cdot 10^{5}\left(273+t\right)}, \qquad (2.11)$$

here B is a barometric pressure; p_r is the amount of rarefaction or absolute pressure of gases; t is a gas temperature.

The formula (2.10) is designed for air, but with some approach it can also be used for flue gases.

The value of charge q, which is obtained by a conducting particle of a spherical shape under the action of an electric field, is calculated by the formula:

$$q = 3 \cdot \pi \cdot d_{\text{ч}}^2 \cdot \varepsilon \cdot E, \qquad (2.12)$$

where ε is a dielectric permeability of the medium; $d_{\text{ч}}$ is a particle diameter; E is the intensity of the electric field of the corona discharge. The amount of charge that an electric conductive particle acquires:

$$q = \frac{3\varepsilon_{\text{ч}}}{\varepsilon_{\text{ч}} + 2} \cdot \pi \cdot \varepsilon \cdot d_{\text{ч}}^2 \cdot E \qquad (2.13)$$

where $\varepsilon_{\text{ч}}$ is a relative dielectric particle permeability.

The boundary charge of a particle with a diameter of more than 1 μm is determined by the formula:

$$q_{\text{пред}} = n \cdot e = 0{,}19 \cdot 10^{-9} \cdot r^2 \cdot E, \qquad (2.14)$$

where n is a the number of elementary charges; e is the value of the elementary charge; r is a particle radius; E is a electric field strength.

Formula (2.14) is directly applicable if the dielectric constant of the dust substance is equal to 2.5.

Dust with low electrical conductivity causes the phenomenon of a reverse "crown", which is accompanied by the formation of positively charged ions, partially neutralizing the negative charge of particles, as a result, they lose the ability to move to the precipitating electrode and settle. The dust conductivity is influenced by the composition of gas and dust. As the humidity of the gases increases, the specific electrical resistance of the dust decreases. At high gas temperatures, the electrical elasticity of the inter-electrode space decreases, which leads to deterioration of dust trapping. In an electrofill, the charge of particles is very fast.

The velocity of motion of suspended particles, having received a charge, depends on the size of the particles and the hydraulic resistance of the gas medium. Deposition time can be found from the equation:

$$\omega_{\text{ч}} = \frac{\mathrm{dx}}{\mathrm{d}\tau}, \quad \tau_0 = \int_{R_1}^{R} \frac{dx}{\omega_{\text{ч}}}, \qquad (2.15)$$

where R is the distance from the axis of the electrode to the surface of the depositing electrode; R_1 is a electrode radius. The value $\omega_{\text{ч}}$ varies with a change in value.

2.1.7. Thermoferesis of aerosol particles

Termophoresis is called the phenomenon of repulsion of particles by heated bodies. It occurs under the action of forces from the side of the gaseous phase on the unevenly heated particles in it. The action of forces to a large extent depends on the ratio of the d_τ particle size to the average free path of gas molecules, ℓ_t [1, 2].

The thermophoretic force arises due to the fact that from the more heated side of the particle the molecule of the gas depart at a higher speed than from the less heated side, and thus transfer the momentum to the particles in the direction of lowering the temperature.

Termophoresis is not intended for industrial purposes. But the effect of thermofores we observe in practice. Yes, there is a dusting on the outside walls in front of the central heating equipment. It is undesirable to settle particles that are hanging in hot gases, on the cold walls of boilers and heat exchangers. The formed layer has low thermal conductivity, which leads to deterioration of the thermal characteristics of the apparatus.

A separate case of thermophorez is photophorezus, which occurs due to uneven illumination of the sides of the body, and, accordingly, their heating.

2.2. Cleaning of gas pollutants

Gas pollutants, like aerosols, pollute the atmospheric air, greatly impair its quality, and in some cases make it unfit for human existence in it [7].

As a result of the development of technology and the improvement of technological processes, new types of substances released into the atmosphere appear. At the same time, there is a modernization of existing and development of new types of technological equipment, in which complete sealing, automation, remote control is carried out. There is developing a non-waste technology, in which the elimination of harmful gases in the atmosphere, new methods of clearing air from harmful gases and vapors arise, new technological equipment is being developed and used, which includes integrated units for the destruction of harmful substances. All this gives hope that near the time when practically all technological processes will become waste-free [1, 2].

At cleaning of harmful substances from gas pollutants it is necessary to solve simultaneously a number of problems connected with the fact that harmful substances containing harmful vapors and gases also contain aerosols - dust, soot; harmful substances are in some cases heated to high temperatures, the pollutants contained in them are multicomponent, and they must be subjected to different methods of cleaning the consumption of harmful substances over time is unstable, changing the concentration of various harmful substances in them.

All of this, of course, complicates the purification, requires the adoption of appropriate decisions in each individual case.

2.2.1. Absorption of gas impurities

Some liquids and solids in contact with a multicomponent gas medium can selectively remove and absorb individual ingredients from it.

Absorption is the phenomenon of the transfer of components of the gas mixture in the volume of the condensed phase. At absorption there is a selective absorption of one or several components from the volume of the condensed gas mixture with liquid absorbers [1].

The reverse process, that is, the removal from the volume of the condensed liquid of absorbed gas molecules, is called degassing or desorption.

A substance that is in the gas phase and during absorption does not pass into the liquid phase, is called a carrier gas, the substance in which dissolving absorbable components occurs, is called solvent. A substance that is in the gas phase and when absorbed into a liquid phase, ie absorbed component, is called absorbent, absorbent in absorber volume absorber.

Absorbate is kept in absorbent, evenly distributed among its molecules, as a result of dissolution or chemical reaction.

The process, which ends with the dissolution of absorbent in the absorber, is called physical absorption. When physical absorption occurs, the physical dissolution of the absorbent component in the solvent occurs, while the absorbent molecules and absorption molecules do not enter into chemical interactions [1, 2].

Sometimes dissolved gas enters a chemical reaction directly with the solvent itself. The process, which is accompanied by a chemical reaction between the absorbent component and the absorbent, is called chemical absorption (hereinafter chemisorption). At chemisorption, the absorbent component enters a chemical reaction with the absorber, forming new chemical bonds in the liquid phase.

Absorption represents the process of chemical technology, including the mass transfer between the gas component and the liquid solvent that occurs in the apparatus for contacting the gas with the liquid. Apparatus in which the absorption process takes place are called absorbers.

The rate of absorption depends on a number of factors, mainly pressure and temperature. With increasing pressure and temperature, the absorption rate rises.

The process of reverse absorption is called desorption. If the conditions change, for example, there is a decrease in pressure above the liquid or a decrease in temperature, the process becomes reversed and there is a discharge of gas from the liquid.

Thus, a cyclic process of absorption-desorption may occur. This allows you to highlight the absorbed component.

Using absorption and desorption, it is possible to use almost always without loss the liquid absorber in the closed circuit of the apparatus: an absorber-desorber-absorber (cyclic process), isolating the absorbed component in its pure form [1, 2].

Absorption cleaning of harmful substances in the atmosphere is used to remove the valuable component from the gas, and for sanitary purification of gas. Absorption is the most common process of purifying the gas mixture in many industries.

For a more complete removal of the component from the gas mixture during physical absorption, the principle of counterflow with a continuous feed into the fresh solution absorber must be used. For repeated use, the sink is regenerated, while absorbent is removed from it, which is sold as raw material for other processes or the target product product.

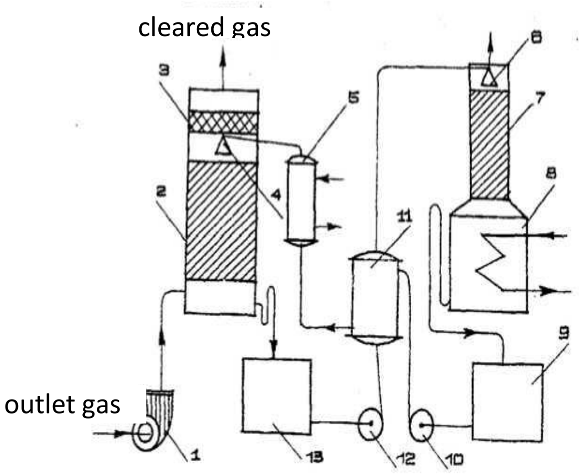


Fig. 2.1. Scheme of absorption unit [1]:
1 - fan; 2 - absorber; 3 - a birdman;
4.6 - irrigation systems; 5 - a refrigerator; 7 - desorber;
8 - desorber cube; 9,13 - Absorbent capacity; 10,12 - pumps;
11 - heat exchanger-recuperator

If the removed component does not represent any value or the regeneration process is associated with great difficulty, the sink is used once and after the appropriate treatment is drained into the sewage system. The diagram of the absorption unit is shown in Fig. 2.1.

The absorption system may be simple, in which the liquid is applied only once and is removed from the system without separating absorbed contamination. In another variant, the contamination is separated from the absorbing liquid, isolating it in its pure form. Then the absorbent is again fed to the absorption stage, re-regenerated and returned to the system. Regeneration of sinks is carried out by physical methods: increase in temperature, decrease in pressure or together specified parameters. Apart from the regeneration of the absorbent by means of evaporation (desorption) removal of absorbed contaminants by settling and settling, by their chemical destruction as a result of neutralization, oxidation, reduction or hydrolysis, as well as by extraction, liquid adsorption and other methods, is possible [1, 2].

2.2.2. Solutions of gases in liquids

By its nature and properties of solution of gases in a liquid do not differ from other liquid solutions. Usually the concentration of gases in them is insignificant, and the solutions are dissolved. Exceptions are systems in which the solubility of gases is very significant due to their chemical interaction with a solvent, for example, ammonia or hydrogen chloride with water. The solubility of gases, regardless of the type of gas and solvent, depends more heavily on temperature and pressure [1, 2].

The influence of pressure at not too high its values is quite well expressed by Henry's law: at a constant temperature, the solubility of gas in a solvent is directly proportional to the pressure of this gas over the solution. As a rule, the dissolution of gases in water occurs with the release of heat and with a decrease in volume, so in accordance with the principle of Le Chatelier with increasing temperature, their solubility decreases.

But in some cases, when the solubility is accompanied not by the release, but by the absorption of heat, the increase in temperature leads to an increase in the solubility of the gas.

The phenomenon of dissolution of gases in a liquid is used in various processes, namely, in absorption methods for the purification of gases leaving industrial enterprises, for saturation and for the removal of individual particles of the gas mixture with liquid absorbers. The use of absorption is particularly effective at significant concentrations of gas contaminants. The use of solvents is possible even at low concentrations, when the solubility of gas in the liquid is very high.

Very often water is used as a solvent. To absorb gases that are poorly soluble in water, it is possible to use tiny solvents with low vapor pressure, for example, carbohydrates.

As an absorbent, you can use any liquid that dissolves the removed component. For application on an industrial scale, the absorbent must meet a number of requirements, including: absorbing capacity (absorbent capacity), high selectivity with respect to the absorbent component, low volatility, low viscosity, regeneration capacity, thermochemically stable, no corrosion activity , affordability and low price. It is desirable that the absorbent solution has a boiling point higher than water.

Since there is no absorbent suitable for all needs, they stop at the absorber that satisfies a particular condition.

Physical absorption usually uses as an absorbent water, as well as organic solvents and in organic, which do not react with the withdrawn components and their aqueous solutions.

Water is a cheap and affordable absorbent for cleaning large volumes of gas. As absorbents for the cleaning of harmful substances in practice only drip fluids are used. The choice of absorbent depends on a number of factors; the main among them is the ability to absorb pollutants from the gas phase.

At chemisorption as an absorbent, aqueous solutions of salts, organic substances and aqueous suspensions of various substances are used. When using water, absorbable gas should dissolve sufficiently well in it at a given temperature in the gas-liquid system.

It is inappropriate to use water for cleaning harmful substances with insoluble organic mixtures in it. Such pollutants are generally well absorbed by organic liquids, which can be used as absorbents, that is, substances that have a high boiling point and ethanolamines and heavy carbohydrates (mineral oils).

Absorption with an organic solvent is more effective for the removal of organic gaseous pollutants, because in this case, good solubility is provided. Before treatment with an organic absorbent from harmful gases it is necessary to remove disperse mixtures, otherwise the absorbent is quickly polluted and becomes a waste, and the purification is practically not exposed [1].

Organic absorbents should have low vapor pressure at the process temperature. Solvents with insufficiently low elasticity of vapor will intensively evaporate and pollute the treated gases. In addition, an absorbent that has a low boiling point is difficult to regenerate, as it is not possible to remove the capture material by heating [2].

The intensity and intensity of the transition of a pollutant from the gas phase to the liquid is strongly influenced by the temperature and pressure of the process, as well as the way of organizing the contact of the phases. With increasing pressure and lowering the temperature, the absorption rate increases. Absorbents, which work at negative temperatures, are called coolers, and the absorption process, which occurs in such conditions - contact condensation.

2.2.3. Equilibrium in the processes of absorption

The transfer of components in phases that are close to each other, to achieve a dynamic equilibrium between them. The phenomenon that occurs at absorption at the interface between the phases is described on the basis of the two-film theory of Whitman, according to which the change in the concentrations of the transition substance occurs in the thin near-surface layers of the film of gas and the condensed matter [2].

It is believed that there is no convection in the boundary films, and the mass transfer is carried out solely by molecular diffusion, while the transfer from the volume of gas to the film and from the film into the volume of the condensed phase takes place very rapidly (due to turbulent diffusion). Therefore, the concentration of the transition component in the volume of the gas phase and in volume are considered constant.

Carrying continues until equilibrium, in which the chemical potentials of the transition component in the gas and condensed phases are aligned.

Thus, the state of equilibrium is a moment in the mass transfer process in which the transition rates of matter from one phase to another and back are equal. But this does not mean equality of concentrations in phases. At absorption purified gases, the concentration of trapped mixtures is usually small, which makes it possible to consider the system as weakly concentrated. Concentrations corresponding to the equilibrium of phases, that is, equilibrium concentrations in the gas and condensed phases, for such systems are sufficiently precisely determined by the laws of Raoul and Henry [1, 2].

With increasing temperature, the solubility of gases in liquids decreases. It is convenient to analyze and calculate the absorption process, expressing the concentration of the distributed gas in relative units, as in this case, the estimated values of streams of gas and liquid phases of steel.

The factors that improve the solubility of gases in liquids include increased pressure and lowered temperatures, and factors that contribute to desorption-lowered pressure, increased temperature and the addition of additives to the absorbent, which reduce the solubility of gases in liquids.

If the absorption is carried out without heat dissipation or with its incomplete discharging, the process temperature rises due to the removal of heat when dissolved gas in the liquid.

2.2.4. Material balance of absorption

Given the number of components in the phases of the equation of the material balance will be written in the form [1]:

$$G_H \cdot y_H + L_H \cdot x_H = G_K \cdot y_K + L_K \cdot x_K \tag{2.16}$$

where G_H, G_K - flow of the gas phase at the entrance to the absorber and exit from it; x_H, x_K - the concentration of the distributed component in the liquid phase at the entrance to the absorber and the exit from it; L_H, L_K - consumption of absorbent at the outlet to the absorber and exit from it; y_H, y_K - the concentration of the distributed matter in the gas phase at the inlet and outlet of the absorber.

$$G(Y_1 - Y_2) = L(X_1 - X_2), \tag{2.17}$$

or

$$G(Y_H - Y_K) = L(X_H - X_K), \tag{2.18}$$

where G - consumption of inert gas; L - absorbent consumption; Y_H i Y_K - relative concentrations of components in a carrier gas; X_H i X_K - relative concentrations of components in the absorber. Equation (2.17), (2.18) is the equation of the material balance.

Total absorbent consumption is equal [1]:

$$L = G(Y_H - Y_R)/(X_K - X_H). \tag{2.19}$$

Determine the specific consumption of the sink:

$$\ell = L/G. \tag{2.20}$$

The degree of seizure is the ratio of the amount of the actual absorbed component to the amount absorbed with the complete seized:

$$\varepsilon = G(Y_1 - Y_2)/(G \cdot Y_1) = 1 - \frac{Y_2}{Y_1} \tag{2.21}$$

The moment in the process of absorption, when the working line touches the line of equilibrium, corresponds to the minimum consumption of the sink. At the point where the working line touches the line of equilibrium, the moving force is zero. This requires an absorber of infinitely large height. With the increase in the specific consumption of the sink decreases, we need the height of the absorber, but the cost of desorption increases, and the absorption of the absorber increases. The optimal specific consumption of the absorber is determined by technical and economic calculations.

At absorption, the working line is located above the equilibrium line, because in this process the presence of a component in the gas phase is greater than that of equilibrium. On desorption, on the contrary, the working line is below the equilibrium line.

2.2.5. Mass transfer in the process of absorption

Let the concentration of the distributed substance in the G-phase of higher equilibrium, and the substance moves from G-phase to L-phase, the distributing substance in the G-phase is transferred to the phase separation surface, and in L-phase it is transferred from this surface [1].

The mass transfer in both phases is carried out by molecular and convective diffusion. Molecular diffusion is the diffusion of molecules through the carrier layer. Convection diffusion is the diffusion of the particles of the moving medium and of the distributed matter. In the main mass of the phase, that is, the nucleus of the phase, where it is usually intense mixing, the transfer of matter occurs by means of convective diffusion.

The transfer of matter in the boundary layer occurs by means of convective and molecular diffusion, and, as the surface of the phase separation approaches, the damping of convective flows occurs and the role of molecular diffusion increases. The molecular diffusion equation has the following form:

$$M = D \cdot F \cdot \Delta c_{сл} \cdot {}^{\tau}\!/_{\delta} \qquad (2.22)$$

where M - amount of component diffusing through a substance layer; - diffusion coefficient; F - surface of the layer; $\Delta c_{сл}$ - change in the thickness of the layer; τ - duration of the process; δ - layer thickness. Equation (2.22) s a mathematical expression of Fick's law.

The diffusion coefficient D depends on the properties of the diffusing component and the medium in which diffusion occurs, as well as on the temperature and pressure of the process.

The diffusion coefficients in liquids are much lower than in gases. The equation of convective diffusion has this form:

$$M = \beta \cdot F \cdot \Delta c_{ф-сл} \qquad (2.23)$$

where M - the amount of substance that is transferred from the phase giving the substance to the phase separation surface; β is a coefficient of mass return; F is a phase separation surface; $\Delta c_{ф-сл}$ is a the concentration difference of the distributed substance in the phase and on the partition surface.

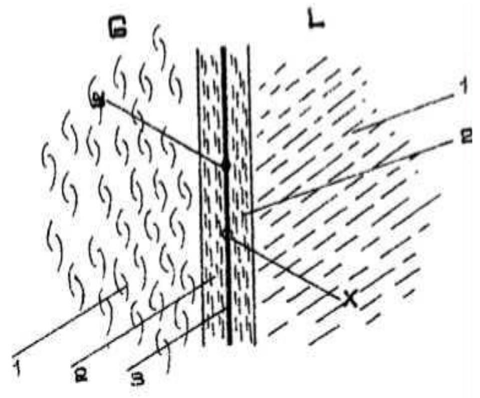


Fig. 2.2. Scheme of mass exchange process between liquid and gas:
1 is the core of the phase, 2 is the boundary layer, 3 is the phase separation surface.

Masoud coefficient depends on the hydrodynamic, physical and geometrical factors and is determined experimentally from the data processing with the help of similarity theory [1].

The mass transfer equation has the following form [1]:

$$M = K \cdot F \cdot \Delta \qquad (2.24)$$

where M - the amount of substance that moves from one phase to another; K - mass transfer factor; F - surface of collision of phases; Δ - the mobile force of the mass transfer process.

From equation (2.24) it is seen that the mass transfer coefficient expresses the amount of substance that passes from one phase to another per unit time through the unit of the collision surface at a moving force equal to one.

Sometimes, the mass transfer ratio is one unit of the working volume of the device.

The application of the theory of similarity to the processes of mass transfer showed that the processes are determined by the Reynolds criterion R_e and the diffusion criteria of Nuselta Nu' and Prandtl Pr', which are analogous to thermal criteria Nu' and Pr'.

Criteria R_e and Pr' are defining, a criterion Nu' is definite. The relationship between the criteria is expressed in general terms by the equation:

$$Nu' = f\left(\mathrm{Re}, \mathrm{Pr}'\right). \qquad (2.25)$$

By the calculated value Nu' the coefficient of mass deductibility β the coefficient of mass deductibility is calculated is calculated.
Below are the values of the diffusion criteria and the Reynolds criterion:

$$Nu' = \beta \cdot \ell / D \qquad (2.26)$$

$$\mathrm{Pr}' = \mu / \left(\rho \cdot D\right) \qquad (2.27)$$

$$R_e = w \cdot \ell \cdot \rho / \mu \qquad (2.28)$$

Here β is the coefficient Masoud; ℓ is the defining geometric size; D is the coefficient of diffusion; μ is the dynamic viscosity; ρ is the density; w is the speed [1, 2].

2.2.6. Kinetec of absorption

The moving absorption force is the difference between the partial pressures of the dissolved gas in the gas mixture and its equilibrium pressure over the film of the liquid in contact with the gas. Absorption occurs if the partial pressure of the absorbent component in the gas phase is greater than the equilibrium partial pressure of the same component over the given solution. The greater the difference between these pressures, the greater the moving force and the more absorption takes place at a higher rate [1, 2].

If the value of the mobile force is not a positive number, then the absorption process does not occur. If the value is negative, then the desorption process takes place, and the amount of pollutants in the treated gas may increase.

The rate of absorption during the transfer of matter from one phase to another is determined by the mass transfer equations [1]:

$$M = K_y \cdot F \cdot \Delta Y_{cp}; \; M = K_x \cdot F \cdot \Delta X_{cp} \qquad (2.29)$$

where K_y and K_x is the coefficients of mass transfer over gas and liquid phases; F is the phase contact surface; ΔY_{cp}, ΔX_{cp} is the the average moving force, respectively, in the gas and liquid phase.

To determine the absorption rate, it is necessary to know the moving force of the process, which is expressed by the difference in the concentrations of the component in one of the phases and in equilibrium concentration, that is, [1]:

$$\Delta Y_{cp} = Y - Y^*; \qquad (2.30)$$

$$\Delta X_{cp} = X^* - X. \qquad (2.31)$$

The bigger the difference, the faster the process proceeds. It varies with the height of the machine and depends on many factors, including the nature of the motion of the phases.

The concentration of the gas and liquid phase changes with the motion of the phases along the surface of their collisions; as a result of this usually changes along the surface of the collision and the moving force of mass transfer. In the calculations use the average value of the mobile force.

The average moving force of the mass transfer process can be calculated as the mean integral, mean logarithmic or mean arithmetic value of the moving forces at the input to the apparatus and at the output.

In the course of the chemical reaction in the liquid phase, the absorbable component reacts with the absorber. In this case, the gradient of concentrations increases near the surface of the separation, and, in comparison with physical absorption, the rate of absorption increases.

The coefficient of acceleration of absorption in the liquid phase during the course of a chemical reaction is equal to:

$$k = \beta'_{жс} / \beta_{жс}, \qquad (2.32)$$

where $\beta_{жс}$ and $\beta'_{жс}$ is the coefficients of mass deducing in the liquid phase for physical absorption and chemisorption.

The coefficient of acceleration depends on the speed of the chemical reaction and the degree of fluid turbulence. As the chemisorption proceeds, the coefficient of mass transfer in the liquid phase $\beta'_{ж}$ decreases, which complicates the calculations of the mobile force sufficiently [1].

In the case of absorption, which is accompanied by a chemical reaction, there is a superficial convection, which greatly accelerates the mass transfer process.

2.2.7. Processes of absorption

In the practice of absorption, several basic schemes of the process are used. Often, direct-current and anti-flow diagrams are used. In the flow-through pattern of absorption, the flows of gas and absorbent move in parallel to each other. In this scheme, the interaction of substances in the process of absorption of gas with a higher concentration of the distributed substance y_H is brought into contact with a liquid having a lower concentration x_H of the distributed substance, and a gas with a lower concentration interacting at the outlet of the apparatus with a liquid having a higher concentration x_K of the distributed substance. In the case of an explosive absorption scheme at one end of the apparatus contact gas and liquid, which have large concentrations of the distributed substance y_H and x_K, at the opposite end, are smaller y_K and x_H.

Consequently, the countercurrent process provides a large final concentration of absorbed gas in the absorbent and, together with this, we obtain lower absorbent costs.

By using an anti-flow diagram, it is possible to achieve the complete removal of the component from the gas mixture, than with a straight-flow circuit. In the absorption technique, one-stage circuits with recirculation and multi-stage recirculation, which involve multiple returns to the apparatus or liquid or gas, are also used.

In the circuit with liquid recirculation, the gas passes through the apparatus from the bottom up, and the concentration of the distributed matter in it varies. The absorbing liquid is brought to the upper part of the apparatus at concentration of the distributed substance, then it is mixed with the liquid, which is withdrawn from the apparatus, resulting in increased concentration. Recirculation schemes can be counter-current and direct-flow.

In the scheme of recirculation of the absorber at one and the same amount of fresh absorbent the amount of liquid passing through the device, more. The result of this phenomenon is an increase in the coefficient of mass deducing by increasing the coefficient of mass transfer in the liquid phase and some reduction of the mobile force, which can lead to a decrease in the dimensions of the apparatus. Liquid recirculation always has the advantage, if necessary, to accompany the cooling absorption process, because in this case switching on the refrigerator in the branch of the recirculating absorbent allows it to easily remove heat from the interacting substances.

Multistage circuits with recirculation can switch on direct current, countercurrent, gas recirculation. Of great practical importance is the multi-stage counterflow circuit with fluid recirculation in every degree. Multi-stage circuits with gas and liquid have all the advantages of single-stage schemes and at the same time provide a large moving process force [1].

2.2.8. Adsorption of gas impurities

Adsorption is called the process of selective absorption of a gas component, a pair, or a solution using absorbents - porous solid materials with a large specific surface [1, 2].

The absorption processes are selective and reversible. Each squirrel has the ability to absorb only prominent substances and not absorb others.

The absorbent substance can always be isolated from the absorber by desorption.

In contrast to absorption methods, adsorption allows for the purification of gases at elevated temperatures. By the nature of the interaction of adsorbate with the surface distinguish physical and chemical adsorption.

In the physical adsorption between the adsorbent molecules and the molecules of the adsorbed substance there is no chemical interaction. The process of physical adsorption can be reverse, that is, alternating stages of adsorption and desorption (allocation of the absorbed component from the adsorbent).

Physical adsorption is determined by the forces of intermolecular interaction. The intermolecular forces are weak, therefore, in the case of physical adsorption, only a small deformation of adsorbed particles occurs. This type of adsorption is a purely physical process with an activation energy of about 4-12 kJ / mol. In the case of physical adsorption, the absorbed molecules of gases and vapors are held by Van der Waals forces, with chemisorption, by chemical forces.

In the case of chemical adsorption, the adsorbent and adsorbent molecules chemically interact. Desorption is practically not carried out. At chemical adsorption a considerable amount of heat is allocated, than at physical adsorption.

Chemical adsorption (chemisorption) is carried out at the expense of the unsaturated valence forces of the surface layer. In this case, surface chemical compounds can be formed, properties and structure of which have not yet been studied. It is only known that they differ from the properties of bulky compounds. In the formation of superficial compounds, it is necessary to overcome the energy barrier, which is usually 40.100 kJ / mol. Since chemisorption requires significant activation energy, it is sometimes called activated adsorption. In physical adsorption, the interaction of molecules with the adsorbent surface is determined by comparatively weak forces (dispersive, inductive, orientational). Physical adsorption is characterized by high velocity, low elasticity of the bond between the surface of the adsorbent and the adsorbent, the small heat of adsorption (up to 60 kJ / mol).

The basis of chemical adsorption is the chemical interaction between the adsorbent and the adjuvant. The forces in this case are much larger than in the physical adsorption, and the heat that is released coincides with the heat of the chemical reaction. The quantities of chemical and physical adsorption with increasing temperature decrease, however, at a certain temperature, physical adsorption can jump-start to activated.

At adsorption, very high absorption rates and complete removal of components are possible, removal of which by adsorption would be impossible due to their low concentration in the mixture.

Adsorption is used to clean gases with a low content of gaseous and vaporous contaminants to obtain their very low volumetric concentrations. Adsorption continues to be the main method of purification of technological gas contaminants.

However, the possibilities of the adsorption process are far from exhausted. In some cases, it can be used to create a new generation of treatment systems that will satisfy not only sanitary norms, but also economic needs. For example, adsorption can be applied in two-stage purification schemes for pre-concentration of highly dissolved organic pollutants, which then fall on heat treatment. Thus, the concentration of pollutants in ventilation contaminants can grow tenfold. Adsorption can proceed in a stationary layer, in a layer which moves (moves), in a layer of an adsorbent which boils [1, 2].

2.2.9. The theory of adsorption. Adsorbents

The ability of surface particles of condensed bodies to attract and retain gas molecules is due to the excess energy on the surface and is inherent in all solids and liquids [1, 2].

The amount of adsorbate contained on the unit plane of the phase of the interface surface is ultimately determined by the interaction power between the molecules of the adsorbed substance and the particles in the near-surface layers of the adsorbent.

Due to the constant oscillation of charge centers of atoms near the middle position, dipole, quadrupole, and higher multipole moments occur continuously and disappear. They form a pulsating electric field in the space around atoms, the characteristics of which can be calculated in the simplest cases by the equations of quantum mechanics.

The forces that arise in the interaction of the quantum electric fields of particles that take part in the adsorption process are called Van der Waals or dispersion forces. The dispersion forces act on the boundary of the phase separation and are similar to the forces of interaction between molecules in the volume of gas, which cause the deviation of the characteristics of real gases from the ideal.

According to quantum mechanical calculations, the Van der Waals forces sharply decrease with increasing distance between the charge centers of the interacting particles and a few orders of magnitude weaker than the volumetric forces that create the chemical bond. However, unlike volumetric forces, dispersion can operate at relatively large distances and is characterized by unsaturation.

It is believed that the dispersion interactions of the generalization of electrons does not occur, and the chemical bond is not formed. One of the two limiting adsorption models, considering that when the gas molecules are retained on the surface of the adsorbent, there is no electronic exchange and the formation of a chemical bond, called physical adsorption or simply adsorption.

Another model of adsorption is the formation on the surface of the chemical bond between the gas molecule and the particle adsorbent. Such a model is called chemical sorption or chemisorption.

The energy of interaction in the process of chemisorption is close to the energy of the chemical bond of the molecule, which consists of the corresponding elements. For theoretical calculations of the energy of the chemisorption process, the Schrödinger equation is used.

Adsorbent is a solid on the surface and in the pores of which adsorption occurs. Adsorbents are high porosity, have a large specific surface.

The adsorbent must have a high sorption capacity, that is, the ability to absorb a large amount of adsorbent at its low concentration in the gas medium, which depends on the specific surface area and the physical and chemical properties of the surface particles.

The adsorption capacity of the adsorbent depends on its nature. It increases with increasing surface, porosity, with decreasing pores pore size of the adsorbent, as well as with increasing adsorption concentration in the carrier gas and pressure in the system. As the temperature and humidity rise, the adsorption capacity of the adsorbents decreases. Adsorbents withstand several hundreds and thousands of cycles of "adsorption-desorption" without significant loss of activity.

The adsorbent must have high selectivity with respect to the adsorbent component. And also for the process of physical sorption should be chemically inert with respect to components that clean the gas environment, and for chemical sorption - to enter the molecules of pollutants in a chemical reaction. To reduce the cost of desorption of cemented components, the holding capacity of the adsorbent should not be very high, that is, it should be able to regenerate. Adsorbents should not be expensive and made from accessible materials.

Adsorbent with large pores is better adsorbed substance with large molecular sizes and at high pressures. The middle porous adsorbent adsorbs more efficiently at medium pressure, and is slightly porous - at low pressures.

Activated carbon is a porous hydrocarbon adsorbent. Several grades of activated carbon are used, which differ in the size of micropores.

Silica gel is a synthetic mineral adsorbent. Used to absorb moisture.Its advantage over activated carbon is incombustibility, low temperature of regeneration, low cost in mass production, relatively high mechanical strength.

Alumogel is an active alumina. Alumogel () is obtained by calcining aluminum hydroxides. Alumogels are resistant to droplet moisture. Hydrophilic adsorbent with a developed porous structure. It is used, like silicagel, to drain gases and to absorb a number of polar organic substances from them. Due to its positive properties it is widely used.

Zeolites are aluminosilicates containing alkali and alkaline earth metal oxides. Characterized by a regular structure of pores, the size of which is equal to the size of the molecules. This adsorbent is called a "molecular sieve" for its ability to separate matter at the molecular level due to the structure and size of its pores. Zeolites adsorb gases whose molecules correspond to the size of "windows" in a crystalline lattice. However, from the damp streams of zeolites, only steam is removed from the water. Zeolites also have high selectivity [1, 2].

Ionites are high molecular weight compounds of natural and artificial origin. Not yet widely used for purification of harmful gases.

The only adsorbent that works in humid environments is activated carbon. It satisfies most of the other requirements, which is why it is widely used.

One of the main disadvantages of activated carbon is chemical instability to oxygen, especially at elevated temperatures. Other adsorbents exhibit, as a rule, selectivity to capture contaminants. Most polar adsorbents can be used to dry gases. For the processes of chemisorption, the impregnation of some of these sorbents is used. Impregnating (impregnating) substances can act in two ways: to react with certain pollutants or to catalyze reactions leading to their neutralization - decomposition, oxidation, etc.

2.2.10. The mechanism of the adsorption process

Adsorption phenomena develop on the boundary of a solid or liquid phase with another liquid phase or gas. The adsorption on the surface of solid particles is the most practical [1].

When passing the gas flow through adsorbent, at first only a layer of H0 height takes part in the work, in which the initial concentration of the withdrawn substance is reduced to zero (working layer or mass transfer zone). In the calculations of adsorbers with a fixed adsorbent, a model of an adsorption wave is widely used, which is based on such assumptions. It is believed that at the beginning of the process, the lower layer of the adsorbent in the thickness h0 (Fig. 2.4) is rapidly saturated to a state close to the equilibrium.

Concentration of pollutants as the passage of harmful gases through the subsequent layers of the adsorbent is reduced by some law, expressed graphically by curve 1, and at a certain height h_1 is zero. Then pure gas is filtered through a layer of pure adsorbent in height ($H - h_1$). After some time, the saturation wave of the adsorbent reaches its height h_2, and harmful gases are completely released from the pollutants at a height H, that is, at the outlet of the layer of adsorbent (curve 2).

The process of adsorption is discontinued when the concentration of pollutants in harmful gases at the outlet of the layer reaches a predetermined value of the breakthrough П (curve 3). At the same time, the saturation wave reaches the height h3 and is directed to regeneration.

At adsorption, a "jump" of a component may occur when the adsorbent ceases to absorb it. Under the activity of adsorbent is understood its ability to absorb substance. Adsorbents are characterized by static and dynamic activity.

Dynamic activity of the adsorbent is the amount of substance absorbed by the unit of weight (volume) of the adsorbent during the time from the beginning of adsorption to the start of the jump.

The static activity of an adsorbent is the amount of substance that is absorbed by the same amount of adsorbent from the beginning of adsorption to equilibrium.

Dynamic activity is always less than static, so the consumption of adsorbent is determined by its dynamic activity.

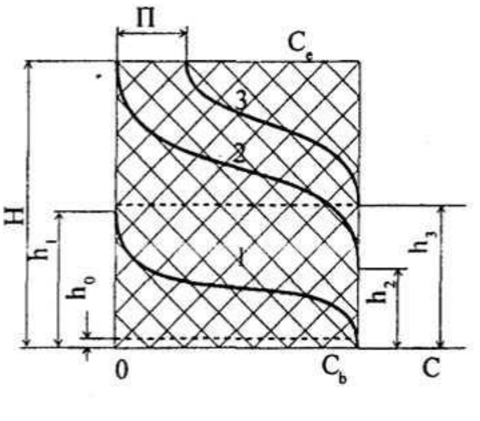


Fig. 2.4. The "adsorption wave" model

The activity of the adsorbent depends on the size of the adsorption apparatus, the efficiency of gas cleaning.

The process of adsorption for a certain time proceeds at a constant value of the absorption rate of the adsorbed substance. This time is called the time of the protective action of the layer of adsorbent [1].

2.2.11. Equilibrium with adsorption

The process of adsorption is

accompanied by the release of heat, so reducing the temperature contributes to its carrying.

Regardless of the nature of the adsorption forces, the following factors influence the amount of adsorption: the nature of the substance being absorbed; temperature; pressure; impurities in the phase from which the substance is absorbed [1, 2].

The nature of the absorbing substance - it is assumed that the equilibrium concentration in the adsorbent is the higher, the greater the molecular weight of the absorbing gas, and in the case of solutions - the less solubility of the absorbing substance in the liquid.

As the temperature increases in other equal conditions, the equilibrium concentration decreases [1].

As the pressure in the vapor phase increases, the equilibrium concentration increases.

In the presence of a phase in which the adsorbent absorbs substance A, competing substance B, that is, a substance that has the ability to absorb this adsorbent, the equilibrium concentration of substance A in the adsorbent decreases. In this case, the substance B or partially or completely extrinses or replaces substance A in the adsorbent.

Over time, adsorption results in an equilibrium, in which a definite relationship between the concentration of the adsorbed substance and its concentration in the gas phase is established:

$$X = A \cdot Y^{1/n}, \qquad (2.33)$$

where Y is an equilibrium concentration of the inert portion of the gas mixture; A, n is coefficients determined by experimental way.

The dependence (2.33) of the adsorption of the target component under conditions of equilibrium between phases at a constant temperature is called an isotherm of adsorption.

Equation (2.33) can be represented in a different form (because the concentration of the component in the gas mixture at constant temperature is proportional to its pressure):

$$X = A_1 \cdot P^{1/n}, \qquad (2.34)$$

where A_1 is a coefficient; P is an equilibrium pressure of the absorbing substance in the gas-vapor mixture.

Adsorption accelerates when the temperature decreases or when pressure is high. These same factors influence the process of desorption in the opposite direction.

Desorption is accelerated with an increase in the temperature of the adsorbent and the reduction of pressure, as well as through adsorbent of vapors displacing the absorbed substance.

At high temperatures or small partial pressures, the isotherms of adsorption are approximated by Henry's law:

$$a^* = A_p \cdot p\,, \tag{2.35}$$

where a^* is an amount of absorbed substance; A_p is a constant phase equilibrium; p is a partial pressure of the component in the gas.

On the absorbed molecule from the surface of the adsorbent, the force of gravity is proportional to the adsorption potential:

$$E = R \cdot T \cdot \ln \frac{p_s}{p} \tag{2.36}$$

A significant deviation from the actual characteristics of adsorption is the assumption of the isothermal process. Adsorption can be isothermal only with the proper organization of heat transfer from the condensation zone. In other cases, the heat released during condensation of adsorbate and wetting of the surface of the adsorbate will go on heating the processing gas and adsorbent particles [1].

2.2.12. Material balance of the adsorption process

The adsorption processes are carried out periodically or, if the adsorbent moves through the apparatus, continuously. The material balance of such a process is expressed by the equation common to all processes of mass transfer:

$$GdY = LdX\,, \tag{2.37}$$

where G is a consumption of the steam-gas phase or solution; L is a consumption of adsorbent; Y is the working concentration of adsorbent substance in the vapor phase or solution; X is working concentrations of the adsorbed substance in the adsorbent. Adsorption in a layer of a fixed adsorbent is a periodic process in which the concentration of the absorbent in the adsorbent and in the vapor phase changes over time and in space.

The total material balance of the sorbing substance in the element in time $d\tau$ without taking into account the longitudinal mixing of the gas stream is expressed by the equation:

$$-w\frac{\partial C}{\partial z}Sdzd\tau=\frac{\partial\bar{a}}{\partial\tau}Sdzd\tau+\varepsilon\frac{\partial\bar{C}}{\partial\tau}Sdzd\tau\,, \tag{2.38}$$

or final equestion:

$$\frac{\partial\bar{a}}{\partial\tau}=-\varepsilon\frac{\partial\bar{C}}{\partial\tau}-w\frac{\partial\bar{C}}{\partial z}\,. \tag{2.39}$$

The equation (2.38) are called the differential equation of the material balance of the periodic adsorption process in the layer of a fixed adsorbent.

2.2.13. Adsorption kinetics

The adsorption process consists of successive stages of diffusion of the absorbing molecule from the gas stream to the outer surface of the adsorbent (external diffusion), the permeability of the molecules inside the porous sinter (internal diffusion), and the sorption (condensation) of the molecules on the inner pores of the pores [1, 2].

The mechanism of a particular diffusion process is determined on the basis of studying the dependences of diffusion coefficients on pressure, temperature, molecular masses of the absorbing substance and gas carrier. The equation of adsorption kinetics:

$$\frac{da}{d\tau}=\beta_0\left[C-C^*(a)\right]\,, \tag{2.40}$$

where β_0 is a mass transfer coefficient, which is expressed in terms of coefficients of outside β_1 and inside β_2 mass transfer

$$\frac{1}{\beta_0}=\frac{1}{\beta_1}+\frac{1}{\beta_2}+\frac{D^*}{w^2} \tag{2.41}$$

where D^* is a coefficient of longitudinal diffusion; w is a gas flow rate.

Distinguish stationary and nonstationary adsorption processes. In a stationary process, the concentration of adsorbate in each point of the absorber layer has become continuous. In the practice of sanitary gas purification, the most common non-stationary periodic processes.

The required height H of the absorber layer can be calculated according to the general mass transfer equation:

$$w_0 \cdot dc = \beta_0 \left(c - c^* \right) \cdot dH \, , \tag{2.42}$$

where the height of the layer equals

$$H = \frac{w_0}{\beta_0} \int_{c_k}^{c_0} \frac{dc}{c - c^*} = h_n \cdot n_y \, , \tag{2.43}$$

where $h_n = \dfrac{w_0}{\beta_0}$ is a transfer unit; n_y is a number of transfer units.

The number of transfer units is determined by the formula

$$n_y = \int_{Y_K}^{Y_H} \frac{dy}{\left(Y - Y^* \right)} \, , \quad n_x = \int_{X_K}^{X_H} \frac{dx}{\left(X^* - X \right)} \, . \tag{2.44}$$

Equations (2.44) are usually explained by the method of graph integration. The isotherm of adsorption is based on experimental or reference data.

If the isotherm of adsorption is unknown, it can be constructed using an isotherm of adsorption of a standard substance. As a standard substance benzene usually comes in.

The duration $\tau(c)$ of the adsorption process is determined from the type of adsorption isotherm.

1) If the isotherm of adsorption is expressed by a linear dependence (in the first region of the adsorption isotherm), then the adsorption isotherm approximates the Henry law:

$$\tau^{1/2} = \left(\frac{X^* \cdot H}{w_r \cdot Y_H} \right)^{1/2} - b \left(\frac{X^*}{\beta_y \cdot Y_H} \right)^{1/2} \, , \tag{2.45}$$

where Y_H is an initial concentration of adsorbed substance in the vapor-gas stream; X^* - the equilibrium amount of the adsorbed substance (used by the isotherm of adsorption and multiplied by the bulk density of the adsorbent); H is a height of the adsorbent layer; b is a coefficient, determined by reference data.

$$\tau=\left(\frac{X^*}{w_r\cdot Y_H}\right)\Bigg\{H-\frac{w_r}{\beta_y}\Bigg[\left(\frac{Y_1^*}{Y_H}\right)\ln\left(\left[\frac{Y_H}{Y_K}\right]-1\right)+\ln\left(\left(\left[\frac{Y_H}{Y_K}\right]-1\right)\right)\Bigg]\Bigg]\Bigg\}. \qquad (2.46)$$

Here Y_1^* is a substance in a gas stream equilibrium with the amount equal to half the substance absorbing the adsorbent as much as possible at a given temperature.

If the dependence of the gas concentrations and the amount of the absorbed substance is curvilinear (another area of adsorption isotherm):

$$\tau=\left(\frac{X^*}{w_r\cdot Y_H}\right)\Bigg\{H-\frac{w_r}{\beta_y}\Bigg[\ln\left(\left(\left[\frac{Y_H}{Y_K}\right]-1\right)\right)\Bigg]\Bigg]\Bigg\}. \qquad (2.47)$$

2.2.14. Desorption of absorbed impurities

Adsorption processes are cyclic in nature, since periodic regeneration of saturated target components of sinks is required.

The process of extracting the adsorption substance from the adsorbent is called desorption. The adsorbent released from the absorbent substance can be reused. The process of desorption is carried out, using the temperature increase, displacement adsorbate better sorbing substance, reducing the pressure or a combination of these techniques [1, 2].

In thermal desorption, the saturated adsorbent is heated by contact with a stream of water vapor, hot air or inert gas, or heated through a wall with a feed of a removable inert gas [1].

Displacement desorption (cold desorption) is based on the sorption of the target component and the substance used as a displacer (desorbent). To desorb the organic matter you can use carbon dioxide, ammonia, water, some organic substances.

Desorption of pressure reduction can be realized by reducing pressure in the system after saturation of the absorber under excess pressure or creation in the system of rarefaction at the stage of adsorption under normal pressure.

Time of desorption of target components:

$$\tau_\partial=\frac{1}{\dfrac{K_\partial}{(1-\varepsilon_n)\cdot\rho_K}}\cdot\ln\frac{a_0}{a} \qquad (2.47)$$

where K_∂ is a constant desorption rate; ε_n is a porosity of the layer; ρ_K is an adsorbent density; a_0 and a respectively, the initial and current adsorption value.

2.2.15. Thermochemical neutralization of gaseous emissions

Among the mechanical, physico-chemical and chemical methods of gas purification, thermal methods are widely used. Methods of combustion of harmful mixtures that can be oxidized are increasingly used to purify drainage and ventilation contaminants. These methods favorably differ from others with a higher degree of purification, the absence in many cases of corrosive environments and the elimination of sewage. Typically, mixtures are burned in chamber furnaces using gaseous or liquid fuels. Sometimes in practice it is possible to oxidize organic substances that are in gaseous pollutants on the surface of the catalyst, which makes it possible to lower the temperature of the process [1, 2].

Widespread for the destruction of toxic substances in harmful gases were installed torch burning. High standards are required for flare installations to ensure safe and reliable operation in the conditions of fire and explosion hazard of chemical production.

The chemical reactions between harmful gas components, which under normal conditions are virtually imperceptible, are significantly accelerated with increasing temperature. A system containing toxic substances can be disinfected by heat treatment if the reactions occurring in it lead to the formation of less toxic components.

By the type of reactions that occur, the methods of thermal decomposition can be divided into reducing and oxidative. Therapeutic methods are specific and are developed individually for each specific pollutant. Of these, until now in the technique of gas purification methods of thermochemical (using ammonia) and thermocatalytic restoration have been found.

Of all the thermo-oxidation processes for thermosetting, only oxygen can be used, since with the participation of other oxidants it is generally impossible to obtain harmless oxidation products. Therefore, in the future, the term "oxidation" refers to a process that oxidizes oxygen.

Thermooxidation of gaseous pollutants can occur in the gas phase or at the interface between the phases (on the surface). The gas phase process is carried out directly by the fire treatment of harmful gases at temperatures exceeding the ignition temperature of combustible components of pollutants. To organize the oxidation process on the boundary of the phase separation, catalysts are used - condensed matter that is capable of accelerating the oxidation of a particular pollutant at temperatures below the ignition temperature due to the activity of surface particles.

Possibilities of the thermo-oxidation method of decontamination are also limited by the amount of harmful gases and the content of combustible components in them. If the concentration of combustible components of pollutants does not reach the lower limit of ignition, their fire treatment requires additional fuel consumption for heating the contaminants to the temperature of spontaneous combustion [1, 2].

2.2.16. Catalytic methods for cleaning gas emissions

Catalytic methods of purification are based on the interaction of removed substances, introduced into the purified gas medium with a substance in the presence of a catalyst. As a result of reactions in the gas impurities are converted into other compounds that are less dangerous, or easily separated from the gas. Catalytic purification is used mainly with a small concentration of the removed component in the purified gas [1, 2].

Catalytic thermal damage is used when the content of combustible organic products in harmful gases is small, and it is unprofitable to use a direct burning method for their neutralization.

Catalytic gas purification methods are based on heterogeneous catalysis and serve to convert mixtures to harmless or easily removable compounds. The essence of the catalytic processes of gas purification is the realization of chemical interactions, which lead to the conversion of neutralization of mixtures into other products in the presence of special catalysts.

Catalysts do not cause a change in the energy level of molecules of interacting substances and a shift in the equilibrium of simple reactions. Their role is to increase the speed of chemical interactions. Catalytic interactions in heterogeneous catalysis take place at the interface between the phases of the gas mixture and the catalyst surface.

The catalyst provides interaction on its surface of convertible substances with the formation of activated complexes in the form of intermediate surface catalyst compounds and reactants that form the products of catalysis, releasing and restoring the surface of the catalyst. Changing the path of chemical interaction in the presence of a catalyst leads to a decrease in its activation energy, which is expressed in the accelerating action of the catalyst

The accelerating action of the catalyst is expressed by its activity. The activity of the catalyst is determined by the combination of physical and chemical properties of the catalyst itself, and converts my gas flow. In the greatest degree, it depends on the temperature of the catalytic conversion, the structure of the catalyst, the content of promoters, pressure, volume volumes, concentrations and molecular masses of the initial reagents and conversion products in the gas mixture.

The peculiarity of the processes of catalytic purification of gases is that they occur at low concentrations of the removed mixtures. The main advantage of the catalytic method of purifying gases is that it gives a high degree of purification, and the disadvantage is the formation of new substances that need to be removed from the gas by adsorption or absorption.

In the course of the operation of catalysts, they are to some extent subject to the gradual decontamination or destruction caused by chemical poisoning, catalytic poisons, mechanical abrasion, which leads to the need for periodic regeneration (activation) or replacement of catalysts.

Catalysts should have high activity and thermal conductivity, developed by a porous structure, resistant to poisons, mechanical strength, selectivity, heat-resistant, low temperature "burning", have low hydraulic supports, low cost jewelry [1].

2.2.17. Theory of the process of catalysis

Catalysis is called the change in the reaction rate or its excitation, which occurs under the influence of substances that participate in the process, but it does not differ and until the end of the reaction remain chemically unchanged, although physically may change. The presence of catalysts is not reflected by stoichiometric equations of chemical reactions [1].

Catalysts vary equally in the speed of direct and reciprocal reactions, sometimes in millions and more times. The level of action on the speed of direct and reciprocal reactions causes an important feature of the catalysts: they do not change the state of chemical equilibrium, the constants of equilibrium, but only accelerate or slow down the achievement of reactions of its equilibrium state.

The increase in the reaction rate is called positive catalysis or simply catalysis, and slowdown is negative catalysis. The mechanism of action of inhibitors is different from the action of catalysts.

The chemical reactions occurring in the presence of catalysts have become known as catalytic. Among them there are autocatolytic (self-accelerating) reactions, in which the role of catalysts perform one or several reaction products.

In turn, other catalysts (catalytic poisons and promoters) influence the effectiveness of the catalysts.

Catalytic poisons are substances that reduce or completely destroy the activity of catalysts. In production conditions, reactants try to clear from catalytic poisons, in turn poisoned catalysts regenerate.

Promoters is substances that enhance the action of catalysts.

Catalysts may have the so-called property of specificity. The specificity of the catalyst is that in many cases, it selectively increases the speed of only a definite reaction, without affecting the speed of others that are possible in this system. With homogeneous catalysis, the reactants and the catalyst form a single-phase system (liquid or gas).

It was established that the rate of chemical reaction under homogeneous catalysis is proportional to the catalyst concentration. Under heterogeneous catalysis, the catalyst is an independent phase (usually solid). This type of catalysis has become widespread in the industry. All reactions under heterogeneous catalysis proceed on the surface of the catalyst. Solid catalysts, which are most common, are most often produced in the form of grains, pills, granules.

Carriers or triggers are porous, indifferent substances. Carriers increase the surface of the catalyst, as well as the strength of the contacts. The mechanical strength of catalysts is their most important property. In general, the use of the carrier reduces the cost of the catalyst.

The effect of catalysts is reduced to the activation energy of the reaction. Reducing the activation energy of the reaction in the presence of a catalyst is due to the formation of intermediates (activated complexes). First, the catalyst and the reactant form intermediate compounds, which then react with another starting substance, obtaining the final reaction products and slow down the catalyst.

An intermediate compound in catalysis is an unusual stable compound that can be isolated in its pure form or exists as a separate phase. Intermediate connections are very unstable, with a small period of life, exist only during the process of catalysis. Their properties are sharply different from the properties of similar compounds, forming a volumetric phase.

A lot of theories of catalysis have been developed. Common to them is the notion that the reaction takes place in one form or another because of the formation of surface intermediates. This suggests that the activity of a catalyst depends on such properties of its surface as size, chemical composition, structure, state.

Different processes can occur on the surface of the phase separation in the heterogeneous catalysis: the interaction of the atoms of the crystalline or amorphous surface, the adsorbed particles of the gaseous molecules with the surface, the interaction of adsorbed molecules among themselves, etc. The central problem of the theory of catalysis is the creation of catalysts with predefined properties [1, 2].

2.2.18. Kinetics of reactions of heterogeneous catalysis

Heterogeneous catalytic transformation is a complex multi-stage process, which involves the diffusion of initial reagents from the nucleus of the gas stream to the surface of the catalyst pellets (external diffusion), the penetration of these substances into the pores of the catalyst to the active centers of its internal surface (internal diffusion), the adsorption of the prodifunded reagents with the catalyst surface the formation of surface chemical compounds, the chemical interaction of adsorbed substances with the formation of new products, desorption of products and their transfer to the outside noyi surface of the catalyst granules and then from the surface into the core gas flow [2].

The intensity or rate of the catalytic conversion can be expressed by the number of convertible units per unit time or the amount of catalytic interaction product generated per unit time [1]:

$$W = \frac{dG_A}{d\tau} = -k \cdot \Delta C \; ; \quad W = \frac{dG_n}{d\tau} = k \cdot \Delta C \; , \qquad (2.48)$$

where k is a constant speed of the process; ΔC is the driving force of the process, which represents, in accordance with the law of mass action, the concentration of reactants.

The constant velocity of the catalytic transformation at a given temperature are the function of the constants of velocities of the direct, reciprocal and by-effects reactions, as well as the diffusion coefficients of the initial reagents and the products of their interaction. The speed of a heterogeneous catalytic process is determined by the relative speeds of its individual stages and is limited by the slowest of them.

2.2.19. High-temperature disinfection of gas emissions

Burn treatment, as well as catalytic thermal oxidation, essentially neutralize possible only substance whose molecules do not have any other elements besides hydrogen, carbon and oxygen. As a result of the burning of the possible disposal of these substances in gaseous, liquid and solid states, dispersed or compact, and with catalytic thermal oxidation - only gaseous. Termokataliz not used for the processing of gas (vapor) and high-temperature high-compounds which evaporate from poor catalyst koksuyutsya and "poison" it is filled with active surface sooty products of incomplete oxidation [1].

Contaminants that contain any elements other than H, C and O, sulfur, phosphorus, halogens, metals, etc. can not be submitted for thermo-oxidation treatment, since combustion products will contain highly toxic compounds. In real conditions, when combustion of purely organic compounds, it is not possible to provide completely complete oxidation of the initial components to virtually harmless carbon dioxide and water vapor. In flue gases, there is always carbon monoxide and other products of chemical incomplete oxidation. In addition, at elevated temperatures, the reaction of nitrogen oxidation, which enters the combustion zone with fuel and air, is significantly accelerated.

Some nitrogen oxides have a detrimental effect on the human body and the environment. Direct combustion methods are used to remove gases from easily oxidizing toxic, as well as mixtures that have an unpleasant odor. Their advantages are relative simplicity of hardware design and versatility of use, as the work of thermal converters is little influenced by the composition of the processing gases [1, 2].

The essence of high-temperature gas purification is oxidized from the detrimental components of oxygen. They are used to virtually eliminate any vapors and gases whose combustion products are less toxic than the starting materials. Direct combustion is used in those cases where the concentration of combustible substances in the gases that are removed, does not go beyond the outbreak.

Combustion gases can be burned for the destruction of toxic organic substances, but the application of this method is complicated by the fact that the concentration of organic mixtures, which is common in large volumes of air, is very low/

Exhaustion is a method of purifying gases by thermal oxidation of carbohydrate components of CO2 and H2O. During the burning process, other components of the gas mixture, for example, halogen and sulfur organic compounds, also undergo chemical changes and can be effectively removed or removed from the gas streams in a new form.

2.2.20. Condensation of gaseous impurities

Condensation processing of harmful gases is usually included in the process cycle, if the process is accompanied by significant losses of intermediate or final products. Sometimes condensation is used to extract valuable or particularly harmful substances from the gas stream. Condensation of more dilute pollutants presents a technically difficult task and requires significant costs [1].

The degree of capture of a pollutant depends on the degree of cooling and compression of gas contaminants. Under production conditions, the temperature and pressure are taken such that the energy consumption of condensation is a small fraction of the total loss of technology.

At the same time, condensation treatment can be successfully applied in multi-stage cleaning schemes for harmful gases. There are three areas in the field of gas purification, where condensation is not only useful, but also necessary:

- is a premature precipitation of the bulk of the vapor of pollutants before adsorbers with a high degree of pollution of harmful gases;
- Partial extraction of vapors that have compounds of phosphorus, arsenic, heavy metals, halogens before the thermosetting of a mixture of pollutants;

- condensation of pollutants after chemical treatment for the purpose of transition to easily condensed compounds, for example after chemisorption apparatuses.

Condensation can be used to treat systems that have a pair of substances at temperatures close to their dew point. This method is most effective in the case of carbohydrates and other organic compounds having sufficiently high boiling temperatures under normal conditions and present in the gas phase at relatively high concentrations.

Condensers with water and air cooling can be used to destroy pollutants that have a sufficiently low steam pressure at normal temperatures. For more volatile solvents, two stage condensation with the use of water cooling in the first stage and low temperature on another is possible.

The maximum reduction of inert or non-condensed gases in the processing mixture will simplify the process of condensation and increase its economic efficiency, as it enables to exclude the possibility of necessary cooling to very low temperatures, corresponding to the dew point.

Condensation can be used for the pre-treatment of gases, which allocates valuable solvents and reduces the amount of pollutants before the next stage of treatment. Partial condensation can be used in cases where the processing gas does not deviate, and then returns to the process or is used during the burning process. Preconditioning with condensation is appropriate in cases where before the main treatment the gas flow must be cooled, for example, when adsorption is carried out.

When a cooled multicomponent mixture has conventional non-condensing gases, the cooling of the mixture is initially due to convection, and the heat transferred to the surface decreases until the gas phase is saturated with one or more of its condensable components. With additional cooling condensate gases, diffuse to the heat transfer surface, where their condensation occurs with the release of latent heat.

After the condensation begins, the temperature of the gas will be reduced only with the removal of the appropriate amount of heat and latent heat, which will result in the gas remaining in the process of reducing the temperature by a saturated component.

Since the vapor of the substance must be diffused to the heat transfer surface, the process is controlled by heat and mass transfer. In a system that has other condensing components, each of these components will begin to condense when the gas becomes saturated with this component and a partial pressure ratio will be applied to it [1, 2].

2.3. Dispersion of atmospheric emissions

In the conditions of accelerated growth of volumes of industrial production, the main way of solving the problem of rational use of natural resources and reducing the negative impact on the environment when processing them is to develop and introduce non-waste industries using all components of raw materials, air and water in a closed loop [8].

Industrial sources of emissions are divided into organized and unorganized ones. Organized industrial sources include pipes, mines, etc. Unorganized industrial emissions include open warehouses of mineral raw materials, quarries, storage of solid and liquid waste, places of loading and unloading of railway cars, automobiles, non-leaky equipment, etc. In some cases, unorganized sources are ground-based. Organized industrial sources can be divided into three types: high, low and intermediate [21].

Through high sources there is an outlet for technological gases and contaminated ventilation air. These include pipes, emissions from which are applied to the upper atmosphere, above the boundary of the intermediate zone, which ensures their good dissipation.

Low sources are the most common for the release of ventilation air and technological atmospheric blowing. Emissions from such sources occur directly into the aerodynamic shadow zone (Fig. 2.5), which is created by buildings and structures, and pollute mainly the territory near these buildings and structures.

Intermediate sources include pipes, the upper markings of which are above the boundary of the intermediate zone, but not less than 20% higher than the boundary of the aerodynamic shadow zone (Fig. 2.5).

Background concentration is a characteristic of the existing pollution of atmospheric air at industrial sites and in settlements and represents the total pollution of the atmosphere caused by all sources, including unorganized ones.

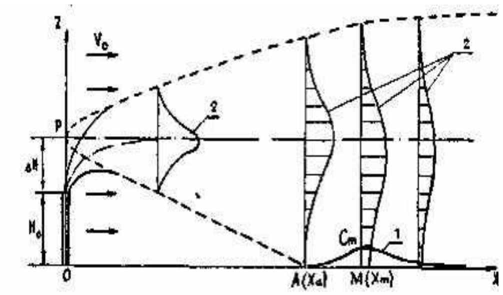


Figure 2.5. Diagram of a gas-air torch in a flowing stream [1]:
1 - distribution curve of the concentration of pollutants near the earth's surface;
2 - profiles of concentration of pollutants in the sections of the torch.

When designing for the construction of enterprises in areas where atmospheric air and the area are already contaminated with harmful chemicals released by other enterprises, the amount of calculation and background concentration for each harmful chemical in the atmosphere should not exceed the values set for it.

In order to prevent and maximize the reduction of organized and disorganized emissions of harmful substances, the most modern technology, methods of purification and other technical means should be used in accordance with the requirements of the sanitary norms of designing industrial enterprises. The use of the possibility of scattering of harmful substances in the atmosphere due to an increase in ejection height is allowed only after the application of all possible modern techniques for reducing harmful substances.

2.3.1. Diffusion processes in the atmosphere

Gaseous and dusty mixtures dissipate in the atmosphere by turbulent winds Accordingly, the mechanism of transfer of the mixture is twofold: convective transfer with a moderate motion and diffusion called as turbulent pulsations. The mixtures are usually passive in the sense that their presence does not exert a definite influence on the kinematics and dynamics of flow. This assumption can be very rough for aerosol particles of large size [21].

Approximately, it is believed that the buoyancy forces associated with the presence of a temperature gradient in the height of the atmosphere do not generate averaged motion along the vertical, but significantly affect the structure of turbulence, that is, the size and intensity of the turbulent vortices fluctuations [1].

$$u \cdot C = M\delta(y) \cdot \delta(z-H), x=0 \tag{2.49}$$

argues that the convective flow of a mixture from a point source is equal to its intensity:

$$C \to 0 \text{ при } z \to \infty \text{ і при } |y| \to \infty \tag{2.50}$$

stems from the obvious fact of reducing the concentration with the distance from the source:

$$D_z dC / dz = 0 \text{ при } z=0 \tag{2.51}$$

This is the condition of the impenetrability of the superimposed surface for the mixture. The underlying surface may partially or completely absorb the mixture. For example, a water or wet surface can absorb gas mixtures by dissolving them; The settling of disperse pollutants on the surface should also be considered as their absorption. In these cases, the condition of impenetrability (2.51) should be replaced by the condition of partial or complete permeability [1, 21].

The structure of turbulence in the atmosphere, and hence the value of the coefficients of turbulent diffusion, depends in a complicated manner on the height, the roughness of the superimposed surface, and on the Richardson criterion, which characterizes the ratio of buoyancy and inertia forces in the atmosphere:

$$R_i = \left(\frac{g\beta}{\Pr_T}\right)\left[\frac{(dT/dz)}{(du/dz)^2}\right] \tag{2.52}$$

The value of the gradient dT/dz determines the temperature stratification (stratification) in the height of the atmosphere. If there is no transfer of heat vertically, the atmosphere is in an equilibrium stratification state.

Under condition $dT/dz > g/c_p$ the state of the atmosphere is unstable, the heat fluxes contribute to the development of convection in the vertical direction and the strengthening of turbulent exchange. If the temperature gradient is positive, then there is a stable stratification, which is called temperature inversion.

This situation contributes to pushing the convective movement and weakening turbulence. The height of the surface inversion layers can range from tens to hundreds of meters [1, 21].

The value of the temperature gradient varies over the course of the day and season and depends on the radiation balance of the underlying surface. In the presence of wind in the case of unstable stratification will also be unstable; in the case of stable stratification, the character of the vertical convective motion is determined by the Richardson number.

2.3.2. Distribution of pollutants in the atmosphere

In fig. 2.5 shows the scheme of distribution of contaminated flow, which flows out of the pipe in the presence of wind, which it is demolished. The effect of the wind determines the distortion of the flow. At some height ($H + \Delta H$), the effect of a strong stream becomes predominant, the flow turns, its axis takes a horizontal position.

The torch further acquires the shape of a paraboloid with a peak at the point P where the fictitious source is placed. In this way, the real picture of the spread of pollutants is replaced by a torch from a fictitious source located at a height ($H + \Delta H$). The paraboloid's vertex does not necessarily lie above the center of the pipe, but the bias may not be taken into account, assuming that the source is at the point $p(x = 0, y = 0, z = H + \Delta H)$ [1].

The torch, expanding, reaches the ground, at some point $M(x_M)$ the surface concentration reaches a maximum C_M, going to zero for destruction.

Value C_M in a complex way depends on the speed of the wind. When enlarged, the latter decreases ΔH, that is, the torch is pressed against the ground, which contributes to the growth of concentrations on its surface. On the other hand, increasing the speed of the wind enhances the process of scattering the torch in a vertical direction, which leads to a decrease in concentrations [1].

Above the aerodynamic shadow zone, the region of the excited stream (intermediate zone) is formed, which is characterized by increased turbulent diffusion.

Contamination from intermediate sources, falling into the region of excited flows above the zone of aerodynamic shadows, dissipate in the same way as from high pipes. Under the action of more intense vertical diffusion, the lower part of the torch can, under certain conditions, be dragged into the aerodynamic shadow, causing its additional pollution, as well as from low sources [1].

As the distance from the low source concentrations of the mixture in the atmosphere is sharply reduced.

Intermediate sources, as well as high, create the maximum ground concentration at a distance of 10 - 40 heights of the pipe and simultaneously the lower branch of the discharging torch pollute the aerodynamic shadow zone, where high concentrations of pollutants can be created.

The most universal method for studying the patterns of propagation of the mixture in the atmospheric air is the mathematical description of propagation by solving the equation of turbulent diffusion. Which allows to determine the level of pollution, depending on the characteristics of meteorological conditions and the mode of pollution of the source [1].

2.3.3. Change in the concentration of impurities in the atmosphere

The process of dispersion of pollution has a significant impact on the state of the atmosphere, the location of enterprises, the nature of the area, the physical properties of pollution, the height of the pipe, etc. Horizontal displacement of the mixture is determined mainly by the wind speed, and vertical - the distribution of temperatures in the vertical direction.

As the distance from the pipe in the direction that coincides with the direction of the wind, the concentration of harmful mixtures in the surface layer of the atmosphere first increases, reaches a maximum at a distance of 10 - 40 heights of the pipe, and then slowly falls, which suggests the presence of three zones of uneven atmospheric pollution: the zone of transfer of the flares of pollutants, characterizing the relatively low content of harmful substances in the surface layer of the atmosphere, the zone of smoke with the maximum content of harmful substances and the zone of gradual reduction of pollution level nation

The presence of local anomalies of pressure and temperature associated with the influence of various factors can significantly affect the shape of the torch and the distribution of concentrations.

It is completely different from the spread of a mixture of low sources, which are located in whirlpools formed by winding buildings and structures.

The mixture is included in the circulation, its concentration increases until the moment when the turbulent transfer through the edge of the vortex zone is balanced by the intensity of the source of the mixture. Further, the distribution of concentrations in the vortex zone is stationary.

CHAPTER 3. IDENTIFICATION AND USE OF THE CONDITIONS OF MODERN TECHNOLOGIES OF CLEANING OF WATER OBJECTS AND SOIL. PROTECTION OF HYDROSPHERE

3.1 Hydro mechanical methods of wastewater treatment

Periodic and continuous hydro mechanical processes of stratification, gravity and centrifugal settling and filtration are used for the destruction of suspended particles from wastewater. The choice of method depends on the size of the mixture particles, the physical and chemical properties and the concentration of suspended particles, wastewater and the required degree of purification.

Before thinner purification, the sewage is directed to strain through the gratings and sieves installed in front of the septic tanks to remove a large mixture from them.

The separation of liquid inhomogeneous systems is called deposition by removing from the liquid phase of solid or liquid suspended particles under the influence of gravity, centrifugal force. Accordingly, gravity deflection and precipitation are distinguished by centrifugation [5]

Precipitation is defended by gravity. For the process of using the pots, tanks and luminaires. In the illuminators simultaneously with settling is filtration of wastewater through a layer of suspended particles [2,5]

3.2 Material balance of mechanical separation of sewage from the mixture.

In the absence of material losses in the process of mechanical separation of sewage from the mixture of the equation of the material balance has the form[2]:

For the total amount of substance

$$G_{см} = G_{осв} + G_{ос} \; ; \tag{3.1}$$

For the dispersed phase

$$G_{см} \cdot x_{см} = G_{осв} \cdot x_{осв} + G_{ос} \cdot x_{ос} \; , \tag{3.2}$$

where $G_{см}$, $G_{осв}$, $G_{ос}$ - the mass of the original waste water , clarified water and sludge mixture which get ; $x_{см}$, $x_{осв}$, $x_{ос}$ - content in the initial mixture of wastewater, water and lit in the sediment .

The joint solution ' Liabilities these equations to determine the mass amount of clarified water $G_{осв}$ and a lot of sediment $G_{ос}$, which get content for a given mixture in the sediment and water illuminated [2] :

$$G_{осв} = G_{см} \cdot \frac{x_{ос} - x_{см}}{x_{ос} - x_{осв}}, \quad (3.3)$$

$$G_{ос} = G_{см} \cdot \frac{x_{см} - x_{осв}}{x_{ос} - x_{осв}} \quad (3.4)$$

.

The content of suspended particles in the lighted water and in the siege is chosen depending on the specific technological conditions of the separation process.

3.2. Precipitation of sewage

The main parameter used in the calculation of the sediment is the particle deposition rate.

When a particle falls under the action of gravity, the force that moves a particle in diameter $d_ч$ is expressed by the difference between its weights [2]:

$$G = m_ч \cdot g = \pi \cdot \frac{d_ч^3}{6} \cdot \rho_ч \cdot g, \quad (3.5)$$

And a pushing Archimedean force equal to the phase of the liquid in the volume of the particle [1]

$$A = m_0 \cdot g = \pi \cdot \frac{d_ч^3}{6} \cdot \rho_ч \cdot g; \quad (3.6)$$

$$G - A = \pi \frac{d_ч^3}{6} g\left(\rho_ч - \rho_0\right) \quad (3.7)$$

Where $\rho_ч$ - the density of the solid particle.

The rate of deposition can be found from the condition of equality of force, the moving particles and forces of resistance of the aqueous medium [1]:

$$w_{ос} = \sqrt{\frac{4 \cdot d_ч\left(\rho_ч - \rho_0\right) \cdot g}{3\varsigma \cdot \rho_0}}. \quad (3.8)$$

There is also a minimum particle size, below which there is a deviation from the Stokes law and at $R_{eч} < 10^{-4}$ the rate of precipitation of very small particles begins to affect the thermal motion of the molecules of the medium. In such conditions, the d particle size becomes equal to the average free path of the medium molecules. Calculations show that $d \approx 0{,}1 мкм$ particles do not settle down, but only chaotic Brownian motion is observed [1,2]

The rate of deposition of non-uniform particles is less than the rate of deposition of non-small particles. For non-circular particles in the calculated formulas an equivalent diameter is used $d \approx 0{,}1 мкм$, which is determined by the volume $V_ч$ or mass of the $G_ч$ particle.

When defending sewage there is a compressed sediment, which is accompanied by a collision of particles, friction between them and the change in the velocities of large and small particles. The compressed compression rate is less than the free-settling rate because of the outflow of fluid and the increase in the viscosity of the media [1,2]

The rate of settling of the polydisperse system continuously changes over time. Due to the agglomeration of particles, it can vary several times compared to the theoretical one. The possibility of agglomeration depends on the concentration, shape, size and density of suspended particles, on the ratio of particles of different sizes and media viscosity [1].

The process of defending is also used to clean industrial wastewater from oil, oils, resins, fats. Cleaning from the flowing mixture is similar to the precipitation of solids. The difference is that the density of the popup particles is less than the density of water. Oil catchers are used to capture oil particles, and fat scavengers are used for fats [2].

Movement of the light phase particles upwards causes secondary waste streams in the wastewater to stop the rise. The process of the section is affected by turbulence, coagulation and hydrodynamic complexation. When entering sewage into the traps, there may be a crushing of the light fluid in the impact of the flow on the surface, which is accompanied by a change in pressure [2].

The ratio of the number of lightweight particles of a predetermined size, which settled down to the total number of particles of this liquid, is called the protective effect. Precipitation of sewage is carried out in apparatuses, which are called septic tanks or thickeners. There are horizontal, radial, vertical, tubular, lamellar tanks with sloping partitions [2].

3.3. Centrifugal sedimentation of impurities from sewage

The rate of separation of heterogeneous systems in the field of centrifugal forces is higher compared with the rate of separation of these systems in the field of gravity. The ratio of centrifugal force to gravity can be made by comparing the accelerations that act on the particles of the mixture in the centrifugal and gravitational fields, since it is possible to apply the particles to a certain mass of force proportional to acceleration [2].

In the general case, the centrifugal force $P_ц(H)$ is expressed by the level [1].

$$P_ц = \frac{m \cdot \nu_0^2}{r} = \frac{G \cdot \nu_0^2}{g \cdot r} \ , \tag{3.9}$$

Where m - the mass of the rotating particle; G - particle weight; ν_0 - rotational speed; r - radius of rotation

The ratio of centrifugal acceleration to acceleration of gravity is called the factor of separation [2]

$$K_P = \frac{\nu_0^2}{g \cdot r} \ . \tag{3.10}$$

The separation factor is an important characteristic of the hydro cyclones and centrifuges, since, under other equal conditions, the separating action in the settled centrifugation increases in proportion to the magnitude .

Pressure and open hydro cyclones are used to clean sewage. Pressure hydro cyclones are used to precipitate solid mixtures, and open hydro cyclones to remove the mixture that precipitates and expands.

When the fluid is rotated in the hydro cyclones , the centrifugal forces act on the particles, which reject heavy particles on the periphery of the stream, the forces of the resistance of the moving stream, the gravitational forces and the flow forces. The forces of inertia in the fluid flow are negligible and can be neglected. At high speeds of rotation, centrifugal forces are much greater than the force of gravity[1,2]

In addition to the physical properties of the fluid on the efficiency of hydro cyclones , affect the design parameters: the diameter of the apparatus, the ratio of input and discharge nozzles. Small diameter hydro cyclones combine into a common unit in which they operate in parallel.

Such devices are called multihydrococyclones. Multihydrocyclones are more effective in cleaning small amounts of water from fine dispersion mixtures [1,2]. Open hydro cyclones are used to clean sewage from a large mixture. From pressure hydraulic cyclones, higher productivity and lower hydraulic resistance [1] characterize them.

Sewage and filtration centrifuges are used to destroy wastewater from wastewater. In the suction centrifuges with solid rotor walls, a section of suspensions and emulsions is carried out on the principle of settling. The separation in the suction centrifuge consists of the stages of solid particles settling on the rotor walls and the density of the resulting precipitate. The first of these stages proceeds under the laws of hydrodynamics; the second one is according to the laws of soil mechanics (porous media). At low concentrations of solids in sewage (no more than 4% v / v), free placement of them in the rotor is observed without the formation of a clear surface of the separation between a pure liquid and an undiluted slurry. At high concentrations, a clear boundary of the interface is formed due to limited solid particles settling. Due to the heterogeneity of the intensity of the field of centrifugal forces and the area of precipitation, the regularities of precipitation processes in the settling centrifuges differ from the settling in the settling tank [1,2]

The efficiency of the downhole centrifuges is reduced in comparison with the theoretical due to the lag of the speed of rotation of the fluid from the speed of rotation of the rotor, the unevenness of the flow of fluid along the rotor, the formation of vortex zones, tightening the particles that settled.

3.4. Sewage filtering

In the process of sewage treatment, it is necessary to deal with a large amount of water, so use filters that do not require high pressures. Proceeding from this, filters with mesh elements (micro filters and drum grids) and filters with a filtering grainy balloon are used[2]

Mechanism of extracting particles from water on filters with granular partition [1,2]

1) strain with mechanical removal of particles;
2) gravitational deposition ;
3) inertia capture;
4) chemical adsorption;
5) physical adsorption;
6) adhesion;
7) coagulation does not subsist;
8) Biological cultivation.

In general, these mechanisms can work together, and the filtering process consists of three stages:

1) transfer of particles to the surface of the substance forming the layer;
2) attachment to the surface;
3) Detachment from the surface.

By the nature of the mechanism of delaying, the suspended particles distinguish two types of filtration:

1) filtering through the film (siege) of pollutants formed on the surface of grains of loading;
2) Filtering without formation of a film of pollutants.

In the first case, particles that are larger than the pores of the material are delayed, and then a layer of contaminants forms, which is also a filtering material. This process is typical for slow filters that work at low filtering speeds. In the second case, the filtration occurs in the thickness of the loading layer, where the particles are retained on the grains of the filtering material by adhesion forces. This process is typical of high-speed filters. The magnitude of the adhesion forces depends on the size and shape of the grains, on the roughness of the surface and its chemical composition, on the flow velocity and temperature of the liquid, on the properties of the admixture [1]

With the equality of the number of particles entering a unit time on the surface of the filtering layer and leaving it, the saturation of the surface occurs and it ceases to illuminate the wastewater.

The important characteristics of the porous medium are porosity and specific surface area. Porosity depends on the structure of the porous medium and is related to the size of the grains, as well as their shape and layout [1]

The specific surface of the layer is determined not only by the porosity, but also by the porosity of the individual grains, and depends on the shape of the grain [1]

The suspended matter when passing through the material layer reduces porosity and changes the surface. The resistance of the filtering layer increases as wastewater passes [1]

Granular filters are divided into slow and high-speed, open and closed. The height of the layer in the open filters is from 1 to 2 m, in the closed from 0, 5 to 1 m. Pumps and [1] create the pressure of water in closed filters.

Slow filters are used to filter non-regulated sewage. The rate of filtration depends on the concentration of suspended particles: up to 25 mg / l take the speed of 0, 2.0,3 m / h; at 25.30 mg / l - 0.1.0.2 m /h [1].

High-speed filters are single and multi-layer. In a single-layer filter, the layer consists of the same material, in multilayer-different materials (for example, anthracite and sand) [2].

The choice of the type of filter for sewage treatment depends on the amount of filter water, the concentration of pollutants and the degree of their dispersion, the physical and chemical properties of solid and liquid phases and the required degree of purification.

3.5. Physio-chemical methods of sewage treatment

Physio-chemical methods of wastewater treatment include coagulation, flotation, adsorption, ion exchange, extraction, distillation, evaporation, distillation, reverse osmosis and ultrafiltration, crystallization, desorption, and others. These methods are used to remove fine-dispersed suspended solid and liquid particles, soluble gases, mineral and organic substances from sewage [1,2]

The use of physic-chemical methods for the treatment of sewage compared with biochemical has a number of advantages [1]:

1) The possibility of removing toxic, biochemically non-oxidizing organic pollutants from the sewage;
2) Achieve a deeper and more stable degree of purification;
3) Smaller sizes of buildings ;
4) Less sensitivity to load changes;

5) The possibility of complete automation; a deeper study of the kinetics of some processes, as well as issues of simulation, mathematical description and optimization, which is important for the correct choice and calculation of equipment;
6) Methods not related to the control over the activity of living organisms;
7) The possibility of recovery of substances.

The choice of the purification method is determined taking into account the sanitary and technological requirements related to the purified industrial wastewater for the purpose of their further use, and taking into account the amount of wastewater and the concentration of pollutants in them.

3.6. Coagulation and flocculation of sewage contamination

Coagulation of particles is used for acceleration, that is, they are enlarged with coagulants, which are introduced into a suspension, resulting in the action of molecular forces of adhesion, there is the adhesion of small particles into large conglomerates (flakes, flocculates) [2].

Coagulation is the process of aggregation of disperse particles because of their interaction and integration into aggregates. In the purification of sewage, it is used to accelerate the process of settling fine particles and emulsified substances. Coagulation is most effective for the removal of colloid-dispersed particles from water, that is, particles in the size from 1 to 100 microns. Coagulation can occur spontaneously or under the influence of chemical and physical processes. In the process of wastewater treatment, coagulation occurs under the influence of special substances added to them - coagulants. Coagulants in water form flakes of hydroxides of metals, which rapidly deposited under the influence of gravity. Flakes have the ability to capture colloidal and suspended particles and aggregate them. Since colloidal particles have a weak negative charge, and flaccid coagulants - a weak positive charge, then between them there is a mutual attraction [2,5].

For colloidal particles, the formation of a double electric layer on the surface of the surface is characteristic. One part of the double layer is fixed on the surface of the phase separation, and the other creates a cloud of ions, that is, one part of the double layer is still, and the other is a moving (diffusive layer). The potential difference between the stationary and moving parts of the layer (in the volume of the liquid) is called the zeta potential or the electro kinetic potential, different from the thermodynamic potential, which is the potential difference between the surface of the particles and the liquid. The zeta potential depends both on the thermodynamic potential and on the thickness of the double layer. Its value determines the value of the electrostatic forces of repulsion of particles, which protects the particles from sticking together with each other. Small size of colloidal particles of pollutants and negative charge, distributed on their surface, causes high stability of the colloidal system. To cause coagulation of colloidal particles, it is necessary to reduce the magnitude of their zeta potential to a critical value by the addition of ions that have a positive charge. Thus, during coagulation, the destabilization of colloidal particles occurs due to the neutralization of their electric charge. The coagulation effect depends on the valence of the coagulant ion, which carries a charge opposite to the charge particle sign. The higher the valence, the more effective the coagulating death coagulation, destabilization of colloidal particles occurs due to the neutralization of their electric charge. The coagulation effect depends on the valence of the coagulant ion, which carries a charge opposite to the charge particle sign. The higher the valence, the more effective the coagulating death coagulation, destabilization of colloidal particles occurs due to the neutralization of their electric charge. The coagulation effect depends on the valence of the coagulant ion, which carries a charge opposite to the charge particle sign. The higher the valence, the more effective the coagulating [1,2].

To begin coagulation, the particles must approach each other at a distance at which gravity and chemical affinity are in force between them. The convergence of particles occurs because of the Brownian motion, as well as in the laminar or turbulent motion of the stream of water. The coagulating action of salts is the result of hydrolysis, which occurs after the dissolution.

The choice of coagulant depends on its composition, physical and chemical properties and value, the concentration of impurities in water, the pH and salt-water composition.

The coagulation rate depends on the concentration of the electrolyte. At low concentrations of the electrolyte, the collision efficiency of the particles, that is, the ratio of the number of collisions that ended with sticking to the total number of collisions, is close to zero ($y = 0$). As the concentration increases, the coagulation velocity increases, but not all collisions end with particle splitting - this coagulation is called slowly [2].

In polydisperse systems, coagulation occurs faster than in monodisperse, since large particles with detachment capture more small ones. The shape of the particles also affects the coagulation rate.

In addition to the coagulants, small quantities of flocculants contribute to the fluid's illumination, which facilitate the adhesion of aggregately unstable solids.

Flocculation - the process of aggregation of suspended particles when added to the sewage of high molecular weight compounds, which are called flocculants. Unlike coagulation at flocculation, aggregation occurs not only with direct contact of particles, but also because of the interaction of molecules of flocculent adsorbed on particles [1,2,5].

The use of flocculants allows reducing the dose of coagulants, reducing the duration of the coagulation process and increasing the rate of settling of formed flakes [2].

Natural and synthetic flocculants are used for sewage treatment. Natural flocculants include starch, ethers, cellulose, and others. The mechanism of action of flocculants is based on the phenomenon of adsorption of reagent molecules on the surface of colloidal particles, the formation of a reticulate structure of reagent molecules, and the cluster of colloidal particles at the expense of the forces of Van der Waals. When the flocculants act between the colloidal particles, three-dimensional structures are formed, which are capable of more rapid and complete separation from the liquid phases [1,2].

3.7. Purification of sewage flotation

Flotation is the process of molecular sticking of particles of flotation material to the surface of the gas and liquid separation, due to the excess free energy of the surface boundary layers, as well as surface phenomena wetting [5].

Flotation is used to remove insoluble dispersion impurities from sewage, which are self-defensively resistant, as well as to remove dissolved substances, such as surfactants (surfactants). The process of sewage treatment from surfactant is called foam separation or foam concentration. Flotation is used for sewage treatment of oil refineries, artificial fiber, pulp and paper, leather, food and chemical industries. It is also used to isolate active sludge after biochemical purification [1,2].

The advantages of flotation are the continuity of the process, a wide range of applications, low capital and operating costs, simple equipment, selectivity of the extraction of impurities, high speed of the process in comparison with settling, the possibility of obtaining a slurry of lower humidity, high degree of purification, and the possibility of recovery of the removed substances. Flotation is also accompanied by aeration of sewage, a decrease in the concentration of surfactants and light oxidizing substances, bacteria and microorganisms [1].

The process of wastewater treatment containing surfactant, petroleum products, oils, fibrous materials, flotation method consists in the formation of "particles-bubbles" complexes, the expulsion of these complexes and the removal of the formed foam layer from the surface of treated liquids [1].Adherence to the surface of a particle of a gas vapor is possible only when there is an insomnia or poorly wetting of the particle with a liquid.

The external manifestation of the ability of the liquid to wet is the magnitude of the surface tension at the boundary with the gas phase, as well as the difference in polarity at the boundary between the liquid and solid phases. The flotation process is effective when the surface tension of water is no more than 60.65 mN / m. The larger the angle, the greater the hydrophobia of the surface of the particle, that is, the increased probability of sticking to it and the strength of holding air bubbles on its surface. Such particles have a small wettability and easy to float [1].

The basic act of flotation is as follows: when converging in water bubble in the air with a solid hydrophobic particle separating their layer of water breaks up at some critical thickness and there is a sticking bubble with a particle. Then the complex "bubble-particle" rises to the surface of the water, where the bubbles are collected and there is a foam layer with a higher particle concentration than the source of sewage [1,2].

When fixed bubbles formed a three-phase perimeter-line, which limits the area of adhesion of the bubble and is the boundary of three phases - solid, liquid and gaseous[1].

Surfactants – reagents collectors, adsorbing on particles that reduce their wettability that is hydrophobic.As reagents - collectors use oils, fatty acids and their salts, pathogens, alkyl sulfates, amines. Increasing the hydrophobicity of particles can also be achieved by adsorption of molecules of dissolved gases on their surface [1,2].

The flotation separation effect depends on the size and number of air bubbles. This requires a high degree of saturation of water with bubbles, or high gas content. Increasing the concentration of impurities increases the probability of collision and adherence of particles to bubbles. To stabilize the size of the bubbles in the flotation process, various foaming agents are introduced, which reduce the surface energy of the phase separation: pine oil, phenol, sodium alkyl sulfate, which have generalizing and foaming properties [1].

The following methods of flotation treatment of wastewater in the following are distinguished [1].

- With the release of air from solutions;
- With mechanical dispersion of air;
- With air supply through porous materials;
- Electro flow
- Chemical flotation.

Flotation with the release of air from the solution. This method is used for the treatment of wastewater containing very small particles of pollutants. The essence of the method is to create a supersaturated solution of air in the wastewater. When reducing the pressure from the solution, air bubbles that float the pollutants are released. Depending on the method of creating a supersaturated solution of air in water, a distinction is made between the vacuum, pressure and the airlift floats[1].

When vacuum flotation - waste water pre-saturated with air at atmospheric pressure in the aeration chamber, and then sent to the flotation chamber, where the vacuum pump supports dilution 29,9 ... 39,3 kappa (225 ... 300 mm Hg). The smallest bubbles that stand out in the chamber carry away part of the pollutants.

The flotation process lasts about 20 minutes. The advantages of this method are: the formation of gas bubbles and their adherence to particles occurs in a calm environment, which minimizes the probability of destruction of aggregates "bubble-particle"; energy consumption to process is minimal. Disadvantages: insignificant degree of saturation of effluents with gas bubbles, therefore this method cannot be used at a high concentration of suspended particles (no more than 250-300 mg / l); the need to create a hermetically sealed floater and place a scraper mechanism in them [1].

Pressure flotation units are more widespread than vacuum. They are simple and reliable in operation. Pressure flotation allows to clear sewage. To increase the degree of purification into the water coagulants are added. Pressure flotation devices provide, in comparison with oil ponds, 5-10 times less residual contamination content and have 5-10 times smaller dimensions [1].

The process is carried out in two stages [1].

1) Saturation of water by air under pressure;
2) The separation of dissolved gas under atmospheric pressure.

In the case of the need for simultaneous oxidation of contaminants, water saturated with air enriched with oxygen or nitrogen. In order to eliminate the oxidation process, inert gases are supplied to the flotation instead of air.

Airlift installations are used for sewage treatment of chemical industry. They are simple in terms of equipment; the energy consumption for conducting the process in them is 2.4 times less than that of pressure equipment. The disadvantage of these installations is the need to place flotation chambers at high altitudes[1].

Flotation with mechanical dispersion of air. Turbines of pump type - impeller, representing a disk with radial, upward-facing, shoulder blades, provide mechanical dispersion of air in flotation machines. Such installations are used for the treatment of sewage with a high content of suspended particles. The degree of grinding of vortex gas flows into bubbles and the efficiency of cleaning depend on the speed of the impeller: the higher the speed, the smaller the bubble and the greater the efficiency of the process [1].

Pneumatic installations are used for the treatment of wastewater containing dissolved impurities, aggressive to moving mechanisms. The blending of air bubbles is achieved by passing it through special nozzles with holes of 1 to 1.2 mm in diameter , with a pressure in front of them 0.3-0.5 MPa. Flow rate at the outlet from the nozzle 100-200 m / s. Duration of flotation - within 15-20 minutes [1].

Flotation with porous plates. When passing air through ceramic porous plates or caps, small bubbles are released. This method has the following advantages: simple design flotation chamber; less energy due to lack of pumps, impeller. Disadvantages of the method: frequent clogging and overgrown openings of porous material; heterogeneity of pore size porous material [1].

3.8. Purification of sewage by adsorption

Adsorption water purification can be regenerative, that is, with the extraction of substance from the adsorbent and its disposal, and destructive, in which the substances extracted from the wastewater are destroyed together with the adsorbent.

As sorbents, activated carbon, synthetic sorbents and some waste products (ash, slag, and sawdust) are used. The most versatile adsorbents are activated carbon, but it should have certain properties. Activated charcoal should be weakly interact with water molecules and well - with organic substances, be relatively coarse porous so that its surface is accessible to organic molecules. In the short time of contact with water, its molecules should have a high adsorption capacity, high selectivity and low retaining ability during regeneration [2].

Substances that are well adsorbed from aqueous solutions of activated carbon have a convex isotherm of adsorption, and poorly adsorbed - concave. The experimental route [2] determines the isotherm of adsorption of a substance contained in sewage water.

If several extracted components are present in sewage water, then for determining the possibility of their general adsorption for each substance, the values of the standard differential free energy are found.

The speed of the adsorption process depends on the concentration, physical and chemical nature and structure of the dissolved substances, water temperature, type and properties of the adsorbent. In general, the adsorption process consists of three stages: the transfer of matter from wastewater to the surface of the grains of the adsorbent, the actual adsorption process, the transfer of matter inside the grains of the adsorbent. The limiting process stages may be external or internal diffusion, or both of these stages[2].

In the outer diffusion region, the velocity of mass transfer is determined by the turbulence of the fluid flow, which depends on the velocity of the fluid. In the interior diffusion region, the intensity of the mass transfer depends on the type and pore size of the adsorbent, on the shape and size of its grains, on the size of the molecules of adsorbent substances, on the mass transfer coefficient. The optimal adsorption process should be carried out under intensive hydrodynamic regimes so that it is limited in the interior diffusion region, whose resistance can be reduced by changing the structure of the adsorbent, reducing the grain size [2]

The process of adsorption wastewater treatment is carried out by intensive mixing of the adsorbent with water, by filtering the water through the layer of adsorbent or fluidized bed on the units of periodic and continuous action.

Static single-stage adsorption is used in cases where the adsorbent is very cheap or is a waste of production. When using a multi-stage installation, the process takes place at a lower cost adsorbent [1]

Adsorbed substances from coal are removed by desorption of saturated or superheated water vapor, or heated inert gas. The temperature of the superheated steam at an excess pressure of 0, 3-0, 6 MPa is 200-3000 ° C, and the temperature of inert gases is 120-1400 ° C. The consumption of steam during distillation of the volatile matter is 2, 5-3 kg per 1 kg of discharged substance, for high boiling - 5-10 times more [1,2]

After desorption, the vapor is condensed and the substance is removed from the condensate.

3.9. Ion exchange in sewage solutions

Ion-exchange purification is used to extract heavy metals from the sewage (zinc, copper, chromium, nickel, lead, mercury, cadmium, vanadium, manganese), as well as compounds of arsenic, phosphorus, cyanide compounds and radioactive substances. The method allows recuperating valuable substances at a high degree of water purification. Ion exchange is widespread during desalting in the process of water treatment [1].

Ion exchange is the process of interaction of a solution with a solid phase, which has the properties of exchanging the ions contained in it to other ions present in the solution. Substances forming this solid phase are called ion exchangers. They practically do not dissolve in water. Those of them that are capable of absorbing positive ions from solutions of electrolytes, are cation exchangers, absorb negative ions - anion exchangers. Cationites have acidic properties, and anion exchangers are the main properties. If ion exchanges and cations and anions, they are called amphoteric [1].

The absorption capacity of ion exchanges is characterized by exchange capacity, which is determined by the number of ions equivalent, absorbed by the unit of mass or volume of ion exchangers. There are complete, static and dynamic exchange capacities. Full capacity is the amount of substance absorbed at full saturation of a unit volume or mass of ion exchanger. Static Capacity is the exchange capacity of ionize at equilibrium in given working conditions. The static exchange capacity is usually less than full. Dynamic exchange capacity is the capacity of the ion exchanger to "jump" the ions into the filtrate, which is determined by the filtration conditions. Dynamic capacity is less than static [1]

Ionizes are inorganic (mineral) and organic. These can be natural substances or artificially obtained substances.

Inorganic natural ignites include zeolites, clay minerals, feldspars, various mica. Organic natural ion exchangers are hemic acids of soils and coal. They exhibit weak acidic properties. To enhance the acid properties and exchange capacity, coal is crushed and sulfated into an excess of oleum [1].

Sulfonated stones are cheap polyelectrolytes containing strongly and weakly acid groups. Among the disadvantages of such ionizes is their low chemical resistance and low mechanical strength of grains, as well as a small exchange capacity, especially in neutral media [1].

Organic artificial ion exchanges include ion-exchange resins with a developed surface. They have the most practical value for wastewater treatment. Synthetic ion exchange resins are macromolecular compounds, the hydrocarbon radicals of which form a spatial grid with fixed ion-exchange functional groups on it. The spatial hydrocarbon mesh (frame) is called a matrix, and the ions that are exchanged are counter ions. Each counter ion is connected to oppositely charged ions, which are called fixed or anchors. Polymeric hydrocarbon chains, which are the basis of the matrix, are linked (cross-linked) to each other by transverse bonds, which gives the strength of the framework [1,2]

Ionizes containing the same active groups are called nonfunctional, and ionizes containing functional groups of different chemical nature - polyfunctional. They may have mixed strongly - and weak basic properties [1]

Cationites as counter ions may contain hydrogen ions, and metal ions are in saline form. Similarly, anion exchangers may be in saline form if they do not contain ions of hydroxides as ions and acids ions as antlions. When heating ion exchangers in water and air, the destruction of their grains, splitting of active groups, which leads to a decrease in their capacity. For each resin, it cannot be used above a temperature limit. The thermal stability of anion exchangers is lower than that of cation exchangers[1]

The selectivity of the ion exchange depends on the magnitude of the pressure of the swelling in the pores of the resin and on the size of the pore of the ion exchanger. At small pore sizes, large ions cannot reach the internal active groups. In order to increase the selectivity of ion exchangers into certain metals, substances that can create intracellular compounds (chelates) with ions of these metals are introduced into the resin [1].

Ion exchange occurs in equivalent relationships and is most often reversible. Reactions of ion exchange occur because of the difference in the chemical potentials of exchange ions. The reaction goes to the establishment of ion-exchange equilibrium. The rate of equilibrium determination depends on external and internal factors: hydrodynamic fluid regime; concentration of exchange ions; structure of grains of ionize; its penetration for the ion[1]

The rate of ion exchange is determined by the slowest of these stages - diffusion in a film of liquid or diffusion in grains of ion exchangers. The chemical reaction of ion exchange occurs quickly and does not determine the overall speed of the process.

The functional dependence of the anionic composition of ion exchangers on the anionic composition of the external solution at constant temperatures and pressure is called an isotherm of ion exchange. The form of the isotherm of ion exchange depends on the magnitude of the selectivity coefficient [1]

Cation exchangers regenerate with 2.8 percent acid solutions. Regenerative solutions - eluates contain cations. Then, after loosening and washing, the cation exchangers are charged by passing through the solution of the kitchen salt. Eluates contain in concentrated form all the anion extracted from sewage. Eluates, which are solutions of acids and alkalis, are neutralized or treated for recovering valuable products. Neutralization is carried out by mixing acidic and alkaline eluates, as well as by the addition of an acid or alkali [1]

3.10. Purification of wastewater by extraction of pollutants

The treatment of sewage by extraction consists of three stages. The first stage is a mixture of wastewater with an extract ant (organic solvent). In this case, two liquid phases are formed. One phase - the extract contains the extracted substance and the extract ant, the other phase - the refinery contains wastewater and the extract ant. The second stage is the separation of the extract and the caffeinate; the third stage is regeneration of extract ant from extract and caffeinate. When choosing a solvent should take into account its selectivity, physical and chemical properties, cost and possible ways of regeneration [2].

The extraterrestrial agent must [2]:

- dissolving the withdrawn substance is much better than water, that is, have a high distribution coefficient;
- have a high selectivity of dissolution, that is, the less extract ant will dissolve the components that must remain in the waste water, the more completely the substances to be removed will be removed;
- have, if possible, the most dissolving ability in relation to the withdrawn component, the higher it is, the less it will be necessary extra garnet;
- have low solubility in sewage water and do not form stable emulsions, since the distribution of the extract and raffinate is difficult;
- Significantly differ in density from wastewater, to ensure the rapid and complete separation of phases;
- have a large diffusion coefficient; the more it is, the higher the speed of mass transfer;
- regenerate in a simple and cheap way;
- have a boiling point, which differs from the temperature of the extracted substance;
- have a small specific heat of evaporation and a small heat capacity;

- do not interact with the withdrawn substances, since it may impede regeneration of the extract ant;
- Not to be harmful, explosive and flammable and do not cause corrosion of the material of the apparatus;
- have a low cost.

The rate of supply of extract ant to sewage should be minimal. It depends on the degree of purification and the distribution coefficient, which is expressed by the ratio of the dissolved substance in the extract ant and water. This expression is the law of equilibrium distribution and characterizes the dynamic equilibrium between the concentrations of the extractable matter in the extract ants and water at given temperatures [2]

The coefficient of distribution is established experimentally, it depends on the nature of the components of the system. The content of impurities in water and extract ants and temperature. This ratio is valid if the extractor does not dissolve completely in sewage. However, the extract ant is partially soluble in wastewater, so the distribution coefficient will depend not only on the temperature but also on the concentration of the substance extracted in the refinery, that is, it will be the variable variable [1,2]

When extraction of several substances from wastewater simultaneously, the extract ant should not have selectivity of extraction, and the mother has close and high distribution coefficients for all extracted substances. Performing such a purification process complicates the choice of the extract ant and its regeneration[1]

Regeneration of the extract ant can be carried out using secondary extraction - with another solvent, as well as evaporation, distillation, chemical interaction or precipitation [1]

Since absolutely insoluble in water no liquids, then in the process of extraction part of the extract ant dissolves in wastewater, that is, it becomes a new contaminating substance, therefore, it is necessary to remove the extractor from the raffinate. The losses of the solvent with raffinate are permissible only if its solubility in water is not higher than MPC, but only at very low cost. The most common way to remove a refiner from a refiner is by adsorption or distillation of steam (gas) [1,2].

The most commonly used processes for the purification of sewage are antistruming multi-stage extraction and continuous antitumor extraction.

Fresh extract ant and sewage come from opposite sides. First, the wastewater with a low content of impurities is mixed with a fresh extract ant, and in the last step, the initial wastewater is mixed with an extract ant, which already contains a significant amount of the withdrawn substance. Such flow of flows contributes to the creation of a great driving force in the process of extraction and effective treatment of sewage [1].

3.11. Reverse osmosis and ultrafiltration in solutions of sewage

Reverse osmosis and ultrafiltration are called processes of filtering solutions through semipermeable membranes that selectively pass the solvent and completely or partially detain the molecules dissolved in them under pressure above the osmotic pressure[5]

The basis of these methods is the phenomenon of osmosis - the involuntary transition of the solvent (water) into a solution through a semipermeable membrane. The pressure in the solution, which causes the solvent to pass through the membrane, is called osmotic. By creating pressure above the solution π , which is osmotic, osmosis stops and equilibrium occurs. If over the solution create an additional pressure p_2 that exceeds the osmotic pressure by magnitude Δp , the solvent transition will occur in the opposite direction, and then the process is called reverse osmosis [1].

The magnitude of the osmotic pressure π for solutions is determined by the Vent-Hoff equation[1]:

$$\pi = \beta \cdot R \cdot T \frac{C}{M} , \qquad (3.\ 11)$$

where $\beta = (1 + \alpha)$ - Van-Hoff coefficient ; α - the degree of dissociation of the dissolved substance ; R - gas became ; T - absolute temperature of the solution ; C - concentration of the dissolved substance ; M - molecular weight of the dissolved substance .

The mechanism of filtering through the porous membrane is because the pores of such a membrane are large enough to allow the solvent molecules to pass, but too small, to pass molecules of dissolved substances. In the case of reverse osmosis, particles (molecules), whose dimensions do not exceed the size of the solvent molecules, are separated. In the process of ultrafiltration, the membrane retains high molecular weight substances, and low molecular weight substances and solvent freely pass through the pores of the membrane. With reverse osmosis, the membrane retains both high molecular weight substances and most of the low molecular weight substances, and passes through the membrane only a purely pure solvent [1].

Reverse osmosis and ultrafiltration are fundamentally different from ordinary filtering. If, under normal filtration, the precipitate is deposited on a filter septum, then in the case of reverse osmosis and ultrafiltration, two solutions are formed, one of which is enriched with a dissolved substance. Reverse osmosis is widely used for desalting water in water treatment systems of CHP plants and enterprises for the production of semiconductors, kinescopes, drugs, for the purification of some industrial and urban sewage [1, 2].

The mechanism of reverse osmosis is that the membranes collect water, which in the surface layer has no solubility, and through the pores of the membrane will only clear water, despite the fact that the size of many ions of pollutants is smaller than the size of water molecules. This is due to the phenomenon of adsorption of water molecules near the surface of the membranes[1]

When ultrafiltration, the dissolved substances are retained on the membrane because their size is larger than the pore size, or because of the large friction of their molecules on the wall of the membrane pores[2]

The effectiveness of the process depends on the properties of the membranes. They must have high selectivity, high transparency, resistance to the environment, and constant performance during operation, sufficient mechanical strength, and low cost[1]

Non-porous - dynamic and diffusion membranes, which are quasi-homogeneous gels, and porous membranes in the form of thin films, made of polymeric materials, are used for the process. The most common polymeric membranes from acetate cellulose, polyethylene, polytetrafluoroethylene, porous glass[1]

The process of membrane separation depends on the pressure, the hydrodynamic conditions and design of the apparatus, the physical and chemical nature and concentration of wastewater, the content of impurities in them, from temperature. An increase in the concentration of the solution leads to an increase in the osmotic pressure of the solvent, an increase in the viscosity of the solution and an increase in the concentration of polarization, that is, in reducing the permeability and selectivity[1].

Advantages of the method the absence of phase transitions in the separation of impurities; possibility of conducting process at room temperature without application or with small additives of chemical reagents; simple hardware design. Disadvantages of the method: the phenomenon of concentration polarization, that is, the growth of the concentration of dissolved substance near the surface of the membrane, which leads to a decrease in the productivity of the installation, the degree of separation of components and the life of membranes; carrying out the process at high pressures, which requires special seals of equipment[1].

The nature of the dissolved substance affects the selectivity. In the same molecular mass, inorganic substances are retained on the membrane better than organic. As the pressure increases, the specific performance of the membrane increases. However, at high pressures there is a seal of the membrane material, which causes a decrease in permeability, so for each type of membrane set the maximum working pressure. As the temperature rises, the permeability of the membranes increases, but osmotic pressure increases, which reduces permeability; also begins to sequester and capture the membrane's pore, which also reduces permeability; the speed of hydrolysis increases, reducing the life of the membranes. For example, acetate cellulose membranes at 50 ° C are destroyed, so it is necessary to work at a temperature of 20 ... 30 °C [1].

The design of the apparatus for carrying out the processes of reverse osmosis and ultrafiltration should provide a larger surface of the membranes per unit volume, mechanical strength and tightness. By the way, of laying membranes, apparatus is divided into four main types[1].

1) Filter press with flat-parallel filtering devices;
2) Tubular filter elements;
3) Roll or spiral elements;
4) Membranes in the form of hollow fibers.

3.12. Desorption, deodorization and degassing of dissolved impurities

Many wastewater is polluted by lethal inorganic and organic impurities.

When passing air or other inert insoluble gas (nitrogen, carbon dioxide) in water, the volatile component diffuses through the sewage gas into the gas phase.

Desorption is caused by a higher partial pressure of gas over the solution than in the ambient air. The equilibrium partial pressure of the removed gas is by Henry's law. The amount of matter transferred from the liquid phase to the gas is determined by the mass transfer equation[1].

$$M = K_y \cdot F \cdot \Delta C_{cp} \quad , (3.12)$$

Where K_y - coefficient of mass transfer; F - contact surface of phases; ΔC_{cp} - the average moving force of the desorption process.

The degree of removal of volatile substances from sewage water increases with the temperature rise of the gas-liquid mixture, the coefficient of mass transfer and the contact surface of the phases. Debruising from the water, the substance is directed to adsorption or catalytic combustion [1].

Deodorization is carried out to purify wastewaters that are badly shimmers. For this purpose, it is possible to use aeration, chlorination, distillation, and distillation, treatment with flue gases, oxidation, zonation, extraction, adsorption and microbiological oxidation [1,2].

His most effective method is aeration, which consists in blowing air through sewage. The disadvantage of the method is that some pollutants are not removed by the method of aeration and remain in sewage. Wastewater, which is poorly shimmers, is also purified by purging of acute vapor [1].

Industrial application also has chlorination of wastewater that is badly shimmers. In this case, oxidation of chlorine-containing compounds is carried out.

The purification of sewage from hydrogen sulfide is also carried out by the oxidation of air by atmospheric pressure in the presence of a catalyst (iron shavings, graphite materials) [2].

The high degree of purification is achieved by using liquid-phase oxidation of sulfur substances with oxygen under pressure. Hydrogen sulfide from water can be removed with iron hydroxide in alkaline and neutral media[2]

The purification is more effective with the simultaneous introduction of ozone and chlorine dioxide into water and water filtration through the layer of active carbon [1, 2].

Degustation removes dissolved gases from the water, which are carried out by chemical, thermal and desorption (aeration) methods[1]

The most complete degassing is achieved by spraying in a vacuum and simultaneously heating the water [1].

When thermal degassing water from dissolved carbon dioxide or oxygen passes through water and heat it to the boiling point under external pressure. In this case, the partial pressure of gas over water decreases to zero and the solubility of it also drops to zero.

Due to the imbalance in the system there is an excess of gases from the water (physical desorption). For intensive degassing, it is necessary that the water continuously contact the new portions of the steam at a large surface of phase contact for a sufficient time. The water temperature should be close to the temperature of the saturated vapor at the given pressure.

Ammonia is removed from the sewage by blowing with water vapor or air. The rate of transition of gaseous ammonia from water to the atmosphere depends on the surface tension on the boundary of air-water and on the difference in the concentrations of ammonia in water and air [1].

Chemical degassing methods are used at low concentration of gases in water, or in case of inappropriate use of them, and provided that the processing products do not complicate the further purification or use of water. The methods are based on the conduct of reactions, which results in the chemical binding of the dissolved gas [1].

3.13. Electrochemical methods of sewage treatment

For the treatment of wastewater from various soluble and dispersed impurities, the processes of anodic oxidation and catholic restoration, electrocoagulation, electro flocculation and electro dialysis are used. All these processes occur on the electrodes when passing through the sewage of a constant electric current. Electrochemical methods allow extracting valuable products from wastewater with a relatively simple technological scheme of purification, without the use of chemical reagents. The main drawback of these methods is the high consumption of electricity. Electrochemical methods can be purified sewage either periodically or continuously [1, 2].

The density of current, voltage, coefficient of useful voltage, current output, and energy output, estimates the effectiveness of electrochemical methods.

In an electrolyze on a positive electrode, an anode, the ions give electrons, that is, the reaction of electrochemical oxidation proceeds; On a negative electrode - a cathode, there is an electron connection, that is, the reaction of recovery is flowing [1].

As anodes, electrochemical insoluble materials are used: graphite, magnetite, lead dioxide, manganese and ruthenium, which are applied to titanium bases [1].

In addition to the basic processes of electro oxidation and recovery, electro flora, electrophoresis and electrocoagulation can occur simultaneously.

When using insoluble electrodes, coagulation can occur because of electrophoretic phenomena and discharge of charged particles on the electrodes, formed in the solution of substances that destroy solvate shells on the surface of particles of pollutants. Such a process can be used for wastewater treatment with low content of colloidal particles and low resistance of pollutants [1].

For the purification of industrial wastewater containing high-level contaminants, conduct electrolysis using soluble steel or aluminum anodes. Under the action of current occurs dissolution of the metal, resulting in the passage of cations of iron or aluminum, which, when met with hydroxyl groups, form hydroxides of metals in the form of flakes, and intensive coagulation occurs [1,2.21].

Advantages of electrocoagulation: lack of need for reagents, low sensitivity to changing the conditions of the purification process, obtaining sludge with good structural and mechanical properties. The disadvantage of the method is the increased consumption of metal and electricity [6].

Electro lighting. In this process, wastewater treatment is carried out using gas bubbles formed by electrolysis of water. At the anode, there are bubbles of oxygen, and on the cathode - hydrogen. The use of soluble electrodes involves the formation of flocculates of coagulants and gas bubbles, which contributes to a more efficient flotation [1, 2].

Electro dialysis the process of sewage purification by electro dialysis is based on the division of ionized substances under the action of the electromotive force created in the solution on both sides of the membranes. This process is widely used for desalination of salty water [1, 2].

With the use of electrochemically active (ion exchange) diaphragms, the efficiency of the process increases and the consumption of electricity decreases. Ion exchange membranes penetrate only for ions having the charge of the same sign as that of mobile ions.

Homogenous and heterogeneous membranes are used for desalting water. Homogeneous membranes represent a powder of ion exchanger mixed with a binder. Membranes must have low electrical [2].

The main disadvantage of electro dialysis is concentration polarization, which leads to sedimentation of salts on the surface of membranes and reduction of purification rates.

3.14. Chemical methods of wastewater treatment

Chemical methods of wastewater treatment include neutralization, oxidation and reduction. They are used to remove soluble substances in closed water supply systems. Chemical purification is sometimes carried out as a preliminary before or after biological purification as a method of purification of wastewater [2].

3.14.1. Neutralization of sewage

Neutralization can be carried out in different ways: by mixing acid and alkaline sewage, adding reagents, filtering acidic waters through neutralizing materials, absorbing acid gases with alkaline waters, or absorbing ammonia with acidic waters. In the process of neutralization, precipitation can be formed [2].

When neutralizing calcareous milk with sewage containing sulfuric acid, gypsum falls into the sediment $CaSO_4 \cdot 2H_2O$, causing it to be deposited on the walls of the pipelines [2].

To neutralize alkaline sewage, various acids or acid gases are used. The use of acid gases allows not only to neutralize wastewater and at the same time to clean the gases themselves from harmful components [2].

Neutralization of alkaline waters with flue gases is a resource-saving technology, since at the same time waste of sewage is eliminated, fresh water consumption is reduced, heat energy is saved for heating fresh water, and flue gases are purified from acidic components and from dust [1].

3.14.2. Oxidation of pollutants of sewage

The following oxidizers are used for wastewater treatment: gaseous and rarefied chlorine, chlorine dioxide, calcium chlorate, calcium hypochlorite and sodium, potassium permanganate, potassium dichromate, hydrogen peroxide, oxygen, ozone, and others [1, 2].

In the process of oxidation, toxic pollutants contained in wastewater, because of chemical reactions, become less toxic, which are removed from water.

The activity of a substance as an oxidant is determined by the magnitude of the oxidation potential.

Chlorine and substances containing "active" chlorine are the most common oxidizing agents. They are used for the treatment of sewage from hydrogen sulfide, hydrosulfate, and others [1].

Hydrogen peroxide is used to oxidize nitrites, aldehydes, phenols, cyanides, sulfur-containing wastes, active dyes [1].

The processes of water treatment also use the restorative properties of hydrogen peroxide. In neutral and weak-environment media, it easily interacts with chlorine and hypochlorite is, converting them into chloride [1].

$$H_2O_2 + Cl_2 \rightarrow O_2 + 2HCl \quad , \qquad (3.13)$$

$$NaClO + H_2O_2 \rightarrow NaCl + O_2 + H_2O \quad . \qquad (3.14)$$

These reactions are used in DE chlorination of water. Oxygen is used to clean water from iron. Pyrolyuzite is a natural material, consisting mainly of manganese dioxide. It is used to oxidize trivalent arsenic in pentavalent [1] .

Oxidation with ozone simultaneously allows for discoloration of water, elimination of flavors and odors and decontaminates. Ozone oxidizes both inorganic and organic matter, dissolved in sewage [1, 2].

When treating water with ozone, decomposition of organic substances and decontamination of water occurs, bacteria die a few thousand times faster than when treating water with chlorine.

The effect of ozone in the oxidation process can take place in three different directions: direct oxidation with the participation of one atom of oxygen; joining an entire ozone molecule to an oxidizing substance with the formation of ozonizes; catalytic enhancement of the oxidizing action of oxygen present in ozonized air. Oxidation of substances can be direct and indirect, and carried out by catalysis and ozonolizom [1, 2].

Indirect oxidation is oxidation by radicals formed because of the transition of ozone from the gas phase to the liquid and its self- dislocation[1, 5].

Catalysis - the catalytic effect of zonation is to enhance the oxidizing ability of oxygen, which is present in ozonized air [1, 5].

Ozonolysis is the process of fixing ozone on a double or triple carbon bond with the subsequent rupture and formation of ozonizes which, like ozone, are unstable compounds and rapidly decompose [1].

Zonation is an absorption process that is accompanied by a chemical reaction in liquid phases [1].

The process of sewage treatment is greatly enhanced by the combined use of ultrasound and ozone, ultraviolet irradiation and ozone [1].

3.14.3. Treatment of wastewater recuperation

Methods of restorative sewage treatment are used to remove mercury, chromium, and arsenic from wastewater. In the process of cleaning, inorganic compounds of mercury are reduced to metallic mercury, which is separated from water by settling, filtration or flotation [1].

The most common way to remove arsenic from sewage is to deposition it as a highly soluble compound with sulfur dioxide.

The method of purifying sewage from substances containing hexavalent chromium, based on its reduction to trivalent, followed by precipitation in the form of hydroxide in alkaline media [1, 5].

As reducing agents, activated carbon, iron sulfate, sodium bisulfate, hydrogen, sulfur dioxide, organic waste are used.

For the recovery of chromium, most often use solutions of sodium hydrosulfite. In the presence of soda in sewage, chrome is completely removed from neither [1,2]

3.14.4. Waste water treatment from heavy metal ions

For the removal of compounds of mercury, chromium, cadmium, zinc, lead, copper, nickel, arsenic and other substances, the most common are reagent purification methods from the sewage, the essence of which is the transformation of water-soluble substances in insoluble with the addition of various reagents, followed by separation from water in the form of precipitation [1,2]

As reagents for the removal of heavy metal ions from wastewater, calcium and sodium hydroxide, sodium carbonate, sodium sulfides, various waste [1] are used.

The most widely used calcium hydroxide. Metal deposition occurs in the form of hydroxides.

In the processing of sour waters calcium oxide and sodium hydroxide ions of zinc, copper, nickel, lead, cadmium, cobalt, contained in the effluent, bind to soluble compounds [2]

Under the action of soda to the wastewater containing zinc salts, hydroxycarbonates are formed. The purification of sewage from copper is associated with precipitation in the form of hydroxide or hydroxycarbonate [1]

It is possible to remove copper from sewage by fermentation with potassium Ferro cyanide. This reagent can also be used to deposition of other heavy metal ions [1]

The purification of sewage from nickel is based on its separation from the solution in the form of poorly soluble compounds.

Treatment of sewage with alkaline reagents allows reducing the content of heavy metals in the solution to the values comparable with the MPC for reservoirs of sanitary and domestic use. Deeper cleaning from heavy metals is achieved by treatment of sewage with sodium sulfide [1]

For the purification of water with high content of arsenic, a method of chemical precipitation of it in the form of difficult soluble compounds is used. To clean the oxygen-containing compounds of arsenic, use lime milk. Of strongly acid solutions, arsenic is precipitated with sodium sulfide, hydrogen sulfide. Purification of sulfide-alkaline effluents from arsenic is carried out by ferrous sulfate (iron sulfate)[1,2]

Compounds of trivalent arsenic is oxidized prior to deposition pyatyvalentnoho. As the oxidants used bleach, chlorine, hydrogen peroxide, nitric acid, NEO [1]

Removing the water manganese can be achieved follows - potassium permanganate water treatment; aeration combined with liming; filtering water through manganese sand or manganese actionize; oxidation with ozone, chlorine or chlorine dioxide [1]

3.15. Processes of biochemical wastewater treatment

Biochemical methods are used for cleaning of household and industrial wastewater from many dissolved organic and some inorganic (hydrogen sulfide, sulfides, ammonia, nitrites) substances. The purification process is based on the ability of microorganisms to use these substances for nutrition in the process of life, since organic substances for microorganisms are a source of carbon dioxide [1]

3.15.1. Basic indicators of biochemical wastewater treatment

In contact with organic matter, microorganisms partially destroy them, turning them into water, carbon dioxide, nitrite and sulfate ions, and others. Another part of the substance goes to the formation of biomass. Destruction of organic substances is called biochemical oxidation [1]

Sewage, which is directed to biochemical purification, characterized by the magnitude of BOD and COD. BOD is the biochemical need for oxygen, that is, the amount of oxygen used in the biochemical processes of oxidation of organic substances (not including the process of nitrification) over a period.GPC- the chemical need for oxygen, that is, the amount of oxygen, equivalent to the amount of oxidation spent, necessary for the oxidation of all reducing agents contained in water [1,2]

Biochemical activity of microorganisms is called biochemical activity connected with the destruction of organic pollutants of sewage. The possibility of biochemical oxidation is characterized by the biochemical index. The biochemical index is necessary for the calculation and operation of industrial facilities for the treatment of [1,2]

For the possibility of supplying sewage to biochemical purification, establish maximum concentrations of toxic substances that do not affect the processes of biochemical oxidation and the work of treatment plants. For inorganic substances, which practically do not undergo biochemical oxidation, also establish maximum concentrations, with excess of which water can be subjected to biochemical purification [1]

3.15.2. Method of aerobic biochemical purification.

The aerobic method is based on the use of aerobic groups of organisms, which need a constant flow of oxygen and a temperature of 20 ... 40 ° C for life. When aerobic purification, microorganisms are cultivated in an active sludge or biofilm. Anaerobic methods of purification proceed without oxygen availability; they are used mainly for decontamination [1]

Active sludge consists of living organisms and a solid substrate. The community of all living organisms that inhabit ill is called biogenesis. The quality of the sludge is determined by the speed of its settling and the degree of purification of the liquid. The state of the mule characterizes the "sludge index", which is the ratio of the volume of precipitation of active sludge particles to the mass of dried precipitate after defending for 30 minutes. The worse the sludge is, the higher the "gray index" [1]

The biofilm increases on the bio filter filler, it has the form of mucous membrane thickening of 1 to 3 mm or more. The biofilm consists of bacteria, fungi, yeast and other organisms. The number of microorganisms in the biofilm is less than in active sludge[1]

3.15.3. Mechanism of biochemical decomposition of organic substances

The growth of biomass occurs in the process of wastewater treatment. It depends on the chemical nature of pollution, the type of microorganisms, BOD and COD, on the concentration of phosphorus and nitrogen in sewage, from its temperature [1].

In order for the process of biochemical oxidation of organic substances in the wastewater to occur, they must enter the cells of microorganisms. The surface of the cells of the substance comes from convection and molecular diffusion, and inside the cells - by diffusion through the semipermeable cytoplasmic membranes. However, most of the substance gets inside the cells with the help of a specific carrier protein. The formed soluble complex "substance-carrier" diffuses through the membrane into a cell where it decays, and the carrier protein is included in a new cycle of transfer of matter [1].

The main role in the process of wastewater treatment is played by the processes of transformation of matter occurring within the cells of microorganisms. These processes end with the oxidation of the substance with energy release and the synthesis of new substances with energy consumption.

3.15.4. Kinetics of biochemical oxidation

Enzymes, which are complex protein compounds, act as catalysts. As the temperature increases, the rate of enzymatic processes increases, but to a certain extent. For each enzyme, the reaction rate drops above an optimal temperature. Among the substances-activators that increase the activity of enzymes, are many vitamins and cations. At the same time, salts of heavy metals, hydroxide, and antibiotics are inhibitors, that is, reduce the activity of the enzyme [1,2]

Microorganisms are capable of oxidizing organic matter, but this requires a different adaptation time.

Substances in colloidal or fine-discharged wastewater are oxidized at a lower rate than substances dissolved in water.

For the oxidation of organic substances, microorganisms require oxygen, but they can use it only in the form dissolved in water. To saturate sewage with oxygen, an aeration process is conducted, breaking the airflow into bubbles, evenly distributing them in sewage. From air bubbles, oxygen is absorbed by water, and then transferred to a microorganism [1,2]

The amount of absorbed oxygen can be increased by increasing the coefficient of mass return or driving force.

The rate of biochemical oxidation is affected by the tribalization of sewage in the treatment facilities, which contributes to the decomposition of flakes of active, sludge into smaller and increases the rate of receipt of nutrients and oxygen to microorganisms. Tribalization of the stream is achieved by intensive mixing, in which the active sludge is in a weighed state, which ensures a uniform distribution of it in the wastewater [1,2]

The dose of active sludge depends on the "silty index". The smaller the "sludge index", the greater the dose of active sludge must be submitted to the treatment facilities. For cleaning, fresh active sludge should be used, which is well precipitated and more resistant to fluctuations in temperature and pH of a medium [1,2]

The optimum temperature of biochemical wastewater treatment is maintained within the range of 20-30 ° C. Excessive temperatures can lead to the death of microorganisms. At lower temperatures, the rate of purification decreases, the process of adaptation of microbes to new types of contaminations slows down, processes of flocculation and deposition of active sludge deteriorate[1,2]

3.15.5. Anaerobic methods of biochemical purification

Anaerobic methods of neutralization are used for the fermentation of sediments formed during biochemical purification of industrial wastewater, as well as the first degree of purification of highly concentrated industrial wastewater containing organic substances, which are destroyed by anaerobic bacteria in the processes of fermentation. Depending on the final product, the types of fermentation are distinguished: alcohol, propionic acid, lactic acid, methane[1]

Methane fermentation is used for sewage treatment; the process is complex and multi-stage. The process of methane fermentation consists of two phases: sour and alkaline (or methane). In the acid phase of complex organic substances, lower fatty acids, alcohols, amino acids, ammonia, glycerol, acetone, hydrogen sulfide, carbon dioxide and hydrogen are formed. These intermediate products in the alkaline phase form methane and carbon dioxide [1,2]

Under certain conditions, the final product may be ammonia. The main parameters of anaerobic digestion are the temperature, the dose of sediment loading and the degree of its mixing

3.15.6. Treatment of sewage sludge

In the processes of biochemical purification in the primary and secondary sediment deposits, large masses of sediments are formed that need to be disposed of or treated in order to reduce pollution of the biosphere. Sieges have a different composition and high humidity. They are divided into three groups [2]

1) Precipitate in the main mineral composition;
2) precipitate of an organic composition;
3) Mixed precipitates containing both mineral and organic matter.

Sediments are characterized by the content of dry matter; ash content; elemental composition; imaginary viscosity and fluidity; granulomere composition.

Sewage sludge are heavy-filtered suspensions. In secondary sediments, the siege is a surplus active sludge. The sediments contain free and bound water. Free water is relatively easily removed from the siege; the bound water (colloid-bound and hygroscopic) is much heavier. Colloidal bound moisture envelops solid particles with a hydrated shell and prevents their connection to large aggregates [2]

Coagulants with positively charged ions neutralize the negative charge of particle particles. After this, the individual solids are released from the hydrated shell and joined together in a flake. Released water is easier to filter. It is also possible to destroy the hydrated shell by means of short-term thermal treatment. Treatment of sediment active sludge includes [1]

1) Sediment compaction by gravitation, flotation, centrifugal and vibration methods;
2) Stabilization of precipitation in aerobic and anaerobic conditions;
3) Conditioning of sediments by reagent and non-reagent methods;
4) Heat treatment;
5) rare-phase oxidation of the organic part of the precipitate with oxygen air;
6) Dehydration of sludge on sludge fields by natural means and by mechanical means;
7) Drying of precipitates;
8) The burning of sediments.

3.16. Thermal methods of wastewater treatment

Thermal methods neutralize wastewater containing mineral salts of calcium, magnesium, sodium, etc., as well as organic substances. Such sewage can be disposed [1]

- Concentration of sewage with subsequent release of dissolved substances;
- Oxidation of organic substances in the presence of a catalyst;
- Liquid-phase oxidation of organic substances;
- Fire-fighting.

3.16.1. Concentration of sewage

The method of concentration in general is used to dispose of mineral wastewater. It allows extracting from the wastewater salt to obtain conditionally clean water suitable for circulating water supply. The process of separation of mineral substances and water can be carried out in two stages: the concentration stage and the stage of separation of dry substances [1].

Concentration of sewage can be done by evaporation, freezing and crystallization.

Evaporation is an energy intensive process. The energy consumed for evaporation consists of energy for heating waste water from the initial temperature to the evaporation temperature; on deformation and transfer of vaporization centers; to work spent on separation of solvent and solution; on the formation of surface vapor bubbles during evaporation; to overcome the forces of pressure in the formation of bubbles; to overcome the bubble of the boundary of the phase separation and to transport the vapor bubbles to the fissure limit [1]

The process of freezing is that at a temperature below the freezing point pure water forms crystals of fresh ice, and the solution dissolved in it by salts is placed in the cells between these crystals. The freezing temperature of brine is always below the freezing point of pure water and depends on the concentration of dissolved salts. To exclude the formation of small crystals and the separation of anticrystal brine, the process of freezing is carried out under slow cooling modes [1]

Freezing can be carried out under vacuum or with a special refrigeration unit.

3.16.2. Crystallization of substances from solutions

To isolate substances from concentrated solutions, the methods of crystallization and drying are used.

Substances, whose solubility increases significantly with increasing temperature, crystallize when cooling their saturated solutions - is polythermal or is hydric crystallization, which goes with the constant content of water in the system. If with increasing temperature, the solubility of the substance decreases, then crystallization is carried out when the solution is heated. Substances that have little change in solubility when temperature changes, are crystallized by evaporation of water at constant temperature - isothermal crystallization of[1].

Crystallization of salt can also be carried out by introducing into the concentrated solution of substances that reduce its solubility. These substances contain the same ion with this salt or bind water. Crystallization of this type is called melioration [1]

A common type of crystallization is the chemical precipitation of a substance from solutions using reagents. For example, the impurities of metal ions are deposited in the form of hydroxides, adding to the solution of alkali [1]

The formation of crystals consists of two successive flocks [1]

1) The emergence in the supersaturated solution of crystallization centers - nuclei of crystals;
2) The growth of crystals based on these two germs.

The probability of formation of the embryos increases with increasing temperature. This process is facilitated by mechanical vibration, mixing, the effect of acoustic and magnetic fields. The growth of crystals occurs because of diffusion of matter from the bulk of the solution to the surface of the growing crystal, with the subsequent inclusion of particles of the dissolved substance in the crystalline lattice. Some impurities in the solution increase the rate of crystallization, others reduce [1]

3.16.3. Thermo-oxidation methods for wastewater treatment

When using the thermo-oxidation method, all organic substances that pollute wastewater, are completely oxidized by oxygen at high temperatures to non-toxic compounds. These methods include the method of rare-phase oxidation, the method of steam-phase catalytic oxidation and flame or "fire" method. The choice of the method depends on the volume of sewage, composition and calorific value, the cost effectiveness of the process and the requirements for treatment water[2]

Method of liquid phase oxidation. This method of purification is based on the oxidation of organic substances, dissolved in water, oxygen at temperatures of 100-350 ° C and a pressure of 2-28 MPa. At high pressures, the water solubility in oxygen significantly increases, which contributes to accelerating the process of oxidation of organic substances. The effectiveness of the oxidation process increases with increasing temperature. The volatile substances are oxidized mainly in the vapor phase, and non-liquid ones are in the liquid phase. As the concentration of organic impurities in water increases, the efficiency of the process of liquid phase oxidation increases [2]

Method of vapor-phase catalytic oxidation. At the heart of the method is the heterogeneous catalytic oxidation of oxygen by air at high temperatures of volatile organic substances in the wastewater. The process proceeds intensively in the vapor phase in the presence of copper-chromic, zinc-chromic, copper-manganese or other catalyst. The main drawback of the method is the possibility of poisoning catalysts with compounds of phosphorus, fluorine, sulfur. Therefore, a preliminary removal of catalytic poisons from wastewater is necessary [1]

Advantages of the method: the possibility of cleaning large amounts of wastewater without preconcentration, the absence of harmful organic substances in products of oxidation; possibility of combining with other methods; safety at work.

Disadvantages of the method: incomplete oxidation of some organic substances; high corrosion of equipment in acidic environments.

Fire method. This method of sewage disposal is the most effective and versatile of thermal methods. Its essence consists in the spraying of sewage directly into the combustion gases, heated to a temperature of 900-1000 ° C. At the same time, water evaporates, and organic impurities burn off [1]

The fire method is used to dispose of wastewater containing only minerals. The method can also be used to dispose of a small amount of wastewater containing highly toxic organic substances, the purification of which other methods are impossible or ineffective. In addition, the fire method is appropriate, if there is combustible waste that can be used as fuel [1]

Nitric oxides can be released from sewage containing nitro compounds. Between these compounds, there are interactions with the formation of new compounds, including toxic.

Different furnaces are used for the fire-fighting method. The process is carried out at a temperature of 800-890 °C [1]

CHAPTER 4. LITOSPHERE PROTECTION

Accumulation of significant masses of solid waste in industry is due to the existing level of technology of processing of raw materials and the lack of its integrated use. At the same time, a significant part of the waste of industrial enterprises can be effectively used in the national economy [21]

The diversity of types of solid waste, a significant difference in the composition of waste products of the same name complicates the problem of their disposal. At the same time, various technologies of solid waste recuperation are based on methods based on methods, the combination of which enables the utilization of secondary material resources or their processing into target products [8].

4.1. Hydro mechanical methods of liquid waste treatment

4.1.1. Hydro mechanical dewatering of sewage sludge

In the process of sewage treatment sludge is formed. Conditional precipitation can be divided into three main categories - mineral precipitation, organic precipitation and excessive active sludge. The main tasks of modern processing technology are to reduce their volume and subsequently transform into a harmless product that does not cause pollution of the environment [1].

The chemical composition of precipitation has a great influence on their water efficiency. The compounds of iron, aluminum, chromium, copper, as well as acids, alkalis and some other substances contained in industrial wastewater contribute to the intensification of the process of dewatering sediments and reduce the cost of chemical reagents to coagulate them before dehydration. Oils, fats, nitrogen compounds, fibrous matter, on the contrary, are unfavorable components. Surrounding particles of the sediment, they violate the processes of sealing and coagulation, as well as increase the content of organic substances in the siege, which affects the deterioration of its water efficiency [1].

Mechanical dehydration of industrial sediments can be carried out by extensive and intensive methods. Extensive methods are carried out by various types of sealants, intensive dehydration and condensation is carried out by means of filtration, centrifugation, hydrocyclonation, and the like [1].

Filtering is the process of separating solids from a liquid, which occurs when the pressure difference over the filter medium and under it. Vacuum filters; filter presses are usually used for dewatering sediment and sludge. The filtering medium on the filters has a filter cloth and a layer of a precipitate, adheres to the fabric and forms an additional auxiliary filtering layer during the filtration process, which, in fact, ensures the detention of the smallest particles of the suspension. As the layer grows, the role of the filtering partition (fabric) is reduced to supporting the auxiliary filtering layer. An increase in the thickness of the layer provides an improvement in the quality of the filtrate, but at the same time, because of an increase in the resistance of the passage of water through the pores and capillaries of the layer of sediment, the rate of filtration decreases [1, 2].

The filtering properties of the suspensions are characterized by the specific resistance of precipitation. In this case, precipitation means a layer that is deposited on the filter septum when filtering the suspensions [1].

The specific resistance of the sediment is called the solid-mass solids resistance, which is set aside per unit area of the filter by filtering under constant pressure of the suspension, the viscosity of the liquid phase, which is equal to one [1].

By centrifugation, the separation of heterogeneous phases is understood by means of centrifugal forces. It is carried out in apparatuses, which are called centrifuges. Centrifugation of suspensions and slimes is carried out by two methods. In the first case, centrifugation is performed in rotors having a solid wall; in the second one, it is perforated. Centrifugation in perforated rotors is a process, the individual elements of which are similar to filtration and compression of sludge [1].

The centrifugation processes in continuous rotors are divided into centrifugal illumination and precipitating centrifugation. Precipitating centrifugation is a process of separating the suspensions containing a significant amount of solid phase [1].

Among the apparatus for the centrifugal separation of various liquid wastes, widespread liquid separators, operating on the principle of thin-layer centrifugation, have become widespread. In practice, the accumulation and dehydration of sediments from the treatment facilities of small and medium industrial and transport enterprises were most widely used for hydro cyclones, which are generally used in combination with the bottom sediment sealing bunkers [1].

In the hydro cyclones, as in centrifuges, the separation of suspensions occurs under the action of centrifugal force, but by way of action, they are significantly different. In the centrifuges, the suspension along with the drum at a constant angular velocity does not move at all or almost with respect to the drum. In this case, no tangential forces apply to the particles. In the hydro cyclone, the particles of the suspension have large tangential forces that support them in a continuous relative motion. Between the layers of the suspension, there is a shear stress acting on the solid as a transverse force. It is known that in order to increase the depth of the selection of particles in centrifuges at a constant rotational speed of the drum, it is necessary to increase its diameter. In the hydro cyclone, on the contrary, it is directly proportional to the decrease in the diameter of the apparatus. At the same time, the reduction of the diameter of the hydro cyclone leads to a decrease in its productivity. Therefore, in cases where it is necessary to achieve a more thorough purification of the necessary product at significant costs of the latter, use of battery hydro cyclones (multihydrocyclones), representing several parallel elementary hydro cyclones included [1].

4.1.2. Screening of sewage sludge

The filtration is used to remove finely dispersed solid or liquid from the sewage. The separation is carried out using porous or granular barriers that pass through the liquid and delay the dispersed phase. The process goes under the action of hydrostatic pressure of a column of liquid, increased pressure above the partition or vacuum after the partition [2].

Metal punched sheets and nets, partitions of natural material, artificial and synthetic fibers are used as partitions. The filter septum must have minimal hydraulic resistance, mechanical permeability and firmness, chemical resistance; they must not swell and crumble under given conditions of filtration [1].

The difference in pressure on both sides of the filtering partition is created in different ways. If the space above the suspension is reported with a source of compressed gas or the space under the filtering partition is connected to a vacuum source, then a filtration process occurs at a constant pressure difference. At the same time, the speed of the process decreases in connection with the increase in the resistance of the layer of sediment growing thickness [1].

The filtration process is carried out with the formation of a precipitate on the surface of the filtering partition or with the occlusion of the pores of the filtering partition [1].

Filtration with formation of a sediment is observed at a sufficiently high concentration of solid phase in the suspension.

The filtering of the blocked pores of the filtering partition is called lighting, but occurs at a solid phase concentration of less than 0.7 volume triceps centage [1].

When separating suspensions with a small concentration of fine-dispersed solid phase, filtering aids are often used to prevent the penetration of solid particles in the pores of the filtering partition [1].

When the auxiliary substance is added to the separating suspension, the concentration of solid particles in it increases, which prevents clogging pores of the filtering partition.

The filtration proceeds in laminar mode due to the small pore size in the layer of sediment and filtering partition, as well as the low speed of the liquid phase in pores. The rate of filtering in the general case is expressed in the differential form [1]:

$$w_{\phi} = \frac{dV}{S \cdot d\tau} \quad (4.1)$$

Where V - volume of filtrate; S - the surface of the filter; τ - duration of filtering.

For the filtering at constant speed, the derivative $\frac{dV}{d\tau}$ can be replaced by the ratio of finite values $\frac{V}{\tau}$ [1].

After this replacement, the basic filtering equation is solved in relation to ΔP [1]:

$$\Delta P = \mu_0 \cdot r_0 \cdot x_0 \cdot \frac{V_2}{S^2 \cdot \tau} + \mu_0 \cdot R_{\phi n} \cdot \frac{V}{S \cdot \tau} \;. \qquad (4.2)$$

This equation is used for incompressible sediments.

This type of filtration is carried out if a clean liquid is filtered through a layer of precipitate of constant thickness at a constant pressure difference. Taking equality $x_0 \cdot V / S = h_{oc}$ and a replacement $\frac{dV}{d\tau}$ for a constant value $\frac{V}{\tau}$ when $\Delta P = const$ we find [1]:

$$V = \frac{\Delta P \cdot S}{\mu_0 \left(r_0 \cdot h_{oc} + R_{\phi n} \right)} \cdot \tau \;. \qquad (4.3)$$

This equation gives the dependence of the filtrate volume on the duration of filtration of a clean liquid, including flushing fluid.

For most, filtrate production batch wise as often as possible to repeat the cycle of work, giving the filter a small portion of the suspension. However, the frequent repetition of cycles of the filter on major transactions, including the same filtering, washing and blowing sediment entails frequent repetition of the same support operations downloading suspension and removal of sediment. In each case, the optimal duration of the filter cycle, in which the filter has the largest production [1]

4.1.3. Centrifugal filtration of sewage sludge

Centrifugal Filtration sewage sludge is achieved by rotating the rotor suspension in perforated - drum [2, 5].

Filtration under the action of centrifugal force is carried out on filtering centrifuges. The separation of the suspension in the filtering centrifuges consists of the stage of formation, density and mechanical drying of the precipitate with a possible precipitate washing, i.e. the speed of the centrifugal filtration varies over time [1].

Under the action of centrifugal force in the mass of the filtered suspension, a pressure that provides centrifugal filtration is developed. As a result, sediment is deposited on the inner surfaces of the rotor drum and the removal of lighted water through the filtering partition and hole in the drum [1].

Applying to the centrifugal filtering that occurs at, the basic equation for the speed of centrifugal filtering will look like [1]:

$$w_{ф} = \frac{dV}{F \cdot d\tau} = \frac{\Delta P_{ц}}{\mu_0 \left(r \cdot h + R_{фп} \right)} \ . \qquad (4.4)$$

Centrifuges may be periodic or continuous, horizontal, upright or inclined; by the method of unloading the sediment from the rotor [1]: with a manual, knife, piston, screw or centrifugal discharge.

Centrifuges of periodic action are used at a flow rate of suspension less than 5m3 / h in a wide range of concentrations with particles in diameter greater than 10 mm [1].

Continuous centrifuges with screw discharge of the precipitate are used to separate the concentrated suspensions with particle size greater than 100 mm. In wastewater treatment systems, horizontal screw centrifuges are used for the separation of particles of hydraulic size 0.2 mm (antistruminal) and 0.05 mm (direct flow) [1].

4.2. Mechanical processing of solid waste

The utilization of solid waste leads to the need or their division into components with subsequent processing of separation materials by different methods, or giving them a certain type [21].

For those industrial wastes whose utilization is not related to the need for phase transformations or the action of chemical reagents, but which cannot be used directly, two types of mechanical processing are used: grinding or compacting (pressing). It equally applies to waste, both organic and inorganic. After shredding, which can be followed by fractionation, the waste is converted into products ready for further use. The solid material can be crushed and crushed to the particles of the desired size by crushing, splitting, breaking, cutting, spraying, and various combinations of these methods. By the size of the pieces of raw material and the final product, the grinding is conditionally divided into several classes, on the basis of which chopping equipment is chosen [21,1].

One of the disadvantages of shredded viscous, elastic and viscos-elastic materials is that at room temperature, the energy costs for their processing are very high, although no more than 1% of energy is consumed directly on shredding, the main part of it is converted for the warmth. Therefore, in the last 15 ... 20 years more and more application has a technique of crystalline crushing, which allows cooling the material below the brittleness. Typically, as a cooling agent, liquid nitrogen is used, having a temperature of - 196 ° C, which is below the brittleness of most of the polymeric materials [1, 2].

The intensity and efficiency of chemical diffusion and biochemical processes increases with the decrease in the size of pieces of recycled materials. The grinding method is used to get from large pieces of processed materials of products up to 5 mm in size. As the main technological parameters of grinding, consider the degree and energy intensity of grinding [1, 2, 21].

The grinding method is used to obtain from the lump waste of grain and finely dispersed fractions of a size less than 5 mm. In the processing of solid waste, aggregates of coarse and fine grinding are used: rod, ball and knife mills, disintegrators, disc circular mills, runners. As a carrier medium, when dry powdered, air is used most often, rarely smoke or inert gases, and when moist - water. The grinding of waste plastics and bricks and technical products is carried out at low temperatures [1].

In some cases, their division should accompany the processing of shredded waste into fractions by size. Different methods are used to separate lump and bulk materials [1]:

- Sifting and scoring;
- separation under the action of gravity-inertial forces;
- Separation under the action of gravitational-centrifugal forces.

Exclamation is a process of separation into classes by the size of different sized pieces (grains) of a material when it is moved on cellular surfaces. For the separation of solid materials in the form of pulp, classifiers of coarse and fine classification [1] are used.

When gravitational and centrifugal methods of separating crushed products into classes or separating the target product is carried out by the method of separate planting of particles from the environment under the action of gravitational inertia or gravity-centrifugal forces. The separation of bulk materials under the action of gravitational-inertial forces is carried out in gas precipitators and hydraulic classifiers, and under the action of gravitational-centrifugal forces - in cyclone-type separators, with rotary blades [1].

In the event that the waste can have metallic inclusions, they are usually passed through a magnetic separator. In the magnetic field, which is created using electromagnets, the separation of magnetic metals from the organic part of the waste occurs [1].

Along with the methods of reducing the size of lump materials and their division into large-scale classes in the recovery of solid technology of solid wastes, methods are used that are related to the consolidation of fine particles, the methods of granulation, briquetting and high-temperature agglomeration are used [1].

Granulation - is the process of forming aggregates of ball-shaped or cylindrical shapes from powders, pastes, melts and solutions of recycled materials. These processes are based on various techniques for processing materials: rolling, pouring powder in dispersed streams, granulating the melts [1].

Briquetting - preparatory and independent operations in the practice of utilization of solid waste. Briquetting of disperse materials is carried out without pressing pressurizing pressure. The briquetting of disperse materials has a significant influence on the composition, moisture and material size, temperature, specific pressure and duration of pressing. The required specific pressure of compression is usually found in reverse, depending on the moisture content of the material [1].

Pressure at high pressures - one of the ways to improve the conditions of operation of landfills (landfills). Compacted waste gives less amount of filtrate and gas pollutants, thus reducing the probability of fire, more efficiently using the land area of the landfill [1].

4.3. Physio-chemical bases of processing and utilization of waste

4.3.1. Reagent treatment of sewage sludge

Most sediments formed during the purification of industrial and urban sewage, galvanic sludge, etc. are a fractional suspension. For their successful dehydration preliminary preparation is required - air conditioning. The purpose of air conditioning is to improve the water-removing properties of sediments by changing their structure and forms of water connection. The condition of conditioning depends on the performance of dehydrated vehicles, the purity of separable water and the humidity of dehydrated sediment. Conditioning can be carried out in several ways, differing in their physical and chemical influence on the structure of the processing siege. The most widespread among them are chemical (reagent) processing; heat treatment; rare-phase oxidation; freezing and thawing [1, 2].

Reagent treatment - this is the most known and common way of conditioning, with which you can dehydrate most sediments of sewage. During reagent processing coagulation occurs - the process of aggregation of fine particles and colloidal particles, the formation of large flakes with the rupture of solvate shells and the change in the forms of water connection, which leads to a change in the structure of the sediment and to improve its drainage properties. For reagent treatment mineral and organic compounds are used - coagulants and flocculants [1, 2].

The chemical mechanism of interaction of coagulants with a sediment is as follows. The sulfuric aluminum introduced into the aqueous medium interacts with the bicarbonates contained in water, forming a first gel-like aluminum oxide hydrate [1].

The formed hydrated flakes absorb suspended matter, are in a colloidal state of the water, under favorable hydrodynamic conditions, quickly settle into the sealant, and give water well on the machines for mechanical dehydration by filtration or centrifugation. Sulfuric oxide iron is less effective, but cheaper and more affordable reagent. Lime is used not only in conjunction with iron salts, but also as an independent coagulant, which is in some cases quite effective. When used as a coagulant there is a tendency to regenerate it from ash after burning dehydrated sediments. Disadvantages of mineral reagents are scarcity, high cost, corrosion, as well as difficulties in their transportation, storage, preparation and dosage [1, 2].

Synthetic polyolefin or polymers are introduced into the precipitate immediately before centrifugation or filtration. These polymers eliminate or reduce the repulsive forces of suspended solid particles, which tend to keep them at a distance. Due to the gravity of these particles, the formation of flakes and separation occur much faster and more efficiently [1].

4.3.2. Physio-chemical methods of extracting components from waste

Many solid waste recycling processes are based on the use of leaching (extraction), dissolution and crystallization of recycled materials.

The leaching (extraction) is based on the receipt of one or more components of the complex solid material by its selective dissolution in the liquid-extract ants. There are simple dissolving and leaching with a chemical reaction [1].

The dissolution is a heterogeneous interaction between a liquid and a solid, which is accompanied by the transition of solids into a solution [1].

Crystallization is a process of separating the solid phase in the form of crystals from saturated solutions, melts, or vapors [1].

Creation of the necessary solution for crystallization of sulfurization is provided by cooling of hot saturated solutions and removal of solvent particles by evaporation (isothermal crystallization) or a combination of these methods (vacuum crystallization, fractional crystallization, crystallization with evaporation of the solvent in the air stream or other gas carrier) [1].

In the practice of crystallization from solutions, crystallization is sometimes carried out by vulgarization (introduction into the solution of substances that reduce the solubility of the salt), freezing (cooling of solutions to negative temperatures with the separation of crystals of salt or their concentration by removing the particles of the solvent in the form of ice) or at the expense of a chemical reaction that ensures super saturation of the solution, as well as high-temperature (autoclave) crystallization, which ensures the obtaining of crystalline hydrates with a minimum moisture content [1,2].

4.3.3. Enrichment in the recovery of solid waste

In the practice of recovery of solid waste industry use methods of enrichment processing materials: gravity, magnetic, electrical, flotation, and special.

Gravitational methods are based on the difference in speed in a liquid (air) medium of particles of different sizes and densities. They combine the enrichment of the discharge with the action of variables in the direction of vertical jets of water (air); enrichment in heavy suspensions, the density of which is an intermediate between the density of divisible particles; enrichment of moving flows along the sloping surfaces, as well as flushing for the destruction and removal of clay, sand and other mineral, as well as organic impurities [1, 2].

Magnetic enrichment is used to separate the paramagnetic and ferromagnetic components of mixtures of solid materials from their diamagnetic components [1].

Electrical enrichment methods are based on the difference in electro physical properties of separating materials and include separation in an electrostatic field, a corona discharge film, a corona-electrostatic field, and triboadgezial separation. Electrostatic separation is based on the difference in electrical conductivity and the ability to electrify friction (a triboelectric effect) of mineral particles of a separated mixture. With a slight difference in the electrical conductivity of particles, electrification is used to friction. The electrified particles are sent to the electric field, where separation takes place [1, 2].

The separation in the corona discharge field created between the crowning and depositing electrodes is based on the ionization of the intersection of this field with the mineral particles deposited on them by the air ions and the difference in the intensity of the transfer of the charged charge to the surface of the depositing electrode, which is expressed in various trajectories of the motion of particles [1, 2].

Triboadgezial separation is based on the difference in adhesion (adherence) to the surface of electrified friction particles of the material [1].

4.4. Thermal methods of waste treatment

4.4.1. Thermal methods of neutralization of mineralized sewage

The most common methods that allow clearing of mineralized drains are thermal. Here are the following directions [1]:

1) a significant reduction in the volume of wastewater at their limit concentration and storage of these solutions in artificial and natural storage facilities;
2) The separation of wastewater from salts, other valuable substances, and the use of desalinated water for the needs of the agricultural industry.

The process of separation of water and minerals can take place in two stages: concentration of the initial solution and separation of the dry residue from it. If the first stage is performed, then the concentrated solution is sent for further processing or, in the extreme case, to the frozen. It is possible to supply wastewater, passing the concentration stage, directly to the extraction of solids from them, for example, in a spray dryer or into a combustion chamber, for example, a cyclone reactor.

Concentration of solutions can occur in evaporating, freezing, crystalline hydrate installations of continuous and periodic action [1, 2].

In the evaporation plants, the concentration of the solution increases because of the removal of vapor of the solution in the evaporated liquid. These settings are most commonly used in solutions for concentrating. They are divided into vaporization plants in which boiling occurs on the surface of the heating or in the veneered zone, and adiabatic evaporation systems in which the evaporation of the superheated liquid occurs in the adiabatic chamber. Steam installations can be divided into units in which the solution contacts the heating surface and installations in which the solution does not contact the surface of the heating. In installations of the first type, deposits of salt are formed with an appropriate decrease in the density of the heat flow and production plants. This causes periodic shutdowns of the units to clean the heating surface, which reduces technical and economic indicators and complicates their operation. The degree of concentration of the solution in them is significantly limited due to a sharp increase in deposits with increasing concentration of the solution. In order to improve the working conditions, it is necessary to apply special measures to reduce deposits [1, 2].

In plants of the second type, heat is transferred to the intermediate hydrophobic liquid, solid or gas coolant, which then, when directly in contact, heats or evaporates the solution. The heated solution is fed into the chamber of adiabatic evaporation. The degree of concentration of the solution in such plants is significantly increased, because the danger of deposits on the surfaces of heating is practically excluded [1].

In plants where freezing methods are used, the concentration of mineralized effluents is because the amount of salts in ice crystals is much less than in the solution, and ice is formed. As a result, as the formation of ice, the concentration of salts in the solution increases. Concentration of mineralized water can be done in two ways: freezing by evaporation under vacuum or freezing using a special refrigerant [1].

In crystalline hydrate systems, the concentration of sewage is based on the ability of certain substances (frons, chlorine, etc.) under certain conditions to form crystalline hydrates. In this case, the water molecules are converted to crystalline hydrates, and the concentration of solutions increases. When melting the crystals, water is released again, which is a hydrate-forming agent. The process of hydrate formation can occur at a temperature below and above the environment. In the first case, as a rule, it is necessary to use refrigeration plants, and in the second case, the crystalline hydrating plant can use low-temperature heat [1, 2].

Refrigeration and crystalline distillation methods of desalination and concentration of mineralized wastewater are still used relatively rarely, but due to their positive qualities can be widely used in the future.

4.4.2. Thermal methods of conditioning of sewage sludge

The thermal conditioning method includes heat treatment, rare-phase oxidation, freezing and thawing (the latter mainly for the conditioning of sediment of water supply stations) [21].

Thermal treatment is one of the most promising methods of conditioning. It is used for air conditioning of urban and industrial sewage sludge. In technological schemes, which culminate in a stage of dehydration, its advantages, besides preparation for dehydration of precipitation, are to provide reliable stabilization and complete sterilization of precipitation [6-8].

The essence of the heat treatment method is to heat the precipitates to a temperature of 150-200 ° C and to maintain at this temperature in a closed container for 0.5-2 hours. Because of such treatment, a sharp change in the structure of the precipitate occurs, about 40% of the dry matter passes into the solution, and the part acquires water-giving properties. The precipitate after heat treatment is rapidly densified to a moisture content of 92-94%, and its volume is 20-30% of the initial [1].

The liquid phase oxidation of its essence consists in the oxidation of the organic part of the precipitate with oxygen at high temperature and pressure. The efficiency of the process is estimated by the depth of oxidation of the organic part of the sediment. This value depends mainly on the processing temperature. For oxidation by 50%, a temperature of about 200 ° C, 70% or more - a temperature of 250.800 ° C [1] is required.

Oxidation of the sediment is accompanied by the release of heat. At a sediment moisture, about 96% of the allocated heat is sufficient for self-support of the temperature regime and the main energy is spent for the supply of compressed air [1].

4.4.3. Drying of moist materials

Drying is the process of removing moisture from a solid or paste material by evaporating the liquid contained therein by heat brought to the material. This thermal process requires a significant amount of heat. The processes of thermal removal of that part of the moisture that cannot be removed mechanically can also be found in the treatment of industrial waste that needs to be prepared for transportation and further processing, as well as for the treatment of certain wastes of the chemical, food and other industries. Drying is carried out by convective, contact, radiation and combined methods [1, 2].

The drying process is carried out at the expense of the thermal energy produced by the heat generator. Generators of heat can be steam or gas clarifiers, furnaces, working on solid, liquid or gaseous fuels, infrared emitters and generators of electric current [1].

Drying is a heat and mass transfer process. Removing moisture from the surface is closely related to moving it from inside to surface. Drying differs from evaporation by the fact that in the first case, the removal of moisture occurs at any temperature, and in the second - if the pressure of the generated vapors is equal to the pressure of the environment. Evaporation occurs from the entire mass of the liquid, while drying the same moisture is removed from the surface of the dried material. Evaporation is a more intense process than drying, but not all materials can be evaporated. Therefore, the moisture from solid materials is removed only by heat drying [1].

Convection drying with air or gas is the most common. In air-drying, as well as in gas, heat is transferred from the coolant directly to the drying substance. In order to obtain the material of the required quality special attention should be paid to the technological mode of drying, the correct choice of the parameters of the coolant and the mode of the process (the choice of the optimum temperature of the material heating, its humidity, etc.). The optimum drying regime, which affects the technological properties of the material, depends on the relationship of moisture to the material [1].

As moisture is removed from the surface of the material due to the difference in moisture concentration inside the material and on its surface, the movement of moisture to the surface occurs by diffusion. In some cases, there is a so-called there modiffusion, when the movement of moisture inside the material occurs due to a decrease in temperature difference on the surface and inside the material. With convective drying, both processes have the opposite direction, and when dried by high frequency currents - the same [1].

When drying some materials to a low end moisture heat is spent not only on the heating of the material and the evaporation of moisture from it, but also to overcome the connection of moisture with the material. In most cases water is removed during drying, however, in the chemical industry it is sometimes necessary to remove vapors of organic solvents. Regardless of which liquid will evaporate, the regularities of the process are the same.

4.4.4. Thermochemical treatment of solid waste

During solid waste recycling and recycling, various methods of heat treatment of the source solids and products are used: these are various techniques of pyrolysis, remitting, firing and removal(combustion) of many types of solid waste on an organic basis [21]

Pyrolysis is the process of decomposition of organic compounds under the influence of high temperatures in the absence or lack of oxygen. Characterized by the occurrence of reaction reactions and compaction of residual fragments of the original molecules, resulting in the splitting of organic mass, recombination of the products of splitting to obtain thermodynamically stable substances: solid residue, resin, gas. Applying the term "pyrolysis" to the thermal conversion of organic material, means not only its decay, but also the synthesis of new products. These stages of the process are mutually connected and proceed at the same time with the only difference that each of them prevails at a certain interval of temperature or time [1, 2].

Gasification is a thermochemical high-temperature process of the interaction of organic mass or products of its thermal processing with gasifying agents, resulting in the organic part or products of its thermal processing into flammable gases. As gasifying agents, air, oxygen, water vapor, carbon dioxide, as well as their mixtures [1, 2] are used.

Agglomeration is that the small grains of the charge are heated to a temperature at which their softening and partial melting occurs. At the same time, the grains stick together, further rapid cooling leads to their crystallization and the formation of porous, but sufficiently strong lump product suitable for metallurgical processing [1].

Burning of the cubes is carried out when cladding iron ore finely divided concentrates with particle size less than 100 microns. Materials of such a size are well loaded, especially when injected into a charge of 0.5 ... 2.0% plastic compound admixture - bentonite (a special grade of high-quality clay). For obtaining reflux boilers, the required amount of lime is also introduced into the charge [1].

CHAPTER 5. PROTECTION OF ENVIRONMENTAL PROTECTION OF ENERGY ACTION

5.1. Theoretical basis of environmental protection from energy activities

The protective device (RP) has the properties: to reflect, absorb, to be transparent in relation to the flow of energy. ZP can be characterized by the following energy coefficients: absorption coefficient , reflection coefficient , transmission factor ρ . In doing so, the equality [1] is fulfilled:

$$\alpha+\rho+\tau=1. \qquad (5.1)$$

Principles of protection:

1) principle: $\rho \to 1$; protection is due to the reflectivity of the LP;
2) principle: $\alpha \to 1$; protection is due to the absorption capacity of the LP;
3) Principle: $\tau \to 1$; protection taking into account the properties of transparency of PP.

In practice, the principles are combined, obtaining different methods of protection. Most widely used methods of protection of insulation and absorption.

Insulation methods are used when the source and receiver of energy, which are simultaneously the object of protection, are located on different sides of the Frothed basis of this method is the reduction of the transparency of the medium between the source and the receiver, that is, the fulfillment of the condition . In this case, two main methods of isolation can be distinguished: a method in which the reduction of the transparency of the medium is achieved by absorbing the energy of the LC, that is, the condition provided by the condition , and a method in which the reduction of the transparency of the medium is achieved at the expense of high reflectivity of the LC, that is, the condition provided by the condition [27].

The basis of absorption methods is the principle of increasing the flow of energy that has passed in the OP, that is, the achievement of the condition . There are two types of energy absorption ZP: absorption of energy by the RF itself due to its selection from the source in one form or another, including in the form of irreversible losses, characterized by the coefficient , and energy absorption due to the high transparency of the RP, which is characterized by the coefficient .Since at coefficient , then absorption methods are used to reduce the reflected energy flow; while the source and receiver of energy are usually on the one hand from the memory [27,28].

5.2. Protection of the environment from mechanical and acoustic oscillations

The main sources of vibration are rail transport, various technological installations, press-forging equipment, construction machinery, heating and water supply systems pump stations. Harmful vibrations create not only noise pollution of the environment, adversely affecting the human body, but also represent a certain danger to various engineering structures, causing in some cases their destruction. Useful vibrations are used in a number of technological processes, but in this case, appropriate protection measures are required. The zone of action of vibrations is determined by the magnitude of their attenuationin an elastic medium, and on average, this value is approximately [3].

One of the main reasons for the appearance of low-frequency vibrations in the work of various mechanisms is the imbalance of rotating parts that arise because of the displacement of the center of mass relative to the axis of rotation. The occurrence of imbalance in rotation can be caused by [6, 10]:

- Asymmetric distribution of rotating masses, due to the curvature of machine shafts, the presence of asymmetrical fasteners;
- Heterogeneous material density, due to the presence of shells, slag inclusions and other inhomogeneity’s in the construction material;
- The presence of backlashes, gaps and other defects that arise during the assembly and operation of mechanisms.

In these cases, there is a non-equilibrium centrifugal force proportional to the mass of the system m, square angular velocity and eccentricity Center of masses of the system relative to the axis of rotation

$$F = \ell m \omega^2 \quad . \qquad (5.2)$$

Another reason for the appearance of vibrations is the shock-type processes. At the same time, for a rather short time, the impulse of the body is transmitted to another motionless or motionless body. The source of vibration is a variety of resonance oscillations of parts, structures, mechanisms, installations. Infrasonic vibrations often accompany vibrations. The action of vibration on the body manifests itself in different ways depending on how vibration works. Biological action of vibrations in the frequency range up to 15 Hz is manifested in violation of the vestibular apparatus, displacement of organs.

Methods of protection against vibration include methods and techniques for reducing vibrations both in their source of origin and in the ways of propagation of elastic oscillations in different environments. The advantage is given to constructive solutions that have greater rigidity and smaller dimensions and, if possible, have less dynamic load [1].

An effective method of reducing vibrations in the source is the choice of optimal modes of operation, which consists mainly of eliminating resonant phenomena in the process of operating mechanisms. It is important, however, that the own frequency of oscillations of the mechanism does not coincide with the frequencies that arise in the imbalance. To do this, either the mass of the system or its other mechanical parameters are changed [1].

Vibration reduction - a method of reducing vibrations is to increase the mass and stiffness of the structure by combining the mechanism with the foundation, the base plate or bases, which quench vibrations. This increases the reactive part of the impedance of the oscillatory system [5].

Vibrio isolation - this method consists in installing various equipment not on the foundation, but on vibrio isolating supports. This method of placing equipment is simpler and cheaper than the method of vibration and allows you to get any measure of vibration isolation. This method can be used in conjunction with the vibration damping method. When considering the vibration isolating properties in the case of harmonic loads, the concept of transmission coefficient is often introduced to evaluate the vibration isolation efficiency [1].

The mechanism of reducing the level of vibrations due to vibration damping is to increase the active losses of oscillatory systems. In practice, this is implemented in mechanisms with large dynamic loads using materials with large internal friction. Large internal friction has alloys of non-ferrous metals, pig iron with low carbon and silicon [1].

One of the features of infrasound is their weakness, compared with waves of the sound range, absorption in the air. Therefore, infrasound extends over long distances, "cleansing" at the same time from higher harmonics. Infrasound has a harmful effect on the human body, and special protection measures are needed from it [10].

The attenuation of infrasonic oscillations in the surface layer of the atmosphere is approximately $8\cdot 10^{-6}\, дБ/км$, so the distance protection method in this case is extremely ineffective. To protect against the effects of infrasound apply sound insulation source; silencers of various types; absorption of infrasonic oscillations; selection of optimal operating modes of devices; special constructive solutions [9, 10].

Sound insulation of the source of infrasonic oscillations is not sufficiently effective at frequencies below 10 Hz. To increase its efficiency at frequencies below 10 Hz, it is required to create powerful, rigid structures from materials with a surface density $10^{5}-10^{6}\, кг/м^{2}$, which is not very cost effective [1].

For protection against infrasound, the most effective methods are related to the use of mufflers of the most diverse types, the choice of optimal modes of operation and the use of special designs. In the range of infrasonic oscillations, due to their large length, the size of the resonators and the volume of their internal cavities should be larger than in the case of analogous mufflers used for the range of audible waves. In the case of infrasonic sources of aerodynamic nature, measures are taken to limit the rate of gas leakage [1].

Sound no periodic oscillations with a continuous spectrum are perceived as noises. The intensity of the noise can be varied, from rustling leaves to the noise of a lightning discharge. Distinguish sources of noise of natural and fabricated origin [10].

In a real atmosphere, regardless of a person, there are always noise of natural origin with a very wide spectral range from infrasound with frequencies to ultrasound and hyperactive sound [1].

The noise sources of techno genic origin include all the mechanisms, equipment and transport used in modern technology that create significant noise pollution of the environment [21].

Techno genic noises on the physical nature of origin can be classified into the following groups [21]:

- Mechanical noise arising from the interaction of various parts in the mechanisms, as well as in the vibration of the surface of devices, machines, equipment.
- Electromagnetic noise arising from the oscillation of parts and elements of electromechanical devices under the action of electromagnetic fields.
- Aerodynamic noise resulting from vortex processes in gases.
- Hydrodynamic noise caused by different processes in liquids.

Spectral-time characteristics of the noise have a great variety. For the technical evaluation of noise, their classification was introduced according to the spectral and temporal characteristics. By the nature of the spectrum, the noise is divided into broadband and tonal. Broadband noise refers to noise that has a continuous spectrum larger than an octave. Tonal noise is characterized by the presence of separate audible discrete tones in the spectrum [1].

By time characteristics, the noise is divided into constant and non-constant. Continuous noise during the measurement of the time response of the noise meter "slowly" does not change the signal level more than 5 dB. In the case of non-constant noise, this change may be greater than 5 dB [1].

Constant noise is divided into pulsed, intermittent and oscillating in time:

- Pulsed, consisting of one or more sound signals of 1 s duration and sound levels differing by more than 7 dBa;
- intermittent noises are characterized by the fact that the sound level varies by 5 dBa and more than several times during the measurement, with pulse duration greater than when pulsed noise and at the moment of pulse action its amplitude remains constant, exceeding the background;
- fluctuate in time, differ in the fact that the noise level changes over time.

Noises, especially of an industrial origin, have a detrimental effect on the human body. This harmful effect manifests itself in a specific lesion of the auditory apparatus and non-specific changes in other organs and systems of humans. When exposed to a person noise is important their level, character, spectral composition, duration of action and individuality of sensitivity [21].

Because noise is a harmful production factor, and in some cases dangerous, the maximum permissible levels for noise of different types are compared with the equivalent levels of continuous noise. In order to assess the noise pollution of the natural environment, it is necessary to know both the real noise background and the permissible noise level established by the sanitary norms. The following parameters are selected for normal noise ratio [9, 10]:

- Sound pressure level;
- The intensity level of the sound.

In the case of non-constant noise, [9, 10] is selected by the normalized parameters:

- The equivalent sound level;
- Maximum level.

When designing or choosing methods for protecting the environment from noise, a whole set of measures is used [1]:

- conducting necessary acoustic calculations and measurements, their comparison with normalized and real noise characteristics;
- Definition of hazardous and safe areas; development and application of sound absorbing, soundproofing devices and structures;
- Choice of the appropriate equipment and optimal operating modes;
- Decrease in the direction of noise emission of the area of interest;
- Choice of the optimal zone of orientation and optimal distance from the source of noise;
- Architectural planning works;
- Organizational and technical measures on prevention in the part of timely repair and lubrication of equipment;
- Prohibition of work on obsolete equipment has a high noise level.

Part of the energy of the falling sound wave is reflected, part of the energy is absorbed by the medium, and part of the energy passes the obstacle to the thickness . Relative intensity of reflected wave to the intensity of the wave is called the coefficient [1]:

$$K_{отр} = \frac{J_{отр}}{J_0} . \qquad (5.3)$$

The absorption coefficient is related to [1]:

$$K_{П} = \frac{J_{П}}{J_0} , \qquad (5.4)$$

Where $J_{П}$ - the intensity of the wave that is absorbed by the medium.

The coefficient of passage takes the ratio of intensity at the outlet of the medium $J_{Пр}$ to the falling intensity [1]:

$$K_{Пр} = \frac{J_{Пр}}{J_0} \qquad . (5.5)$$

Acoustic permeability of the medium of finite thickness is determined by the processes of absorption of the sound wave, multiple reflections from the interface and subsequent interference. Strict definition of coefficients $K_{отр}$, $K_{П}$, $K_{Пр}$ presents some difficulties, because in real cases it is not possible to calculate the part of the reflected, absorbed energy of the falling sound wave. [21]

Under reverberation refers to the process of gradual decay of sound energy in enclosed spaces after the termination of the sound source. Each oscillation propagating in a closed air space is characterized by its coefficient of attenuation, depending on the absorption of sound energy with its multiple reflection from the boundaries of the section. The reverberation process has a great influence on the acoustics of the room, since the human ear perceives direct sound against the background of previously excited oscillations of its own, whose spectrum changes over time as a result of the gradual decay of some of their own harmonics [1].

Sound power density $\varepsilon_{зв}$ over time, it is possible in general terms to express the formula [1]:

$$\varepsilon_{зв} = \varepsilon_{зв}^{0} \exp\left(-{}^{t}\!/_{\tau}\right) , \qquad (5.6)$$

Where $\varepsilon_{зв}^{0}$ - the density of sound energy now of the exclusion of the sound source; τ - - constant time of reverb, defined by the expression [1]:

$$\tau = \frac{4V}{\upsilon \sum K_{П} S_i} , \qquad (5.7)$$

Where V - the volume of the room; υ - sound speed; $\sum K_{П} S_i$ - the sum of the total sound absorption of all the bodies in the room. Therefore, for an hour the density of sound energy decreases in e time.

Sound absorption is the process of transitioning part of the energy of the sound wave to the thermal energy of the medium in which the sound propagates. Sound absorption has a dispersion, which is quite strongly dependent on the frequency. With its increase in sound absorption increases. Together with the direct transition of part of the sound energy into the heat, the sound wave is relaxed due to its partial penetration through the obstacle of the slit, windows, and so on [1].

Soundproofing designs in the form of acoustic screens are used to reduce the noise level in the environment, created by openly installed sources of noise in the enterprise. The use of acoustic screens is appropriate if the noise level of the source exceeds by more than 10 dB the level of noise generated by other sources in the area. The efficiency of the acoustic screen is calculated taking into account the size and shape of the screen construction, the properties of the materials used the characteristics of the sound field in the acoustic zone due to diffraction phenomena. The construction of acoustic screens can be of the most varied form or stationary, or mobile [1].

Noise mufflers are designed to reduce the noise levels of aerodynamic sources: gas turbine units, gas-dynamic compressed air discharge systems, test stands of various aviation engines, compressors, ventilation chambers. The principle of absorption mufflers is based on the absorption of sound waves in sound absorbing materials. Mufflers of this type have been widely used in aerodynamic installations because of their efficiency over a wide frequency range with relatively little gas-dynamic resistance. In the jet silencers, the phenomenon of reflection of the sound wave back to the source of noise using reflectors and bulk resonators is used. This type of mufflers is used in the case where brightly expressed discrete components are observed in the spectrum of the noise source. They are installed directly in pipelines, whose transverse dimensions are smaller than the wavelength of the muffled sound droop. In combined mufflers, use the phenomenon of both absorption and display of sound [1].

5.3. Protection from thermal radiation

Infrared rays are electromagnetic radiation with a wavelength of from 0.76 microns to about 700 microns. The human eye does not perceive infrared radiation (IR), but the skin feels it. Often infrared radiation is called thermal radiation. Among the infrared spectra, distinguish linearity, striped and continuous [20].

Linear (atomic) infrared spectra produce excited atoms and molecules at transitions between closely spaced electronic levels of energy. Strip (molecular) infrared spectra arise at transitions between vibrational and rotational energy levels of molecules. The oscillating and oscillating-rotational spectra are located mainly in the middle region of the infrared range. Purely rotating spectra are located mainly in the far region of the IR range. The continuous infrared spectrum radiates all heated bodies. The continuous (continuous) spectrum is due to the strong interaction of molecules and atoms in the condensed state in liquids and solids, which leads to the discontinuity of discrete energy levels and the formation of solid spectra of radiation [20].

Sources of IR radiation can be divided into two groups: natural and fabricated origins. The natural source of infrared radiation in the biosphere is the Sun, active volcanoes, thermal water, processes of heat and mass transfer in the atmosphere, all heated bodies, and forest fires. The Earth's surface produces thermal radiation in the range of wavelengths from about three to 80 microns, capturing the entire average IR region. Excessive exposure to infrared radiation, especially in the near area, can lead to burns of the skin [20].

The most common source of infrared radiation of anthropogenic origin is a filament lamp. At the temperature of the filament lamp of incandescence 2300-2800 K, the maximum of radiation falls on the wavelength $\approx 1{,}2\,мкм$ and about 95% of the energy of radiation is infra-red. Used for drying and heating of incandescent lamps with tungsten hair with a power of 1 kW emit in an IR range of about 80% of all energy. When the temperature decreases, the total content of the IR radiation of the source decreases. Among spontaneous sources of infrared radiation of techno genic origin are gas-discharge lamps, coal electric arc, and electric helix with chrome wire heated by the current passing, electric heating devices, plasma units, furnaces of the most diverse purpose with the use of a variety of fuels, etc. [20].

Solar radiation is the main source of energy for all processes occurring in the biosphere. The atmosphere surrounding the Earth, weakly absorbs the short-wave radiation of the Sun, which, basically, reaches the earth's surface. The absorption of fallen solar radiation is due to the presence of ozone, carbon dioxide, water vapor, aerosols in the atmosphere. Direct and scattered components of solar radiation, reaching the earth's surface are partially absorbed by the earth's surface, and part of the falling radiation reflects from it, depending on the nature of the surface. The reflection ability of the bodies is characterized by the magnitude of the albedo, which evaluates the reflection or scattering properties [29].

Under the influence of the incident solar flux because of its absorption, the earth's surface is heated and becomes a source of long-wave radiation, which is directed to the atmosphere. In this case, there is a mutual heat exchange between the earth's surface and the atmosphere. The difference between short-wave radiation absorbed by the earth's surface and effective radiation is called the radiation balance [29].

The main feature of the radiation regime of the atmosphere is the greenhouse effect, which consists in the fact that short-wave radiation predominantly reaches the earth's surface, causing it to heat, and the long-wavelength radiation coming from the Earth is delayed by the atmosphere, while reducing the heat transfer of the Earth into space. The radiation balance of the earth's surface is $105\,{}^{Вт}\!/_{м^2}$, and the effective radiation from it is equal to the difference between the absorbed radiation and the radiation balance and is $52\,{}^{Bm}\!/_{м^2}$ [29, 30].

With the thermal balance of the Earth and the atmosphere, the water balance of the atmosphere is connected. In general, this balance for a certain surface corresponds to the equality of the amount of fallen on the Earth and the amount of water vapor from the Earth's surface.

The real thermal balance of the Earth and the atmosphere is difficult to assess, since it is even more difficult to evaluate those processes that affect this balance due to fabricated activity. Some processes lead to overheating of the Earth, others - to cooling. In addition to the role of the atmosphere as a heat shield and the effect of the greenhouse effect amplified by the human economic activity, certain effects on the thermal balance of our planet make thermal pollutants in the form of waste heat in the reservoirs, rivers, in the atmosphere, mainly the fuel and energy complex, and in the smaller to a degree, from industry [29].

By transforming the energy of organic fuels, about 30% of fuel energy is converted into electrical energy, and part of the energy enters the environment in the form of thermal pollution and atmospheric pollution by combustion products. Increasing energy consumption will increase environmental pollution, unless special measures are taken. Thermal pollution of reservoirs and atmosphere occurs also at the operation of nuclear power plants. The regularity of the overall temperature increase in reservoirs, rivers, atmosphere, especially in the locations of power plants, industrial enterprises in large industrial areas is now established. In turn, this leads to a change in the thermal regime of the ponds that affects to the life of bio organisms, to the occurrence of unwanted air streams because of the temperature rise in the atmosphere, changes in air humidity and solar radiation, and, eventually, to change the microclimate. The heat pollution of the environment, the increase in the Earth's temperature, and the warming of the climate make it pay attention to this problem in order to stimulate the development of fundamentally new sources of energy, low-waste technologies, efficient methods for recycling waste, and existing measures of environmental protection and ongoing global monitoring of the biosphere.

Depending on the method of converting the energy of incident radiation, receivers of the infrared range are divided into the main classes [2.29]:

- Heat receivers in which the absorption of infrared radiation leads to an increase in the temperature of the thermos sensitive element, which affects the parameters of the substance;
- Photovoltaic receivers in which the absorption of incident IR radiation results in the appearance or change of electric current or voltage. They have, as a rule, - -selective sensitivity to operate in both the medium and far regions of the infrared spectrum, require the use of low temperatures;

- Luminescent receivers, which use amplification or quenching of luminescence under the influence of infrared radiation;
- Photocells having sensitivity in the near field of IR radiation with a wavelength of 1.3 microns;
- Receivers, which are intended for visualization of infrared radiation;

Devices that use the method of parametric transformation of infrared radiation in the visible when mixing infrared radiation with coherent laser radiation in nonlinear optical crystals.

5.4. Protection from electromagnetic fields and radiation.

Depending on the frequency of the source of EMF, its power and mode of operation are selected by certain means of protection against the effects of electromagnetic vibrations on the human body. Under the near zone of action is meant a zone in which the electromagnetic field is not formed at a distance $r \leq \frac{\lambda}{6} \approx \frac{\lambda}{2\pi}$ from the radiator. In the near zone, EMF is characterized by an electrical component of the field. In the case of simultaneous operation of several sources in this zone acquires the total value of the squares of field strength [1]:

$$E_{\Sigma}^{2}=\sum_{i=1}^{N}E_{i}^{2} \; . \tag{5.8}$$

In a distant zone, an $r > \frac{\lambda}{6}$ electromagnetic field exists and spreads at distances. EMF is characterized by radiation intensity. As the maximum permissible level of exposure to the population, the following values of electromagnetic fields are taken into account, which, when exposed daily to irradiation in modes of radiation of this type of radiation, do not cause a disease or deviation in the state of health of the population, detected by modern methods of research during the period of exposure or in the long term after its exposure termination. The basic safety criterion for the population is set at a level not exceeding $500\,{}^{B}\!/_{м}$ 50 Hz at places of permanent residence of people [1].

A way of protecting distance and time - this way of protecting the environment from the effects of EMF is basic, including both technical and organizational measures. When placing radio engineering facilities and objects in the service areas for the purpose of obtaining the levels of EMF, the remote control units shall not exceed the following [1]:

- Power and frequency range of the source of EMF;
- Design features, directional diagram and height of the antenna placement of the emitter;

- Relief of the area;
- Optimal mode of operation of the EMF source;
- Storminess and development peculiarity.

In order to reduce the EMF industrial frequency increase the height of the suspension of high-voltage wires, removing residential construction from the power line, apply shielding devices. The method of time protection is that it is near the EMF sources as little time as possible [31].

The method of protecting shielding from electromagnetic radiation uses the processes of reflection and absorption of electromagnetic waves. Screening eliminates the penetration of electromagnetic waves into the environment. In open areas located in zones with higher levels of EMF, screening devices are used in the form of reinforced concrete fences, screening nets, tall trees [27].

With the interaction of the falling electromagnetic waves with the radio-absorbing material (RPM), its absorption, scattering, and in some cases, RPM, is interference. Because of these processes, the dissipation of the falling energy energy occurs in the absorbing coating and the reflected wave becomes insignificant. To ensure a small reflection of a falling wave, from the absorbing coating, it is required that its properties do not differ much from the properties of the free space, that is, the medium in which the wave propagates. On the border of the section "the environment - the surface of the RPM" there should not be a noticeable jump of refractive indexes. In this case, the falling wave, without noticeable reflections at the boundary of the division, will penetrate into the absorbing coating with subsequent absorption and scattering. Therefore, in order to comply with this requirement, it is necessary, so that the complex wave absorption resistance of the absorption coating sought in absolute value to the wave resistance of free space [25].

For effective absorption of the waves, it is necessary that the environment have significant losses. In this case, the imaginary parts of the complex dielectric and magnetic permeability should have high values. Under these conditions, the wave resistance is significantly different from the wave resistance of the free space and the reflection coefficient increases. To reconcile these two requirements, a number of measures are taken that take into account the purpose and scope of the RPM, the frequency range of its work, and the requirements for the mass-size characteristics, especially the operation [27].

Volumetric absorbers use volumetric absorption of electromagnetic energy due to the introduction of electrical or magnetic losses. Absorbent materials of this type consist of a base and a filler. As a base, various rubbers, foam and other organic substances are used. As fillers use powders of graphite, carbon and acetylene soot, carbonyl iron powders, ferrites, thin metal fibers. The outer surface of volumetric absorbers is often performed in the form of cones or pyramids. Varieties of volumetric sinks have a great variety. Their advantage is the high absorption of EMF energy with a low reflection coefficient in a wide range of frequencies. Among the disadvantages can be attributed relatively large weight and dimensions [32, 33].

Resonant absorbers are a composition of the alternating layers of the dielectric and conductive metal films. The dielectric thickness is one quarter of the wavelength of the incident radiation, or a multiple of an odd number. The principle of such systems is based on the interference of the falling wave and the formation of standing waves in them. Such sinks have a low reflectivity, low mass, compactness, but not enough broadband [34].

Influence of fabricated radiation on biological objects. The atmosphere, the hydrosphere, and the upper part of the lithosphere, which is called the biosphere, is an integral, complex, dynamic system in which living organisms and their environment are organically linked to each other and interact with each other [21].

One of the conditions for the equilibrium of the ecosystem is the relative stability of these factors, or their change within the limits that will not exceed the rate of adaptation of living organisms. Irreversible processes in the biosphere occur during a million years, and living organisms that have amazing properties adapt to external conditions, have time to adapt. Anthropogenic changes in the environment have another character, which sometimes leads to a sharp perturbation of the mean values of abiotic factors that go beyond the limits of the sustainability and development of a living organism [8].

The emergence of man as the supreme intelligent being has made and is increasing the increasing influence on the biosphere. Along with the deep dielectric combination of man and nature, their relationship is controversial in nature. On the one hand, people came out of nature, enjoyed its resources, on the other hand, through its turbulent activities, people began to create their own, different from the natural ecosystem of man. The appearance in the biosphere of new components caused by human activity, characterized by the term anthropogenic "pollution". Under this term, waste is understood to mean that when it enters the environment, its biotic and abiotic properties are changed or destroyed. Contamination can also affect the energy balance, physical and chemical properties, levels of radioactivity and the electromagnetic background of the environment [8].

Technological "pollution" and harmful effects can be divided into four major groups: physical, chemical, biological and aesthetic [1].

Physical pollutants include noise, vibration, electromagnetic fields, ionizing radiation of radioactive substances, thermal radiation, ultraviolet radiation and visible radiation resulting from anthropogenic activity [1].

The chemical group of pollutants includes not only various chemical elements and substances, but also those compounds that are formed when the contaminants that have got into contact with the biotic and abiotic factors of the biosphere. This is very dangerous, since it is difficult enough to predict the speed and nature of chemical interactions, resulting in a final product may be even more toxic than in the initial state. The intensive use of aerial spraying chemicals has led to extensive environmental pollution. Of course, these harmful substances affect all the components of the biosphere [1].

To biological pollutants, include microbiological poisoning, change in the structure of biosensors [1].

Aesthetic damage is manifested in disturbed landscapes at the expense of growing urbanization, the construction of industrial objects in the territory of natural reserves [1].

The natural environment that surrounds us has sources that form the noise, electrostatic and electromagnetic natural Earth background. The main sources that form the electromagnetic and noise background are the Sun, the magnetosphere, and atmospheric electricity [3].

The process of transferring energy from the Sun's nucleus to its periphery is quite complicated. Most of the energy from the upper part of the solar corona is caused by the flux of the solar wind. These streams are a plasma. Which radially flows into interplanetary space. The formation of a solar wind is due to the energy fluxes of the deeper layers of the Sun. Depending on the state of solar activity near the Earth's orbit, the concentration of protons is from several particles to several tens of particles in one at the flow $5 \cdot 10^7$ - $5 \cdot 10^8 см^{-2} \cdot с^{-1}$. . The energy that belongs to the solar wind in the interplanetary space is $10^{20} - 10^{22} Вт$. The change in the intensity of the solar wind greatly affects the heating of the upper atmosphere of the Earth, the northern glow, magnetic storms and various biophysical processes. An increase in the intensity of the solar wind occurs because of solar flares that occur in the active regions of the atmosphere and last from a few minutes to several hours. The energy released during the flash reaches$10^{22} Дж$. . At the same time, there is a significant increase in the intensity of ultraviolet radiation of the Sun accompanied by X-ray bursts and radio emission, a significant release of high-energy particles; almost to $10^4 МэВ$.Solar, flares do not give a cardinal value to the energy balance of the Earth. However, solar flares have a significant impact on biochemical and biophysical processes, and the Sun is ultimately one of the main sources of Earth's energy, not only in the form of continuous feeding of electromagnetic energy, but also other energy sources such as organic fuel, mechanical energy of wind, sea surf and etc., whose origin is largely due to solar radiation [6].

In the ionosphere, there are intense streams. Since the motion of charged particles depends on the magnitude and direction of the power lines of the electric and magnetic fields, on their time dependencies, on the sign of the charge and on the velocity vector, then, in accordance with the definition of the trajectory of each individual particle, it is an extremely difficult task. Each charged part, in addition to the action of the fields, undergoes a collision with other particles with an unpredictable pulse exchange during its motion. Currently, a mechanism is developed that explains the basic processes of interaction of the solar wind, the magnetosphere and the ionosphere of the Earth, including the formation of polar light [7].

Atmospheric electricity is a significant abiotic factor in the biosphere, which plays an important role in ecology. The electrostatic forces determined by the Coulomb interaction between two fixed charges are many times greater than the gravitational interaction. When an atmosphere of one kind of electricity appears in the atmosphere, there is always an equal amount of electricity of a different kind. There is no single phenomenon in which a charge of one kind was created or disappeared. There is always a redistribution of charge between bodies. At ionization of atoms, there are free electrons, but there arise positively charged ions [6, 7].

The sources of atmospheric electricity in local areas are eruptions of volcanoes, tornadoes, blizzards, dust storms, spray of sea waves and waterfalls, clouds, sediments, steam and smoke generations of natural and fabricated origin. In this case, the electrification of the atmosphere is very violent, which leads to the appearance of lightning phenomena. In tumultuous clouds, the density of currents is an order of magnitude higher than the density in the storm clouds. The total current flowing to the earth's surface from a single storm cloud is approximately equal to 0.1A (in our latitudes) and reaches 1A in the areas of the equator [6, 7].

Study of electrical processes in the atmosphere and control of the state of the atmosphere are of great importance for ecology both in terms of biological effects of atmospheric electricity, and in terms of reducing its harmful and dangerous effects on various fabricated objects. The electrical processes occurring in the atmosphere are due to not only statistical electricity and electromagnetic, cosmic and solar radiation, but also the clouds themselves are sources of radio emission. Atmospheric electricity manifests itself in the form of various phenomena, of which a prominent place is occupied by lightning [8].

Lightning is a spark discharge between isolated particles of air. Lightning are linear, point and ball. Among linear lightning, distinguish between "ground" and intrinsic.

Spot lightning consist of "spot-dots" that are luminous, separated by dark spaces. Clumped lightning are luminescent oval shapes with a diameter of about 10 - 20 cm. Bullet lightning has a significant amount of energy that it achieves $10^6 - 10^7 \, {}^{Дж}\!/_{г}$. All kinds of lightning’s have a harmful and sometimes dangerous effect on various objects and people [8].

With the intensity of the electric field, more than $500 - 1000 \, {}^{В}\!/_{м}$ the surface of the Earth in the atmosphere there is a glow, which is observed in the sharp parts of the Cathedral of St. Elm, therefore, and called the fire of Elma [8].

The sources of UV radiation are stars and other space objects. In the radiation range $\Delta\lambda = 0{,}09 - 0{,}02\textit{мкм}$ of these bodies, it is absorbed by inter-star hydrogen and partly by the upper layers of the atmosphere. A large number of UV radiation sources have anthropogenic origin. Anybody that is heated to 3000 K or higher has its ultraviolet component spectrum. The higher the temperature of the body, the more visible the ultraviolet component of the spectrum. Any high-temperature plasma is a source of UV radiation that has a linear and continuous spectrum. As the electron temperature increases, the intensity of UV radiation increases, and in some cases, even X-rays [8].

Techno genic sources of UV radiation include more than 70 different laser systems operating in the UV and vacuum UV range. These sources include some metallurgical furnaces and blast furnaces that melt high-temperature metals and alloys using oxygen blast, powerful electronic and plasma streams [21, 8].

The biological effects of UV radiation are based on the photochemical processes of molecules of biopolymers that occur in organisms when absorbed by the upper layers of tissue of plants or animal skin and man of incident radiation. Depending on the intensity and length of the wave, UV radiation acts in two ways on living organisms. On the one hand, small doses of UV irradiation have a beneficial effect on humans and animals and contribute to the formation of vitamin D. On the other hand, UV irradiation has a detrimental effect on living organisms [9].

Given the high energy of UV radiation quanta and their ability to cause degradation of molecular and intermolecular bonds, as well as directly affect intracellular tissues with the formation of radicals, UV rays are a great danger to the living body's cells. Large doses of UV radiation can cause skin burns and carcinogenic reactions, eye damage and other unwanted processes. UV rays with a wavelength of 0.24 - 0.28 microns have a particularly strong effect on the body and lead to lethal and mutagenic effects, as this spectrum coincides with the absorption spectrum of nucleic acids. At absorption quanta of the UV range, chemical changes in DNA occur due to the formation of dimers that counteract the normal DNA doubling in the process of cell division. This leads to the death of the cell or to change its hereditary properties, that is, the formation of mutations. Most living cells have the ability to be installed after damage caused by UV radiation [9].

The mechanism of action of UV radiation on living organisms is not fully understood; the more it is impossible to predict the consequences of the survival of various bio objects with increasing intensity of UV radiation and shifting its spectrum toward short waves. This process is undesirable. Humanity must take care that the atmosphere and the ozone layer remain a reliable protection against harmful short-wave UV radiation [14, 15].

Ozone, which is in the atmosphere, plays an extremely important role in terms of absorption processes of the short-wave component of solar radiation, thereby fulfilling the protective function for the biosphere, as well as from the point of view of the regulator of the temperature regime of the atmosphere [8].

The stratospheric layer of ozone has a great influence on the temperature regime of the atmosphere and the processes of absorption of solar radiation throughout the spectral range. In the tropospheric layer, the temperature with an increase in altitude decreases by about 6 K per kilometer. This layer of the atmosphere is called the first isothermal layer. Above this layer, the temperature rises again to almost 270 K, reaching the level of the stratopause and remains constant until 55 km. This area is called the second isothermal layer. It should be noted that the bulk of the air in the atmosphere falls on the troposphere and stratosphere, and only 1% falls on the mass of the atmosphere, which is above 51 miles. From the exosphere region, located above the region of the thermosphere, scattering of atoms of the atmosphere into the world is due to dissociation processes [8].

Photoemission receivers are most commonly used as an external photoelectric effect. The main purpose of these receivers is to convert an optical signal to an electrical or to convert the spectral composition and a clear image when recording incident UV radiation [14].

The main characteristics of photocells is the spectral sensitivity of the photocathode; current dependence on light flux; anode dependence of current in the circle of anode on voltage; frequency dependence of the output signal on the frequency of the sinusoidal-modulated light flux. The main parameters of FE are the working surface of the photocathode; rated voltage of the current source; area of spectral sensitivity; spectral sensitivity for the wavelength at which the parameter has the maximum value; light sensitivity, dark current, the greatest value of the anode current in linear mode. These devices represent a combination of electronic devices for microwave and photovoltaic devices. This new class of electronic devices, thanks to its sensitivity and broadband, is very promising in laser communication systems [14].

From the quantum theory, it is known that the internal energy of particles and of the matter itself is quantum, that is, it may have a number of certain discrete energy levels. The transition from one state to another is accompanied by radiation or absorption of a quantum. The basic level - the lower energy level of the particle - corresponds to the smallest internal energy. Other levels, corresponding to high-energy values, are called excited. The transition between levels can be radiation and no radiation. In the first case, the energy quantum enters the surrounding space, in the second one it is transmitted to adjacent particles [14, 15].

Radiation transition is accompanied by spontaneous or induced radiation. At spontaneous emission, a spontaneous transition of a particle from the upper energy level to the lower one occurs. In this case, the photons are not interconnected, that is, their polarization, phase, direction of propagation are of a random nature. Induced radiation occurs when the particle passes from the excited level to the main one under the action of the quantum of an external electromagnetic field whose frequency exactly corresponds to this transition.

To obtain the effect of amplifying the field, it is necessary that the upper population level be more populated than the lower level, that is, in the case of a thermodynamic equilibrium; the condition of inverse population must be fulfilled. Such a state of a quantum system is called active. Inverted population is a necessary condition for the operation of all quantum generators and amplifiers. In the case of an equilibrium distribution, in accordance with Boltzmann's law, the upper-level population must always have a lower population density. In the case of an inverse population of the two selected levels, the upper level should have an inversion population that corresponds to a no equilibrium state [34].

To ensure the necessary condition for the operation of a quantum device with the aid of an incoherent source of energy, they seek to ensure that a pair of all levels has a low inversion population. Such a process is called "pumping", with the help of which is established non-equilibrium population of any group of energy levels. To date, there is a large number of methods for creating an inversion population: the method of auxiliary radiation, stationary gas discharge, non-stationary thermal methods of pumping, corpuscular pump, and chemical methods of pumping, method of injection of carriers in semiconductors [34].

All laser systems are divided into four groups [21]:

Solid-state lasers. This group includes quantum devices whose active medium is solid crystalline or amorphous substances activated by certain elements, such as chromium, cobalt, nickel, etc. The most common method for pumping solid-state lasers is an optical method. In this case, intensive light sources are used. The main advantage of solid-state lasers is the high values of power and energy of radiation. This is explained by the fact that it is easy to provide high concentration of atomic activators in a solid in a solid.

Gas lasers this class of quantum devices includes lasers, in which the active medium is gas or a mixture of gases. Depending on the use of energy levels of molecules, atoms or ions, gas lasers can be divided into molecular, atomic, and ionic. Because the energy spectrum of gas exactly corresponds to the energy spectrum of individual atoms, different schemes of transitions between energy levels can be established in these systems. As well as in gas lasers, a high order of monochromaticity and coherence of radiation is obtained, because the gas is an optically homogeneous medium that allows the use of large distances between the mirrors. Next, the gas environment allows you to apply different ways to create a population inversion.

Liquid lasers this class of quantum devices combines the advantages of solid-state lasers in terms of using a large concentration of active carriers and gas lasers in terms of obtaining optical uniformity in large volumes. Making active elements of large size solid-state lasers is difficult and expensive. In liquid lasers, you can use large volumes of the active medium, which is placed in the active resonator. In addition, during continuous operation, the liquid active substance enables during operation to maintain an optimum temperature due to circulation in the space of the optical resonator.

Semiconductor Lasers. In these lasers, various semiconductor materials are used. With these lasers, you can receive induced radiation in a wide range. The main advantage of semiconductor lasers is high efficiency.

Laser radiation, which has high intensity, allows obtaining large values of electric tension in the stream. Laser radiation allows relatively simply vary the power of the beam, change the direction of its propagation by means of focusing lenses, external collimators, reflective mirrors, or special devices. The properties of the lasers allow for unusually high values of the brightness of the radiation. One of the important characteristics of laser radiation is the direction of radiation [34].

The application of traditional methods of measuring the level of pollution of the atmosphere faces the difficulty of the fact that sampling takes place under difficult conditions. The processing of results takes a relatively long time. In addition, the accuracy of the measurements has significant errors due to the mutual influence of the measuring instrument on the object of research. Great advantages are remote methods, and especially methods using laser radiation. Methods of laser diagnostics allow conducting measurements at large distances from the investigated object. It does not require sampling and chemical analysis. The basis of laser sounding methods is the object's exposure to an incident stream with subsequent analysis of the flow that passed through the object. Using any effect of the interaction of incident laser radiation with particles of the atmosphere come to different methods of laser sounding [21].

The method of optical location of the laser sounding of the atmosphere is similar to the radar method. Devices that operate on this principle in the optical range are sometimes referred to as lizards. With this method, it is possible to determine the total concentration of aerosol particles without establishing the kind and properties of scattering particles [30].

The method of combined scattering consists in the fact that during the scattering of light by gas molecules there is a shift of scattering radiation. Combination frequency shift has every molecule of gas, which is characteristic only for it. The environment, which consists of a mixture of gases of molecules, has its own, but it has its own combination spectrum. Registration of the spectrum of scattering radiation allows us to determine the presence of impurities in the investigated medium by analyzing the displacement lines and absorption bands [30].

The method of resonance fluorescence is based on the ability of individual molecules to fluorescence under the action of incident laser radiation of a certain wavelength [30].

The method of registration of radiation passing - based on the registration of radiation, which passes through the investigated environment. This method can be very cumbersome and inconvenient in remote detection systems. Varieties of this method have high sensitivity, which is very beneficial for cases where it is possible to sample air samples with pollutants and perform a thorough analysis with high identification [30].

5.5 Protection of information and information-communication systems (ICS) and information and communication networks as an element of the environment, from the influence of external forces, including EM radiation

One of the most important tasks in studying the influence of EM fields on different structures of electrical systems is the study of the stability of high-voltage and low-voltage power cable lines, as well as the protection of information channels of energy management systems in relation to the action of external electromagnetic radiation of different origin and evaluation. The corresponding currents and voltages given by this radiation in the lines. In this case, external refers to the radiation generated in a wide range of frequencies external to the CL by sources of the most diverse nature.

As such sources, various elements of electrical systems generating EM fields may exist, for example, near power lines, switching devices and current limiting devices, receivers and transducers of low and high voltage electric power, as well as electric lightning discharge, various types of powerful emitters of EM energy (egg, high-power microwave systems, radio transmitters and locator systems), ionizing radiation sources [11].

When screening a CL, the degree of influence of the external EM field, the amplitude of the induced voltage in the conductors of the CL is significantly reduced, as it is said, for example, on the question of the quality of electric energy. In addition, the problem of CL protection has a special significance in resolving issues of effective protection of information flows in control systems, communications and telecommunications used in power facilities. Thus, there is a need to assess the impact of external EM fields, as well as on the quality of electrical energy of CL and secondary circuits, and the reliability of the transmitted information (control signals) - for CL control systems for electrical engineering objects and communication systems [27].

The accounting of electromagnetic compatibility of power, secondary and informational CL with other elements of the considered electrical system allows to prevent the adverse effects of external EM sources. Examples of such actions may be, as already noted, a deterioration of the quality of electricity transmitted by KL, as well as the heating of the shells, and consequently an increase in losses in the line [35].

It should also be noted that in recent years, the use of sensitive electronic equipment and computer technology in electrical systems has become more and more widespread - all kinds of electronic security devices, computer control and control systems for power systems using cable and radio transmission channels. This circumstance, of course, means that supplying such equipment to the line and line used for the exchange of controllers (information) signals require shielding. Unfortunately, the actual effectiveness of shielding is often far from perfect, which leads to the external membranes of the EM fields still penetrating through the screen in varying degrees and affecting the characteristics of the stresses and currents in the central vein. This necessitates a practical study of the degree of such influence [33].

The relevance of these issues suggests that in the last two decades this issue has been given particular attention by a number of international scientific organizations and the scientific community. Another important task in evaluating the changes in the parameters of electrical engineering systems that occur as a result of the influence of the EM field on the KL is the study of the peculiarities of the propagation of the external EM field signal along the line, depending on the nature of the load attached to it, including modulation issues, sinusoidal disturbances, generation higher harmonics, etc. [33].

These considerations determine the relevance of the development of methods and algorithms for modeling the influence of external sources of EM fields on cable lines of different purposes, which would allow taking into account the value of the contribution of this field to the proper voltage of the KL in solving this set of problems [36].

A detailed study of the problem of the external EM influence on the conductor involves analyzing the dependence of the induced voltage on the parameters of the incident wave: their angle of incidence on the conductor, frequency and amplitude. No less important task is to study the effect of the induced signal on the useful signal in the cable and the normal mode of load of the study line [37].

To calculate the fields arising at the fall of the EM wave on the cable, the problem of diffraction was solved for an infinitely extending cable [38].

Often, for solving the problem of the influence of the external EM field on the cable lines, as a coaxial cable, a conductive circular cylinder placed in the outer field is considered. For various cases, the task of spatial field heterogeneity by the energy balance method has been used to obtain a series of formulas for the propagation of current density, losses, electrodynamic forces and moments. However, this approach too simplifies the real geometry of cables and does not take into account the layered structure of the cable line with different electrical and magnetic properties of each of the layers [39].

At present, the problem is solved mainly theoretically, and there are no practical recommendations for design engineers and engineers to account for possible external influences (at the stage of designing electrical networks, as well as for additional protection of the operation of cable lines) [39].

The next step in the study of the effect of external EM on the wireline is to study the distribution of the conduction waves given by the current and voltage (CHF). The mathematical calculation of the CHF is reduced to solving the Cauchy problem for a system of telegraph equations that characterize the change in current and voltage per unit length of the line. However, classical telegraphic equations can count on heterogeneous lines and take into account heterogeneous external influences. When considering a line located in external electric or magnetic field variables, one should describe the voltage given in it by means of a system of differential equations supplemented by terms defined by external fields. Thus, these equations become heterogeneous. One of the main difficulties is that the external field varies along the length of the line. Examples can be drawn from different areas [39, 40]:

- discharge lightning near power line;
- Field effect on cables located on the open substation; in this case, the range of EMF impact can be much less than the length of the cable;
- Changing the route of the cable, for example, its turn by 90 °, etc.

The developed algorithm allows determining the possible deviations of voltage in the cable line with certain parameters from the nominal voltage, depending on the amplitude and frequency characteristics of the incident wave. For this, the parameters of external electromagnetic fields are recommended to be measured with the help of special equipment. As a result, with the help of the obtained nomogram, it is possible to detect cases where such deviations exceed the standards allowed by GOST. Such information is useful, first, when designing or reconstructing energy objects, when it is necessary to take into account the electromagnetic compatibility of cable lines of various purposes and located near the electrical equipment [40].

The approach presented is much simpler and less labor-intensive than others that were used and based on a complex model of a line with distributed sources.

Theoretical and practical results indicating the necessity of solving EMC problems of cable lines with other objects of electric power industry. This is especially true when designing low voltage cable lines, control cables and control and automation cables. Predicting EM environment should be carried out at the stage of construction, design, installation, maintenance and the renovation of electrical facilities and systems. It should be recommended [40]:

1. Before designing the tracks for passing cable lines of different purposes, it is necessary to pre-evaluate the EM situation in the way they follow. This is

especially true for cables supplying electronic equipment for protection, emergency automation and communication.
2. For existing cable lines you need to use additional shielding. The armor used as a screen should be grounded twice - in the territory of the RU and at the entrance to the building of the GSCHU (main board of control) and OPU (operational control panel).
3. Lay cables and bus bars of high voltage lines at significant distances more than 50 m from the premises from the main station and the district heating complex.
4. Use, where applicable, optical communication lines that are superior to traditional cables that are not EMF-insensitive and high-bandwidth, and therefore have high and reliable high-quality connectivity.
5. On secondary cables coming from RU, it is necessary to establish special filters for frequencies, characteristic for switching obstacles, which exist on a concrete energy object. It is necessary to provide low resistance on the ground plane of the power unit in general and grounding devices of switching devices in particular.
6. When laying cables with signals of different types in one tray, it should be provided for their division into different beams by signal types and dilutions at the greatest possible distance from each other. In the presence of cables of different voltages, there is a need for mandatory shielding, especially if the cable does not have metal shells.

5. 6. Radiation. Natural and artificial sources of radioactive contamination. Radiation protection

5. 6. 1. Theoretical foundations of ionizing radiation physics

Radiation is a generalized concept. It includes different types of radiation, some of which are found in nature, others go artificially.

First, it is necessary to distinguish between corpuscular radiation, which consists of particles with a mass different from zero, and electromagnetic radiation. Corpuscular radiation can consist of both charged and neutral particles. Distinguish the following types of corpuscular radiation [34]:

Alpha radiation - are helium nuclei, which are produced by radioactive decay of elements heavier than lead or formed in nuclear reactions.

Beta radiation - these are electrons or positrons, which are formed during the beta decay of various elements from the lightest (neutron) to the heaviest.

Cosmic radiation comes to Earth from outer space. It consists mainly of protons and helium nuclei. The heavier items are less than 1%. Penetrating deep into the atmosphere, cosmic radiation interacts with the nuclei that form part of the atmosphere, and forms streams of secondary particles (mesons, gamma quanta, neutrons).

Electromagnetic radiation has a wide spectrum of energies and different sources: gamma-radiation of atomic nuclei and braking radiation of accelerated electrons, radio waves.

Different types of radiation interact in different ways with matter, depending on the type of particles released, their charge, mass and energy. Charged particles ionize the atoms of matter, interacting with atomic electrons. Neutrons and gamma quanta, when faced with charged particles in matter, transmit their energy to them, in the case of gamma quanta, the birth of electron-positron pairs is also possible. These secondary charged particles, inhibit in the substance, cause its ionization [41].

In the reaction of the organism to irradiation can be identified four phases.

The first, the physical phase of ionization and excitation of atoms lasts 10-13 seconds (all phases last about the same time). In the second, the chemical-physical phase, highly reactive radicals are formed, which, when interacting with various compounds, give rise to secondary radicals that are much larger than the original life span. In the third, the chemical phase, formed radicals react with organic molecules of cells, which leads to a change in the biological properties of molecules [19].

The described processes of the first three phases are primary and determine the further development of the radiation damage. In the ensuing fourth, biological phase, chemical changes in molecules become cellular changes. Different types of radiation are characterized by different biological efficiency, which is due to differences in their penetrating ability and the nature of the transfer of energy to organs and tissues of living objects, consisting mainly of light elements [19].

Alpha radiation has a small particle passing distance and is characterized by weak penetrating power. It cannot penetrate through the skin. The flow of alpha particles with energy of 4 MeV in the air is 2.5 cm, and in the biological tissue, only 31 mm. Alpha-emitting nuclides are a great danger when ingested inside the body through the respiratory and digestive organs, open wounds and burning surfaces [16].

Beta radiation has a greater penetrating power. The run of beta particles in the air can reach several meters, and in the biological tissue a few centimeters. Thus, the runaway of electrons with an energy of 4 MeV in the air is 17.8 m, and in biological tissue 2.6 cm [16].

Gamma radiation has even higher penetrating power. Under its action is the irradiation of the entire body [16].

The lifetime of the excited state is very small (<10-13s), but in some cases, the excited state of the nucleus can exist for a very long time. Such nuclear states are called metastable. The cores that have metastable levels are called isomers. The nucleus-isomer has the property of 2 nuclei: its parameters (mass, spin, magnetic moment) in these states are different. Isomeric states are often found in heavy nuclei. The cause of isomerism may be a strong difference in the form of a nucleus for isomeric and basic states [16].

Internal conversion is a process that competes with γ-radiation, and this competition is characterized by a full coefficient of internal conversion α , which is equal to the ratio of the probability of emission of electrons to the probability of emission γ - quanta, i.e.:

$\alpha = \frac{N_e}{N_\gamma} = \alpha_K + \alpha_L + \alpha_M$, where $\alpha_K, \alpha_L, \alpha_M$ - partial coefficients of internal conversion for electrons K, L, M - shells. The internal conversion is accompanied by β-decay, because the primary nucleus can disintegrate through β-emission to the secondary nucleus to an excited state, which is removed through the corresponding transitions. If E excitation of the kernel is dominated by its own E nucleus twice, then the paired conversion process may occur. In this case, the kernel loses E excitation by releasing the positron electron. The electron shell of an atom on such a process has no effect, it can occur on a nucleus without atomic electrons, but the probability of a pair conversion does not exceed 0.001 from the probability of radiation of the γ-quantum [34].

The problems of protecting the population against ionizing radiation are global and international in nature and therefore relevant research and organizational measures are being developed not only in individual countries but also globally. The aim of the measures of protection is to ensure high indicators of health of the population, which include life expectancy, time-specific characteristics of physical and mental performance, well-being and the function of reproduction. Protection measures include [42, 43]:

1) reduction of radiation exposure of the population from all major sources of radiation;
2) restriction of harmful influence on population of non-radiation factors of physical and chemical nature;
3) increase of resistance and anti-carcinogenic protection of inhabitants;
4) medical protection of the population;
5) raising the level of radiation and hygienic knowledge of the population, psychological assistance to the population, helping to overcome the excessive perception of the danger of radiation;
6) formation of a healthy way of life of the population;
7) Increase of social, economic and legal protection of the population.
8) In cases of emergency, additional protection, measures are taken.

5. 7. Physical principles of interaction of ionizing radiation with matter

Charged particles, passing through a substance, interact with the electron shells and nuclei of atoms. The trajectory of a heavy charged particle in matter is practically straightforward. The main characteristics of heavy charged particles when passing in a substance are energy loss and full mileage until stopped [34].

The general electromagnetic energy losses of charged particles consist of ionization losses, radiation losses, radiation losses and transient radiation.

Ionization losses are energy losses of charged particle, which are related to the violation and ionization of the atoms of a substance. Specific ionization losses are called the inhibitory capacity of the substance. This is the average energy lost by the particle per unit length of the path. Specific ionization losses can be attributed to the value $\xi = x\rho$, where ρ is the density of the medium [34].

Let a ze-charged particle (z = 2 for a-particles) fly at a speed v at a distance ρ from a free electron with a mass me and a charge of - e, and then the electron receives a pulse in the direction perpendicular to the flight paths of the particle. The momentum of an electron in the direction of parallel motion particles is zero, as in the case of flying $F' > 0$ while flying $F'' < 0$ [34].

The force acting on the electron from the particle side on the site 2ρ is equal to. By the second law of Newton $\Delta p = F \cdot \Delta t$. Distance 2ρ particle passes through time $F = \frac{ze^2}{\rho^2} = const$. An impulse that is transmitted to an electron $\Delta p = \frac{2ze^2}{\rho \cdot \nu}$. The energy transmitted to the electron [34].

$$\Delta T = \frac{(\Delta p)^2}{2m_e} = \frac{2z^2e^4}{m_e\nu^2} \cdot \frac{1}{\rho^2}$$

The particle transmits energy to all electrons that are in a cylindrical layer with a radius of ρ thickness $d\rho$ and length dx . Volume of cylindrical layer $dV = 2\pi\rho d\rho dx$. In this volume, there are electrons: $dN = n_e dV$, where n_e - the concentration of electrons. The total loss of the kinetic energy of a charged particle due to interaction with all electrons dN in the cylindrical layer

$$dT = \Delta T n_e dV = \frac{2z^2e^4}{m_e\nu^2\rho^2} n_e 2\pi\rho d\rho dx \text{ [34].}$$

The maximum distance $\rho_{\max}$ is defined as the limiting distance at which the ionization of electrons in the target atom occurs. In this case, the Coulomb energy of the interaction of a charged particle and an electron $\bar{I}$ is equal to the average electron ionization energy $\bar{I} = \frac{ze^2}{\rho_{\max}} = 13{,}5(eB)$. Then $\rho_{\max} = \frac{ze^2}{\bar{I}}$. The maximum energy that can be transmitted by a moving heavy particle of an electron determines the minimum distance $\rho_{\min}$. Maximum pulse, which is transmitted to the electron by a heavy particle $\Delta p_{\max} = 2m_e \nu$, where ν - the particle velocity. Maximum kinetic energy transmitted to the electron $\Delta T = \frac{(\Delta p_{\max})^2}{2m_e} = 2m_e v^2 = \frac{2z^2e^4}{m_e v^2} \cdot \frac{1}{\rho^2}$ from where $\rho_{\min} = \frac{ze^2}{m_e \nu^2}$. Substituting the formulas, we obtain the relation [34]:

$$\frac{\rho_{\max}}{\rho_{\min}} = \frac{m_e \nu^2}{\bar{I}} . \tag{5.8}$$

A more precise formula for Bohr for the complete specific ionization losses of a heavy charged particle that moves at a velocity has the form [34]:

$$\left(-\frac{dT}{dx}\right)_{іон} = \frac{4\pi z^2 e^4 n_e}{m_e \nu^2} \left\{ \ln \left[\frac{m_e \nu^2}{\bar{I}\left(1 - \frac{\nu^2}{c^2}\right)} \right] - \frac{\nu^2}{c^2} \right\} . \tag{5.9}$$

At relativistic velocities of a particle, the maximum energy transmitted to an electron increases. The addendum is $-\frac{v^2}{c^2}$ connected with the Lorentz contraction of the Coulomb field, which leads to the transfer of energy to distant electrons [34].

The main result: the specific loss of the energy of the charged particle on the ionization of the medium, proportional to the square of the charge of the particle, the concentration of electrons, and inversely proportional to the square of the particle velocity [34]:

$$\left(-\frac{dT}{dx}\right)_{іон} \sim \frac{z^2 n_e}{\nu^2} . \tag{5.10}$$

Dependence on the mass of the particle is absent.

Passage of light charged particles (electrons and positrons) through a substance qualitatively differs from the passage of α-particles and protons. The mass of an electron is much smaller than the mass of nuclei. The transfer of a pulse is large when a moving electron collides with electrons of atoms, and the trajectory of its motion is different from the direct one. An electron collides with acceleration, which generates quanta of an electromagnetic field. As the inhibition in the substance of a monoenergetic bundle of electrons becomes a diffusion stream with a complex spatial distribution of electrons by energies.

Complete electron losses consist of ionization losses and radiation losses (losses on braking radiation) [34:]

$$\left(-\frac{dT}{dx}\right)^{(e)}_{повн}=\left(-\frac{dT}{dx}\right)^{(e)}_{іон}+\left(-\frac{dT}{dx}\right)^{(e)}_{рад}. \qquad (5.11)$$

Specific non-relativistic ionization loss of electrons at energies $\beta=\frac{\nu}{c}$ at $c<<1$,

$$\left(-\frac{dT}{dx}\right)^{(e)}_{іон}=\frac{4\pi e^4 n_e}{m_e\nu^2}\ln\frac{m_e\nu^2}{2\bar{I}} . \qquad (5.12)$$

Specific ionization losses of electrons in the general case

$$\left(-\frac{dT}{dx}\right)^{(e)}_{іон}=\frac{2\pi e^4 n_e}{m_e\nu^2}\left[\ln\frac{m_e\nu^2 T}{2\bar{I}^2\left(1-\beta^2\right)}-\ln 2\left(2\sqrt{1-\beta^2}-1+\beta^2\right)+1-\beta^2\right], \qquad (5.13)$$

Where $T=\frac{mc^2}{\sqrt{1-\beta^2}}-mc^2$ - the relativistic kinetic energy of an electron.

The charged particle, which moves with negative acceleration, always emits electromagnetic waves. The emission of photons is due to the scattering of particles in the Coulomb field of nuclei. The Coulomb field inhibits a charged particle. The resulting radiation is called brake radiation. Losses of energy on such braking radiation are called radiation losses. The relations [34] describe specific radiation losses of electrons:

$$\left(-\frac{dT}{dx}\right)^{(e)}_{рад}=\frac{16}{3}nT_e\frac{z^2r_e^2}{137} ,$$

At $T_e<<m_ec^2=0,5MeB$,

$$\left(-\frac{dT}{dx}\right)^{(e)}_{рад}=nT_e\frac{z^2r_e^2}{137}\left[4\ln\frac{2T_e}{m_ec^2}-\frac{4}{3}\right],$$

At $m_ec^2<<T_e<<137m_ec^2Z^{-1/3}$,

$$\left(-\frac{dT}{dx}\right)^{(e)}_{рад}=nT_e\frac{Z^2r_e^2}{137}\left[4\ln\frac{183}{Z^{1/3}}+\frac{2}{9}\right], \qquad (5.14)$$

At $T_e>>137m_ec^2Z^{-1/3}$

Where T_e - the kinetic energy of the electron, $r_e = \frac{e^2}{m_e c^2}$ - the classical radius of the electron in the atom, n_e - the concentration of electrons, Z - the serial number of the atoms of the substance. From formulas (8.6), it follows that radiation radiation losses are of the form $\left(-\frac{dT}{dx}\right)_{рад} \sim Z^2 n_e T_e$. Taking into account that ionization losses, $\frac{\left(-\frac{dT}{dx}\right)_{рад}}{\left(-\frac{dT}{dx}\right)_{іон}} \approx \frac{T_e Z}{800}$ we obtain the following relation between radiation and ionization electron losses [34]:

$$\frac{\left(-\frac{dT}{dx}\right)_{рад}}{\left(-\frac{dT}{dx}\right)_{іон}} \approx \frac{T_e Z}{800} \ . \tag{5.15}$$

The distance traveled by a charged particle in a substance to a complete loss of kinetic energy is called run [34]:

$$R = \int_{T_0}^{0} \frac{dT}{-\frac{dT}{dx}} \ , \tag{5.16}$$

Where kinetic energy of the particle before entering the substance. Empirical formulas for the average mileage of particles with kinetic energy. Average linear run of α-particles in the air under normal conditions [34]

Rα (cm) = 0,31T3 / 2 for (4 MeV <T <7 MeV), or (3cm <Rα <7cm). (5.17)

The average mass flow of the α-particle in a mass with a mass A

Rα (mg / cm2) = 0.56 R α (cm) A1 / three. (5.18)

The average linear run of the α-particle in the air with energy Tα < 200 MeV

Rα (m) = (Tα / 37.2) 1/8. (5.19)

The average mass emitted by the electrons in aluminum (ρ = 2.7 g / cm3):

Re (g / cm2) = 0.407Te1.38 at (0.15 MeV <Te <0.8 MeV), Re (g / cm2) = 0.542Te - 0.133 at (0.8 MeV <Te <3 MeV). (5.20)

Radioactive atoms of the same variety emit electrons of various energies, ranging from zero to some limit value, which is called the upper bound of the β-spectrum. In the case of a simple β-spectrum, the maximum energy is conveniently determined by the thickness of the half-absorbing layer of β-particles in the substance. To do this, we must measure the rate of particle count, which is emitted by the beta-active source, depending on the absorber thickness. As an absorber for β-particles, aluminum foil is usually used. The correction for the absorption of beta particles on the way source-counter is calculated by the formula $I = I_0 \cdot 2^{-\rho d/\Delta}$: where Δ is the thickness of the half absorption layer. The thickness of the half absorption layer depends on the maximum energy of the Emax beta spectrum [34, 44].

Scattering of X-rays occurs because of collision with the atoms of matter and deviation from the direction of the main beam. When radiation in soft (low energy photons are), is elastic collision in which a soft X-ray quantum faces the electron orbits inside the atom, and its energy is insufficient to raise it to the surface electron atoms ma, because X-rays also only deflects aside, without changing the wavelength. In both cases, classical scattering takes place.

If the soft X-ray is in contact with a free electron or hardly In the form of a quantum of radiation, a quantum of radiation transmits a part of its energy to an electron (electron recoil), and in the form of a quantum of scattering it turns into radiation with a longer wavelength and deviates away from the original direction of motion.

The same thing happens when a quantum with more energy (hard radiation) collides with an electron in the internal orbit of an atom. In this case, the Compton phenomenon (diffused radiation with different wavelengths and the number of electrons) occurs, which occurs only when the energy of the quantum is approximately 10,000 times greater than the electron bond in the atom. The electrons of recoil, separating from this atom, cause the excitation and ionization of other atoms and medium molecules.

The X-ray quantum itself loses part of the energy, transferred to the electron, and, accordingly, increases the wavelength. In the interaction of X-rays with matter, one part of the energy is spent in the form of radiation (scattering energy), and the second is transmitted to the electrons of the medium - absorbed (absorption energy) [44].

Almost all types of radiation arising from the interaction of an electron beam with a solid are used to obtain information about its nature (surface topology, crystalline structure, elemental composition, electronic structure, etc.) in devices with an electron probe.

When discussing the processes of dispersion, the key concept is the probability, or the cross section, the scattering (Q), which in general can be regarded as the effective atomic size for this interaction. The value of the cross-section is determined by the following ratio [44]:

$$Q = \frac{N}{n_1 n_2} , \tag{5.21}$$

Where N, n_1 - the number of collisions and atoms per unit volume of the target;   - the number of electrons that fall per unit area of the target's surface. Knowing the scattering cross section, one can calculate the mean free path of an electron (SDW) - the average distance passing through the electron between two successive collisions or interactions:

$$\lambda = \frac{A}{N_A \rho Q} , \tag{5.22}$$

Where A, ρ - atomic mass and density of target material; NA is Avogadro's number.

At radioactive decay, the nuclei produce gamma quanta with energy ranging from several kilo electron volts to several megaelectronvolt. Passing through a substance, gamma quanta lose energy because of practically three effects: photoelectric absorption (photoelectric effect), Compton scattering (komtonneffekt), and the formation of electron-positron pairs [34].

When photovoltaic absorption of gamma-quantum, colliding with a strongly connected electron (more often by electrons of the K-layer) in the atoms of the irradiated substance completely transfers its energy to it, it disappears itself, and the electron acquires kinetic energy equal to the energy of gamma quantum minus the binding energy of an electron in an atom (Fig. 5.1). Thus, with the photoelectric effect, all the energy of the primary gamma quantum is converted into the kinetic energy of photoelectrons, which are ionized by atoms and molecules. On the released place in the orbit of the K-layer, the electron L-layer, on the L-layer - an electron of the M-layer, etc., jumps with the illumination of the characteristic X-rays quanta. The photoelectric effect is not possible on weakly bound and free electrons (not connected with the atom), because they cannot absorb gamma quanta [34].

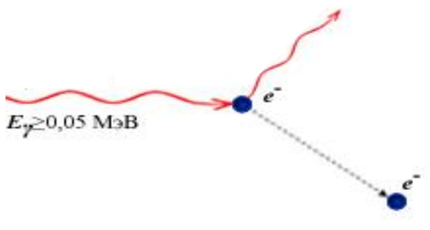


Рис. 5.2. Scattering of gamma quanta by free electrons

Compton's effect is that gamma quanta, in contact with electrons, does not convey to them all their energy, but only its share and after the collision change the direction of its motion, that is, dissipate (Fig. 5.2). Because of collisions with gamma quanta, electrons (electrons) get significant kinetic energy and spend it on ionization of matter (secondary ionization). In contrast to the photoelectric absorption process under the Compton Effect, gamma quanta interact with external, valence electrons, whose binding energy is minimal. Composes scattering is possible on free electrons. Thus, as a result Compton Effect, the intensity of gamma radiation is weakened by the fact that gamma quanta interact with the electrons of the medium, scattering in different directions and extending beyond the boundary of the primary beam, as well as by transferring part of its energy to the electrons [34].

Some gamma quanta with energy of not less than 1,022 MeV, passing through a substance, are transformed under the action of a strong electric field near the nucleus of an atom by a pair of electron positrons. Formation of such a pair of particles is possible only with the energies of gamma quanta, which are not less than the energy equivalent to the mass of both particles - the electron and the positron. Since the masses of the electron and the positron are the same, then for their formation (without giving them additional kinetic energy), the gamma-quantum energy must satisfy the correlation of the mass-energy relationship. If the gamma-ray energy is greater than 1022 MeV, its excess is given to particles. Then the kinetic energy of the formed particles of Ek is equal to the difference between the energy of the photon Eγ and the doubled energy of the electron rest. The created electron-positron pair in the future disappears (annihilates), transforming into two secondary gamma quanta with energy equal to the energy equivalent of the mass of the rest of the particles. Secondary gamma quanta can only cause the Compton effect and ultimately the photoelectric effect, that is, to lose energy only in collisions with electrons. The probability of the formation of pairs increases with increasing energy of gamma quanta and absorber density. Gamma rays of high energies (more than 8 MeV) can interact with nuclei of atoms (nuclear effect). The probability of such an effect is rather small, and this kind of interaction practically does not weaken the radiation in matter [44].

A beam of gamma rays is absorbed continuously with an increase in the thickness of the absorber layer; its intensity does not turn to zero, under any of the thicknesses of the absorber layer. This means that, whatever the thickness of the substance layer, it is impossible to completely absorb the gamma rays stream, but you can only weaken its intensity in any number of times . This is a significant difference in the nature of the weakening of gamma radiation from the weakening of the flow of alpha and beta particles, where you can always pick up a layer of substance in which the flow of alpha or beta particles is completely absorbed [44].

The law of relaxation can also be expressed through the layers of half-loosening D1. The thickness of the absorber, after which half reduce the intensity of the radiation, is called a half-weakening layer. Knowing the half-relaxation layer, one can easily determine which one is to take the absorber layer to reduce the radiation in this number of times [34].

Because the neutrons do not have a charge, and their mass is much larger than the masses of electrons, they have a large penetrating power and lose their energy practically only when they collide with atomic nuclei. In this case, the elastic and inelastic scattering of neutrons by nuclei can be possible [34].

Neutron radiation is dangerous because of its high penetrating ability and the ability to cause in the living organisms the indicated radioactivity. Depending on the energy, they distinguish between ultrashort, fast, intermediate, slow and thermal neutrons [34].

Super-fast neutrons such neutrons are obtained in nuclear reactors or they occur in nuclear explosions. Their energy is 10 ÷□50 MeV. When interacting with heavy elements, super-fast neutrons cause the separation of their nuclei. This produces strongly excited nuclei. As a result of a violation of the ratio of protons and neutrons in the nuclei, the nuclear cluster forces decrease , and the nucleons under the action of repulsion forces diverge to opposite poles. The nucleus is deformed, a constriction occurs in the center, and it splits into two or three fragments. In the course of each act of distribution, colossal energy (about 200 MeV) is released and two to three free neutrons are flown, which can cause the distribution of other nuclei. Therefore, there is a chain process of nuclear distribution [34].

Fast neutrons such neutrons are also formed because of nuclear fission or synthesis reactions. Their energy exceeds 100 keV. When collisions with nuclei of atoms, fast neutrons pass on part of their energy to form fast-moving nuclei (recoil nuclei). Kernels of recoil, like all charged particles, spend their energy on ionization of the medium. The energy transferred to the nucleus increases with decreasing mass of the nucleus. Thus, in the collision of neutrons with hydrogen nuclei, that is, with protons, they are transmitted on average to 60% of neutron energy, since the masses of these particles are practically equal. Therefore, fast neutrons are well slowed down by light substances containing many hydrogen atoms, such as water, paraffin, and tissue, and freely pass through large thicknesses of heavy substances (lead, etc.). In interaction with nuclei, neutrons gradually slow down to thermal velocities, i.e. to the velocities of the motion of the medium molecules [34].

Intermediate neutrons. The energy of such neutrons is 1 ÷□100 keV. They more often interact with matter by type of elastic scattering [34].

Slow and thermal neutrons. The energy of slow neutrons does not exceed 1 keV. In contrast to the fast neutrons, the slow enthralled by the nuclei of atoms, resulting in the formation of new stable or radioactive isotopes. Radiation entrainment of neutrons is accompanied by the release of rigid gamma quanta with an energy of 2.18 MeV. The thermal neutron energy reaches 0.025 eV. Thermal neutrons, as well as slow, are attracted by the absorbing medium [34].

To protect against low-energy neutrons, it is necessary to use in addition to the absorber (water, boron or cadmium) and a screen of heavy material (lead, barium) to reduce gamma radiation.

Ionizing radiation is a great danger to the living organisms of the biosphere, and especially to humans. With such kind of physical fields, special care should be taken, because very often radioactivity without color, smell, taste, has a detrimental effect on the human body with a lethal end. When considering the biological action of radioactivity distinguish external and internal radiation. External radiation is a case where the source of radiation is outside the body and radioactivity products do not fall into the middle of the body. The first signs of chronic lesion: dry skin, there are ulcers, hair loss [42].

Living organisms are constantly exposed to irradiation due to the natural background. Background radioactive radiation consists mainly of three components: the natural background caused by radionuclides of the biosphere, fabricated background caused by human activity, X-ray diagnostics [18].

Based on regulatory requirements, establish the procedure for conducting work with sources of ionizing radiation and ensuring the elimination of radioactive waste [18, 19].

To ensure the radiation hazard, you must comply with the general principles of protection: do not exceed the maximum allowable dose; apply a distance protection method, sometimes; apply shields; use personal protective equipment and.in The choice of a protective screen should be made depending on the type of ionized radiation. To protect against - the radiation used screens of glass thickness of several millimeters. For protection - radiation is used materials with a small atomic mass, and more often combined. To protect against - radiation, materials with a high atomic mass and high density, as well as cheaper materials and alloys are used. Stationary screens are executed without concrete. When working with radionuclides, work clothes should be used [18, 19].

5. 8. Physical basis of radiometry and dosimetry

Three basic methods of radiometry are used to determine radioactivity: absolute, estimated, relative.

The absolute method is based on the use of a direct account of the total number of particles of nuclei decaying under conditions of geometry close to 4π. In this case, the activity of the sample is expressed not in impulses, but in units of radioactivity - Ki and Bk. For this method of estimation of radioactivity, such 4π-meters are used, in which samples are placed: gas-flow type SA-4BFL or liquid scintillators type ЖС-1 or ЖС-7. This method is not widely used yet due to the high cost of 4π-meters and the great complexity of sample preparation. However, it is practically the only method for measuring reference samples [13].

The calculation method is based on the registration of pulses coming from the detector to the unit of registration and the subsequent mathematical processing of the received digital indicators. In this case, the true radioactivity is determined by the formula [13, 34]:

$$\mathrm{A}_{\text{пр}} = \frac{\mathrm{N}_{0\text{пр}+\text{ф}} - \mathrm{N}_{\text{ф}}}{\omega k p q r \gamma m} * 2.22 \cdot 10^{2} \;, \tag{5.23}$$

where $N_{0\text{пр}+\text{ф}} - N_{\text{ф}}$ - the speed of the count from the sample without the background, ω is the correction for the geometric measurement conditions, ε is the correction correction for the detector counting ability, k is the correction for the absorption of radiation in the air layer and the window of the counter, ρ is the correction for self-absorption in the layer q, is the correction for inverse scattering from the cell, r is the correction for the decay scheme, γ is the correction for γ-radiation in the mixed β- and γ-radiation, m is the weight of the preparation, 2.22 102 is the transition coefficient from the number of disintegrations per minute in Key.

The relative method is based on comparing the rate of a number from a drug with a known activity (standard) at a rate of a number from a drug of unknown activity (measured sample). In this case, the activity is calculated from this proportion [13, 34]:

$$\mathrm{A}_{\text{ет}} : \mathrm{N}_{0\text{ет}} = \mathrm{A}_{\text{пр}} : \mathrm{N}_{0\text{пр}}$$

From here

$$\mathrm{A}_{\text{пр}} = \mathrm{A}_{\text{ет}} \mathrm{N}_{0\text{пр}} : \mathrm{N}_{0\text{ет}} \tag{5.24}$$

In this method, the main thing is the correct selection of the standard, the cost of which in some cases is much higher than the most expensive spectrometer. Therefore, the labs of the highest class cannot have standards. They are provided with special plants for the standardization of radiometric equipment. At the plant, standards are carried out standardization-certification of all devices designed for expert assessment of the content of radionuclides. Depending on the tasks of the laboratories, the communication rates for the measured samples are ordered. For each sample type, these coefficients are determined by dividing $\mathrm{A}_{\text{ет}}$ by $\mathrm{N}_{0\text{ет}}$. . After that, the activity of the sample is calculated by the formula [13, 34]

$$\mathrm{A}_{\text{пр}} = \mathrm{K}_{\text{зв}} \mathrm{N}_{0\text{пр}} \tag{5.25}$$

The relative method also includes express methods for determining total β-activity [13]:

1) Methods of determining the specific mass total β-activity.

a) Method of “thin” samples. “Thin” is considered a sample of such thickness in which the absorption of released β-particles is insignificant. The velocity of the number of detectors of β particles released by the sample (the number of impulses recorded per unit time) is related to the specific mass total activity as follows:

$$q = \frac{n_{e\phi}}{d\Omega \varepsilon \mathrm{K}_n m} , \tag{5.26}$$

Where m is the mass of the sample, K_n - the absorption coefficient of β-radiation in the sample substance, $d\Omega$ - the coefficient which takes into account that only part of the released radiation enters the detector, ε - the efficiency of the registration of the radiation by the detector.

It should be noted that the speed of the detector count is determined not only by the β-radiation of the sample but also by the background (mainly cosmic). The speed of the background radiation is measured without the sample, and the difference between the total speed of the count and the background is the speed of the number $n_{e\phi}$, associated with the activity of the sample [13].

The general disadvantage of the “thin” specimen method is the poor sensitivity due to the use of samples with a low mass and low activity, which determines the low speed of the sample β-radiation count and a rather long time of measurements [13].

b) The method of “thick” samples. Applying the method of “thick” samples, the specific mass total β-activity is determined in specimens of such thickness that its subsequent increase does not lead to an increase in the yield of β-particles from the sample. For example, it is known that the run of β-particles in a biological tissue is up to 10 mm. If we take a sparse sample of biological tissue, then its activity, depending on the thickness, will be approximately 7 mm – 70 Bq, 8 mm – 80 Bq, 9 mm – 90 Bq, 10 mm – 100 Bq, 11 mm – 100 Bq, 12 mm – 100 Bq. In this example, a thick layer will be a 10 mm thick sample . The total speed of the number in this case does not depend on the thickness of the sample, but directly depends on its specific mass activity and does not depend on the mass and density of the sample [13]:

$$q = K_T n \tag{5.27}$$

This approach allows you to measure samples without weighing. The coefficient is determined by measuring specimens with known specific activity and different for different radionuclides and their mixtures. Therefore, when measuring the specific mass total β-activity, it is necessary to have information about the radionuclide composition of the sample and use the corresponding coefficient [13].

The advantages of the method are, as indicated, the possibility of measuring without weighing the sample and a relatively small time of measurement, which depends on the activity of the sample [13].

2) Cassette method. Increases the device's readability and sample rate by increasing the number of detectors [13].

3) Cuvette method. It allows improving the geometric conditions of measurement to 4π because in the absolute method, the sample is in the detector, and in this case, the detector is in the sample [13].

4) Determination of total β-activity on the ash residue. It is used at low concentrations of radioactive substances in the sample. The calculation is carried out according to the formula [13]:

$$A_{пр} = K_{зв} N_{0пр} M \qquad (5.28)$$

Where M is the ash content, which is determined by dividing the ash mass in grams by weight of the raw sample in grams.

The basic unit in radiobiology and radioecology is the dose of irradiation, a measure of the energy of ionizing radiation transmitted to the substance, or a measure of the biological effects of ionizing radiation in the human body, its organs and tissues. Irradiation is the effect on a person or any object of ionizing radiation [13, 18, and 19].

Exterior irradiation - irradiation of a human body or any living object by sources of ionizing radiation that lie outside it [16, 19].

Internal irradiation - irradiation of a human's body or any living object, separate organs and tissues from sources of ionizing radiation present in the object itself [16, 19].

Radiation protection, radioecology and radiobiology distinguish five main types of doses of ionizing radiation: exposure, absorbed, equivalent, effective and collective [16].

The exposure dose of photon radiation ($D_{\exp}$)) is the ratio of the total charge of all the ions of one sign (dQ) formed in the air, when all the electrons and positrons, released by the photons in the elemental volume of air mass , completely stopped in the air dm , to the air mass in the specified volume [16].

$$D_{\exp} = dQ/dm \qquad (5.29)$$

In the SI system for the unit dose level, a pendant per kilogram (Cl / kg; C / kg) is taken. The porosity unit of the exposure dose is X-ray (R; R): 1 P = 2.58 × 10-4 Cl / kg [16].

X-ray - this is the amount of ionizing radiation, which forms about 1 billion pairs of ions in 1m3 of dry air under normal conditions. X-ray derivatives are 1 millirentgen (mR) = 1 · 10-3 P and 1 microrententh (μR) = 1 · 10-6 R. The ratio between Cl / kg and X-ray: 1 Kl / kg = 3876 P [34].

The power of the exposure dose of photon radiation (the power of the exposure dose) ($P_{\exp}$) is the ratio of the increase in the exposure dose ($dP_{\exp}$) for the time interval dt to this interval of time [16]:

$$P_{\exp} = dD_{\exp} / dt \tag{5.30}$$

Exposition dose is calculated according to the formula [16]:

$$D_{\exp} = \int_0^t P_{\exp} dt \tag{5.31}$$

Or $D_{\exp} = \int_0^t P_{\exp} dt$

At, $P_{\exp}(t) = Const$

Where t is the irradiation time.

In the SI system, an ampere per kilogram (A / kg) takes the unit of power of the exposure dose. The porosity unit of the exposure dose rate is x-ray per second (R / c): 1 R / c = 2.58 · 10-4 A / kg; 1 R / h = 1000 mP / h = 106 mcP / h [16].

The power of the exposure dose of photon radiation (P) from the point source of this radionuclide is proportional to its activity A (mKi) and inversely proportional to the square of its distance r (sm) [16]:

$$P \approx \mathrm{A}\Gamma / r^2 \tag{5.32}$$

Where G is a complete gamma ray.

Taking into account the absence of an integer ratio between J / kg and P, as well as a gradual refusal from the practical use of the exposure dose in favor of the absorbed dose, it was considered expedient for the exposure dose ( ) and the exposure dose rate (P) to maintain only non-system units and not to use units of the system SI [16].

In radiobiology, clinical radiology and radiation protection, the absorbed dose (D) is the basic physical value used for all types of ionizing radiation and any geometry of radiation [16].

The absorbed dose is defined as the ratio of the average energy (dE) transmitted by the ionizing radiation in the elemental volume to the mass of matter in this volume. The absorbed dose of radiation is equal to the energy absorbed by the mass of a substance. All other values associated with absorbed radiation dose (dose fields, etc.) are a measure of influence on the object being irradiated [16]:

$$D = dE/dm \qquad (5.33)$$

In the SI system per unit of absorbed dose Gray (Gy) is taken; dimension of absorbed dose - Joule per kilogram; 1 Gray = 1 JJ / kg. The derivatives are 1 mGr = 1 · 10-3 Gy and 1 μGr = 1 · 10-6 Gy [16].

The non-system unit of the absorbed dose is a tip. The relationship between Gray and Rad is as follows: 1 Gy = 100 rad; 1 rad = 0, 01 Gy = 1 cGy (Santi gray) [16].

There are certain ratios between units of the given doses for gamma rays. Therefore, 1 rad is approximately equal to 1 P (more precisely 1.04 P). Exposure dose of 1P in the air corresponds to an absorbed dose of 0.87 reds [16].

The power of the absorbed dose of ionizing radiation (radiation dose power) P_{abs} is the ratio of the increment of absorbed dose (dD) over the time interval (dt) to this interval of time [16]:

$$P_{abs} = dD/dt \qquad (5.34)$$

In the SI system per unit of power, absorbed dose is taken Gee / s. The non-system unit is rad / s, 1 Gr / s = 100 rad / s.

If you need to switch from the power of the exposure dose of photon radiation in the air (P_{abs}) to the power absorbed dose in the air (air rudder $P_{\exp}$), use the following relationships [16]:

$$P_{abs} \text{ (Ng / yr.) = 8.73 (mcr / h)} \qquad (5.35)$$

The average dose in an organ or tissue absorbed (dose in an organ D_T) is equal to the ratio of total energy (E_T) released in the organ or tissue (T) to the mass of the organ or tissue (m_T) [16]:

$$D_T = D_T/m_T \qquad (5.36)$$

The value of the sum of the primary kinetic energies (dW_k) of all charged particles formed by the influence of indirect ionizing radiation in the elementary volume of the substance, to the mass (dm) of the substance in this, volume (dW_k/dm). The rudder measurement unit is Gray [16].

An equivalent dose in an organ or tissue (H_T) is a value that is defined as the product of the absorbed dose (D_T) in a separate organ or tissue (T) and the radiation factor (W_R) [16]:

$$H_T = D_T W_R \tag{5.37}$$

The unit of the equivalent dose in SI system is sifter (Sv; Sv). Sievert is the energy of any type of ionizing radiation absorbed by 1 kg of biological tissue, in which the biological effect is identical to the absorbed dose of 1 Gy of control X-ray or gamma radiation [16].

At irradiation of living objects, including humans, the same absorbed dose causes a different biological effect depending on the type of radiation. Therefore, it is customary to compare the biological effects of different types of radiation with effects caused by X-ray or low-energy gamma rays [16].

Radiation weighing factor (coefficient of quality) wR - coefficient taking into account the relative biological efficiency of different types of ionizing radiation. Used exclusively for the calculation of effective and equivalent doses. In the recommendations of the ICRP, the radiation-weighing factor for neutrons, depending on their energy, is replaced by a stepwise continuous function [16, 18].

To take into account the uneven influence of ionizing radiation on an organism distinguish an effective dose [18].

Effective dose (E) - the sum of products of equivalent doses in separate organs and tissues on the corresponding tissue weighing factors W_T [16]:

$$\mathrm{E} = H_T W_T \tag{5.38}$$

The use of the notion of an effective dose is allowed at values of equivalent doses lower than the threshold of occurrence of deterministic effects (0.1 Av in acute irradiation or chronic throughout the year). The unit of the effective dose in the SI-Zivert system (Zv). Possessential unit - be [16].

An effective dose in radiation safety determines the degree of exposure of ionizing radiation to the human body, taking into account the differences in the effects of various types of ionizing radiation on tissues and organs. An effective dose allows you to align the risk of irradiation irrespective of whether the whole body is irradiated evenly or not. This is achieved by means of the ratio of harm to the radiation from the individual organ or tissue to the detriment of the uniform exposure of the whole body to the same equivalent doses. An effective dose of external exposure to the human body and an effective dose of internal radiation due to radionuclides in the human body can thus be added [16].

The tissue-weighing factor is the coefficient that reflects the relative probability of stochastic effects in the tissue (organ). The sum of all weighing factors in all organs is equal to one: dE/dt, нЗв/год. It is used exclusively for the calculation of the effective dose [16, 17].

If necessary, the following ratio [16, 17] should be used for switching from the power of the exposure dose of gamma radiation of radionuclides of natural origin in the air (, μR / h) to the effective dose (nZv / h).

$$dE/dt = 6,46P_{\text{exp}} \tag{5.39}$$

The absorbed dose can be distributed evenly and unevenly in biological objects. It is known that each organ and each tissue have different meanings in the life-support of the whole organism. A critical organ is an organ or tissue, part of the body, or the whole body, the radiation of which causes the greatest damage to the body. Similarly, critical (vital) elements can be isolated in each individual cell, and not just in the whole organism [16, 17].

There are practically three ways of allocating critical organs [16, 17]:

- For the most radio sensitivity in a certain organism system;
- For the largest absorbed dose of radiation;
- By selective accumulation of elevated concentrations of a certain radionuclide and, thus, obtaining the highest effective equivalent radiation doses (another radionuclide may be a completely different organ).

Each of these methods is acceptable for different situations. The first method is convenient in the case of total uniform external irradiation, the second - in the case of uneven irradiation, the third - in the absorption of radionuclides in various tissues and organs. It is known that such a radionuclide, as Sr^{90}, selectively accumulates in the thyroid gland of the vertebrates, and therefore the dose is estimated based on this organ. Sr^{90} Is concentrated in the superficial layers of the bones, and the dose should be counted on this tissue, etc. [16, 17].

In cases of exposure to large populations of people, especially in accidents, it is expedient to allocate critical groups of the population. A critical group is the aggregate of people among a certain contingent of people who are most at risk of exposure according to their conditions of residence, age or health.

The concept of individual and collective equivalent dose was introduced for the assessment of the risk of exposure to one person or a certain group of people, respectively.

It should always be remembered that an effective dose is calculated for a "conditional person" (averaged over the sex with the characteristics defined by the ICRP in the context of radiation protection with anatomical and physiological characteristics), and not for the individual individual. The main area of application of an effective dose is to conduct promising assessments when planning and optimizing radiation protection, as well as to confirm compliance with the limit dose during regulation. It is not recommended to use an effective dose for epidemiological assessments or for detailed retrospective studies of individual exposure and risk [16, 17].

The collective effective dose (equivalent) is the sum of the individual effective (equivalent) doses of exposure of a given population group over a certain period of time, or the sum of the products of the average group effective doses per number of persons in the corresponding groups that form the collective for which it is calculated [16] :

$$S = \sum E_i N_i \qquad (5.40)$$

Where E_i - average effective (equivalent) dose per subgroup of the population - number of persons in the subgroup.

The unit of measurement is man-zivert (human-zv). Possessential unit - man-ber. 1 man-Zv = 100 people-mar. The value of a collective effective dose is a tool for optimizing countermeasures and for comparing different radiation technologies and protection procedures, mainly in the context of occupational exposure. A collective effective dose is not a tool for epidemiological risk assessments, but also for risk prediction. Summing up very low individual doses over a very long period is unacceptable. In particular, it is necessary to refrain from calculating the number of deaths from cancer based on collective effective doses obtained by simply adding individual doses [16].

In order to assess the risk of undesirable biological effects, depending on the time during which the dose was obtained, the expected or half-life dose was equivalent to the dose of internal radiation (E50). It is the sum of the equivalent doses that a person receives for a certain period. At E50, the period taken is 50 years for adults - the average duration of the period of professional activity, and 70 years for children (E70). The unit of the expected equivalent dose is Sievert.

The relationship between units of dose quantities of ionizing radiation is shown in Table. 5.1 [16.17].

An equivalent and effective dose in the body tissues and human body cannot be measured directly. In this regard, the system of protection includes the concept of operating values that can be measured and based, on which an equivalent and effective dose can be estimated [16].

Table 5.1. The ratio between units of the dose dose of ionizing
Radiation [16, 17]

Size, her designation	Unit, designation		Relationship between units
	SI	Non-systemic	
The activity of radionuclides, A.	backcross (bk)	curie (ki)	1 Ki = 3.7 · 1010 Bq
Exposure dose of photon radiation,	pendant per kilogram (Cl / kg)	X-ray (R)	1 P = 2.58 · 10-4 Cl / kg
Exposure dose photon radiation power,	Ampere per kilogram, (A / kg)	X-ray (R)	1P / c = 2.58 · 10-4 A / kg
Absorbed dose of radiation, D	Gray (Gg)	happy (rad)	1 rad = 0,01 Gy
The power of the absorbed dose of radiation,	Gray per Second (G / s)	happy second (rad / s)	1 rad / s = 0.01 Gy / s
Kerma, K.	Gray (Gy)	happy (rad)	1 rad = 0,01 Gy
Equivalent (effective) radiation dose,	siveter, (zv)	Mar (Mar)	1 mar = 0.01 zv
The power of the equivalent dose of radiation,	siret per second, (W / s)	mar per second (ber / s)	1 mar / c = 0.01 zł / s
Collective effective (equivalent) dose, D	human sievert, (human. zv)	man-ber, (man-ber)	1 mar.-mar. = 0,01 ljud-Sv

The main methods for detecting ionizing radiation are:
1) Ionization, 2) scintillation, 3) fluorescent, 4) photographic, 5) chemical, 6) calorimetric and 7) biological [16, 17].

The essence of the ionization method is that under the action of ionizing radiation, ionization of irradiated objects - air, water, solids, biological tissues, etc. - occurs with the formation of positively and negatively charged ions. Ions in the meter under the voltage, receive directional motion, forming ionization current. By measuring the current strength, one can get an idea of the amount (dose) of radiation, while measuring the pulses of current, one can determine the intensity of radiation [42].

Detectors for the detection and measurement of ionization are usually ionization cameras, proportional counters, Geiger-Mueller counters and semiconductor meters [13].

The possibilities of using this type of detector are determined by their performance characteristics and the purpose of the research [13].

According to the principle of ionization method, dosimetry instruments are used: dosimeters (DK-02, DKP-50-A, ID-1, KID-1-6, DKS-04, DKG-08A "Scout", DKG-01D "Grant", DKG -05D, DKS-AT3509, DKS-AT3509A, DKS-AT3509B, DKS-AT3509C, etc.); X-ray (DP-5A, B, V), DKS-0,5, DRH-01-T, Bella, Pripyat, etc.); radiometers ("Toss", DP-100, KRB-1, KRA-1, Beta, KRK-1, UMF-1500, etc.) [13].

The scintillation method is based on the registration of visible light photons that arise when excited atoms of certain substances - scintillators under the action of radiation. For the manufacture of this type of detector most often, use crystals of chemically pure NaI activated by thallium [13].

The process of detecting ionizing radiation occurs in the following sequence: the γ-quantum knock out a photon from the crystal that enters the photocathode of a photoelectric multiplier (FEP) and, in turn, knocks out a photoelectron from it. Photoelectron enters the plate - a dynamo FEP and knocking out of it up to 10 electrons. This process is repeated as many times as the plates (dynodes) have a FEP. Thus, with six dynamos of the FEP at the output, about 1 million electrons are obtained (for example, the FEP of the device SRP-68-01 has 14 dynodes) [13].

On this principle work: X-ray (SRP-68-01, SRP-88); radiometers (RKB4-1eM, RZHS-05); gamma spectrometers (AM-A-02-F1,2,3, AI-1024-9505, AI-4096, MULTIRADGAMMA, SCS-99 "SPUTNIK", SEB- 01-70, SEG-001 "ACP-C "-63, SEG-001m" AKP-S "-63, SEB-01-150 and others); automatic gamma - and beta counters (Gamma- 12 , Beta- 2, etc.) [13].

Fluorescent methods for detecting ionizing radiation are based on the effects of radio photoluminescence and thermoluminescence. In the case of radio photoluminescence, the photoluminescence centers are formed under the action of ionizing radiation in phosphorene’s - phosphate glass (NaI, ZnS, activated silver). During exposure to ultraviolet rays there is a visible luminescence, the intensity of which is initially proportional to the dose of 10-2 -10-1 Gy, at a dose of 3.5-10-2 Gy reaches a maximum and with further increase in dose - falls. Under the influence of ultraviolet rays, centers of luminescence collapse, which makes it possible to conduct dose measurements repeatedly [13].

When absorbed by radio-thermos luminescence, the energy of radiation is transformed into a luminescence only under the action of temperature, and its intensity is proportional to the radiation dose. Therefore, dosimeters of this type can serve as a dose storage device. In order to prevent the loss of the dose, it is necessary to pick up phosphate glass, which will illuminate it at a temperature of about 400˚C. According to this principle, dosimeters DPG-02, DPG-03, ICSA, DTU, etc. [13] work.

The photographic method is based on the measurement of the degree of darkening of the photo emulsion under the influence of ionizing radiation. If you irradiate the film in a lightproof cassette, then after its manifestation can be detected noticeable blackening. Its degree in a certain range of doses is proportional to the exposure dose. Irradiated films of the type PM-5-1, PM-5-3 and RM-5-4 allow recording of γ-radiation in the range of exposure doses 0, 02-2, 0 P, 0, 3-12 P, 0, 01-50, 0 P, respectively. [13]

The advantages of the photographic method are the possibility of its mass use for individual control, documentary registration of the received dose and unacceptability to shock and sharp changes in temperature.

The disadvantages of this method are low sensitivity to small doses, the impossibility of monitoring the course of accumulation of dose directly in the process of exposure, the dependence of the measurement results on the conditions of the film.

The complexity of using this method is that to determine the dose, it is necessary to have a standard made of the same material as in a dosimeter exposed to a known dose and manifested in similar conditions. This means that a source of ionizing radiation is needed that can create a controlled dose.

The chemical method is because, under the influence of ionizing radiation, some substances can be transformed into others. For example, with irradiation of chloroform, hydrochloric acid is formed. If you take chloroform, add to it an indicator of hydrochloric acid, then in the presence of ionizing radiation, its color begins to change. Therefore, on the body of such a dosimeter you can stick a visual scale of color change, depending on the dose of radiation. This gives us the opportunity to observe the progress of its accumulation during the irradiation process. Determination of the exact dose value is carried out on devices such as photoelectrocalorimeters (FEC), degraded in units of ionizing radiation dose that caused it [13].

Currently, so-called "dry" ("blind") ferrous sulfate dosimeters are usually used, which uses an air-saturated FeSO4 solution in dilute H2SO4 in the range of measuring 20-400 Gy. For a higher dose (103-110 Gy), a cerium dosimeter (0.1 M Ce2 (SO4) solution in 0.4 M H2SO4 is used), but chemical monitors based on chloroform and carbon tetrachloride continue to be used, that in the estimation of relatively small doses, they give a greater error [13].

The sensitivity of chemical methods of dosimetry is much lower than that of ionization, scintillation, luminescent and photographic. In addition, the registration of indicators requires significant time expenditures [13].

Calorimetric method is because under the influence of ionizing radiation in irradiated objects, the temperature rises. For example, irradiation dose biological object 1000, his body temperature rises at least 0.001˚C. This method is used to measure extremely high dose rates. Without it, it would not be possible to monitor the situation in the nuclear reactor.

Thus, each of these methods occupies a certain irreplaceable place in the detection of ionizing radiation [13].

The biological method is somewhat different from the above, since it is based on biological changes in cells, tissues, organs of living organisms, which are caused by the action of ionizing radiation. The most common method is to determine the number of cells with chromosomal aberrations in human peripheral blood lymphocytes [13].

Aberrations of chromosomes are their breakdowns, which can occur in small quantities (up to 1-1.5%) in normal cell divisions, and which can occur under the influence of some physical and chemical factors in quantities that exceed many times the norm. One of these factors is ionizing radiation. In addition, the number of aberrations that arise in its action is clearly directly proportional to the dose of radiation [44].

To determine the number of cells with chromosomal aberrations in a person who was exposed to ionizing radiation, the usual method is to remove blood from a finger or other organ. On the drug under the microscope clearly visible lymphocytes - large cells that are divided, and in the mitochondria - and separate chromosomes. In a certain phase of mitosis (usually a metaphase or anaphase), when all the chromosomes are separated from one another, the number of chromosomes damaged is determined, determining the percentage of cells with aberrations. In the end, the pre-cooked gauge curves in the laboratory determine which amount of aberrant cells corresponds to a certain dose of radiation [44].

Because the calibration curve is based on averaged data, and each person has individual radio sensitivity, the method may give a certain error in the assessment of the dose. However, in most cases, this error does not exceed 20-30%. In addition, it will be less; the less will be the time between irradiation and blood analysis [18, 44].

Determination of the number of aberrations is possible in other cells of the body - the bone marrow, epithelial cells - in all who share and therefore have high radio sensitivity. However, the brief description here is most convenient.

With this method, you can determine the dose of irradiation of animals and even plants. In the last chromosomal analysis, cells of meristems - creature tissues, cells of which are divided [44].

The biological method of dosimetry includes the method of determining the number of free radicals in the tooth enamel of mammals in, including humans, and other vertebrates, chitins covers of insects, shells of mollusks. This method is called "retrospective", since it allows you to determine the dose that was received by the individual during the period of individual development - life. In addition, if in life there was an incident involving the receipt of a large dose, such as when testing atomic weapons, accidents at nuclear power plants, the method can detect this case. It is with the help of him that he is currently assessing or "re-evaluating", specifying the doses received by the military during the testing of atomic bombs, liquidators of nuclear accidents and just residents of territories contaminated with radionuclides [18, 44].

Depending on the destination, two classes of devices are used to measure radioactivity in the environment. These dosimeters are devices designed to measure exposure dose or dose rate of X-ray, γ-radiation, absorbed dose or absorbed dose of ionizing radiation power. Radiometers - devices designed to determine the specific activity of objects of radiometric control [18, 44].

In the structure of these devices, there is no special difference. All of them must have a radiation detector of one or another system. As a rule, ionization of atoms causes a slight excitation of the system. Therefore, an act of ionization needs to be strengthened and registered. In addition, of course, all these units of the device must be supplied with energy (power supply) [44].

Dosimeters determine the absorbed dose in Gray units (rad), the absorbed dose rate - in Gy / s (rad / s), the exposure dose - in Cl / kg (P) and the exposure dose rate - in Cl / kg-3 (R /) [13].

Dosimeters are also used to determine the intensity of radiation in units of W / m2 (MeV / cm2). Radiometers determine the specific volume, surface or mass activity, respectively, in Bq / m3 (KI / L), Bq / m3 (Ki / cm2, Bq / kg (Ki / kg) [13].

Portable radiometers are mainly used to determine the specific activity of the surface of the soil, structures, materials, etc. Stationary radiometers are used to determine the specific mass or volume activity of soil, vegetation, feed, food, water [13].

Depending on the destination, dosimeters are divided into three groups [13]:

- Pocket devices for ionizing dosimetry control;
- Portable devices of group dosimetry and radiation-technological control;
- Stationary instruments for dosimetry and radiation-technological monitoring.

5. 9 Elements of radioecology and radiation safety

Wherever we are - in the hot southern or far north, in the valleys or high in the mountains, in the fresh air or indoors, at rest in a sanatorium or at work, surrounded by modern technology, on a steamboat, on a train or on a plane - or the body constantly permeates high-energy photons and corpuscles of ionizing radiation. Falling from the outside of the body, they penetrate into all tissues and organs, which give their energy to molecules and cell structures [45].

In large numbers, they originate within our body from the radioactive substances in it, and then the probability of their absorption by tissues increases. It is about high-energy photons and particles. Their energy many times exceeds the energy of any chemical bond in the molecule. The collision of such particles with the molecules of our body is, as a rule, catastrophe for a molecule: it collapses, it changes its configuration, loses one properties and acquires completely different [44, 45].

Calculations show that every second in an organism of a person weighing 70 kg on average there are about 500 thousand such molecular disasters, 500 thousand collisions of molecules with ionizing particles, accompanied by a temporary or permanent change in the properties of these molecules [44].

The irradiation from natural sources does not stop for a minute: seconds, minutes, hours, days, years, this is the micro bombardment of our cells continuously. Its effects have only become apparent in recent years thanks to numerous radiobiological studies. In addition, as often happens in science, something that seemed obvious a few years ago, acquires new light in the light of the facts. If in the 40's and even in the early 50's of the XX century. Scientists generally had very vague notions about the natural background of radiation, but now it has become clear that it cannot be ignored by discussing such issues as the origin of life, evolution, aging, carcinogenesis, and much more. We distinguish external irradiation from sources located outside the body, and internal - from the incorporated, that is, included in the body of radioactive nuclides. Exterior irradiation consists of irradiation with secondary cosmic rays reaching the Earth's biosphere, and radionuclide emissions scattered around the earth's rocks and building materials around them [44,45].

Natural radionuclides are constantly involved in the circulation of substances, which is so characteristic of living organisms. The ways and extent of their penetration into living organisms will depend on the nature of radionuclide. The radioactive isotope of carbon is continuously formed in the upper atmosphere due to the nuclear reaction of cosmic rays (neutrons) with nitrogen: $n + N_{14} \to p + C_{14}$. Oxidizing with oxygen or ozone, this carbon is converted into radioactive carbon dioxide: $C_{14} + O_2 \to C_{14}O_2$. The latter, uniformly mixed with the usual carbon dioxide (which goes about a year), is absorbed by the green leaves of plants in the process of photosynthesis [44, 45].

It is well known that all parts of the plant are based on the products of photosynthesis. Thus, carbohydrates, fats, proteins and other components of plants containing carbon will be weakly radioactive and, falling into The quality of food in the body of an animal and humans, create a constantly acting small level of internal radiation. Half-life very large (5720 years), so it is a millennium on our planet [44].

Significantly, greater contribution to total activity is made by such a natural nuclide as a radioactive potassium isotope . In ordinary potassium, a radioactive isotope is always contained in a very small amount (0.0118%) . Without potassium there is no normal development of organisms, without it impossible life. The content of potassium is strictly regulated both in animal and plant organisms. Its concentration in plants is higher than in living tissues. There are special mechanisms that work in bio membranes, which regulate the distribution of potassium in the human body. Its content in erythrocytes reaches 460 mg percentage, in muscle - 360 mg percentage, in the brain - 330 m percentage. Potassium is low in bone tissue (50 mg %) and much less in serum (20 mg %). In the male body, in comparison with female it is more, especially during puberty. A young, vigorously functioning organism contains more potassium per 1 kg of weight than the old one. These data were obtained during the examination of 859 people of both sexes in cells, which allow taking into account the level and range of radiation of the entire body [44, 45].

Uranium, thorium, radium everywhere common in the earth's crust. As shown by special experiments, thorium is almost not absorbed by plants. Its content is negligible in the harvest and in the green mass of plants, so it cannot be regarded as an internal emitter in the organisms of plants, animals and humans. Otherwise uranium and radium behave. The uranium salts from the soil come into the plant. Some types of plants actively concentrate uranium. It was even suggested to use some types as peculiar indicators of the presence of uranium in the environment [45].

If only γ-radiation is taken into account when external irradiation, then with the internal basic action they make α- and β-radiation, have the ability to act directly on vital tissues and organs of a person. Most radioactive isotopes accumulate in certain tissues, which leads to uneven irradiation of certain parts of the body [16].

Internal irradiation operates all the time while the radioactive substances are inside the body. Data from radiobiological studies show that not all organs and tissues of the human body have the same sensitivity to irradiation [16].

The foundation based on which the evaluation of the genetic risk of human exposure is the analysis of natural (spontaneous) mutational variability.

Knowing the level of spontaneous variability of a person can be calculated; to what extent this level can be changed after radiation exposure [18].

Mutational changes in any of the human genes, which changes in the structure of any of the chromosomes lead to human ontogenesis to certain changes in its phenotype. The degree of change in the phenotype depends on the importance of the implementation of certain functions of the organism involved in the mutagenesis of genes, from the magnitude of the violation of genetic material, and from the nature of inheritance, mutational changes arose [18].

It is important to consider the classification of genetic changes from the point of view of such changes in phenotypes - genetic diseases. Currently, genetic diseases of man, due to their mechanisms of occurrence and inheritance, are divided into Mendel, chromosomal, multifactorial, genetic diseases of somatic cells and diseases of genetic incompatibility of mother and fetus [18].

Due to the implementation of the international Human Genome Program and the intensive study of hereditary diseases in clinics in many countries, the number of Mendel's hereditary diseases known before January 2000 was 11062. Significant progress has been made in this area, which indicates the high relevance of the study of hereditary diseases human [18].

In relation to many hereditary diseases, the localization of mutant genes has been studied and a molecular analysis of products of such genes has been carried out. More than 6980 genes with well-known function are localized in specific sites of various human chromosomes. On the other hand, more than 1100 clinical illnesses are mapped in certain areas of chromosomes [18].

About the existence of these or other genes, we learn when it becomes possible to study the mutations of these genes. Non-mutated genes cannot be studied. Typically, the spontaneous frequency of mutations in individual genes in humans is from 10-4 to 10-6 per gametes per generation. It should be noted that the spontaneous frequency of mutations depends on the age of the parents, especially from the age of men [18].

After extensive research by A.Cyizel in Hungary, special attention has been paid to multifactorial illnesses. Multifactorial illnesses combine a wide class of diseases against which it is known that they have a genetic component, and at the same time, these diseases are not subject to simple succession. Such illnesses are interpreted as the result of the interaction of a large number of factors of genetic nature and environmental factors. Most multifactorial illnesses are not subject to classical inheritance laws, that is, they are not clinical manifestations of defects in single genes. At the same time, they are found among relatives of patients with a higher frequency than in the general population. However, the risk of contracting this multifactorial illness among relatives varies depending on the specifics of the disease and may be different in different families. For most multifactorial diseases, the knowledge about the genetic control of these diseases of the genes, their numbers, type of mutational changes and nature affecting the manifestation of these diseases of the environmental factors is still very limited. Taking into account the epidemiological problems of the classification of multifactorial diseases and the problems of assessing the risk of the appearance of such diseases under the influence of environmental mutagens, this group of diseases can be subdivided into congenital anomalies and conventional (chronic) multifactorial illnesses [18].

In general, the level of natural variability in humans in all categories of diseases is quite high - it is at least 70% of different genetic abnormalities for 70 years of human life, taken conventionally for the average life span of a person. In other words, more than 70% of people during their life manifests at least one genetically determined deviation from the norm, which reduces the life expectancy of a person compared with the norm, or interferes with normal human capacity [18].

The radiation impact of nuclear power plants is unlikely to increase the natural level of radioactivity on our planet. There are no grounds for anxiety, especially when comparing the benefits of nuclear power plants with their immeasurably small impact on the radioactivity of the surrounding environment. All calculations were carried out on a large scale: on the whole planet and on humankind for decades ahead. Naturally, the question arises: do not we encounter invisible rays in everyday life? Does not a person around him create additional sources of radiation in one or another activity, do not we use these sources, sometimes not associate them with the action of atomic radiation [18]?

Let us consider well-known X-ray diagnostic devices, which are provided with all clinics and which we encounter with all kinds of preventive surveys conducted on a mass scale among the population. Statistics show that the number of persons undergoing X-ray examination increases with each year by 5-15%, depending on the country, the level of medical care. We all know well what great benefits the modern medicine brings to the X-ray diagnostics. Man got sick. The doctor sees signs of a serious illness. X-ray examination often gives decisive evidence, following which a doctor prescribes treatment and rescues a person's life. In all these cases, it does not matter what dose of radiation will get ill in one or another procedure. It is about a sick person, about the elimination of a direct threat to his health, and in this situation, it is unlikely that it is appropriate to consider possible long-term consequences from the very procedure of exposure [18].

However, over the past decade, the trend in the use of X-ray examination of a healthy population, from pupils and conscripts to the army and ending with the population of the mature age - was observed in medicine, in the order of medical examination. Of course, doctors here are putting humane goals: to promptly detect the beginning of a still hidden disease, in order to timely and with great success start treatment. As a result, thousands, hundreds of thousands of healthy people pass through X-ray rooms. Ideally, doctors tend to conduct such surveys annually. As a result, the total irradiation of the population increases. What are the doses of irradiation referred to in medical examinations.

The Scientific Committee for the Study of the Effects of Atomic Radiation on the United Nations has carefully studied this issue, and the findings of many surprised. It turned out that to date; the largest dose of radiation from the population receives precisely from medical examinations. Having calculated the total average dose of radiation for the entire population of developed countries from various sources of radiation, the committee has found that irradiation from power reactors, even up to 2000, is unlikely to exceed 2-4% of natural radiation, from radioactive fallout of 3 - 6%, and from medical illnesses the population annually receives doses reaching 20% of the natural background [18].

On average, the medical diagnostic "illumination" of X-ray for the population of developed countries (England, Japan, the USSR, USA, Sweden, etc.) constitute the average annual dose, which is one fifth of the natural background radiation. This, of course, is on average very large doses, comparable to the natural background, and it is unlikely that it is appropriate to talk about any danger here. However, modern technology can reduce the dose load during prophylactic examinations, and this should be used. Significant reduction of radiation dose during X-ray examinations can be achieved by improving equipment, protection, increasing the sensitivity of recording devices and reducing the time of exposure [18].

Different types of ionizing radiation cause a person and animals of the same type - radiation sickness. The speed and nature of the manifestation, as well as the depth of radiation damage, depend on a number of factors, in particular, on the absorbed dose, its power, the reactivity of the organism and, finally, on the conditions of exposure. In the course of experiments on laboratory animals, when their total irradiation was more than 100 rad was found that the average life expectancy after irradiation depends on the absorbed dose. At irradiation of the order of 100 rads in dogs, life expectancy is reduced only slightly. At irradiation of 100-150 rads there are diseases of different severity, and the life expectancy of the animal is sharply reduced. At irradiation of 1000-15000 rads, animals die on the third or fourth day after exposure to radiation, and when irradiated more than 20,000 rad animals die several seconds after irradiation or during irradiation - the so-called death under the beam (molecular death). There are observations that show that with the same absorbed doses in cases of lower dose rate, the harmful effect of radiation is reduced. This is associated with processes for repairing damaged tissues for the time between irradiation sessions. However, multiple re-exposures at low levels of radiation also cause disease. Based on available statistical data on radiation sickness in humans, as well as based on the results obtained at higher mammals, provisions have been developed on the maximum permissible doses of radiation, that is, the maximum absorbed doses, the receipt of which does not cause significant somatic disorders in the human body. Such a dose for humans is currently 0.1 bar per week above the natural background for people working with radioactive sources, 0.01 beats per week for those who are in contact with them and 0.001 for all other people. The individual features of the organism [42, 43] play an essential role in the development of radiation damage.

Different types of radiation are accompanied by the release of different amounts of energy and have different permeability, and therefore they have different effects on the tissues of a living organism. A sheet of paper delays alpha radiation, which is a stream of heavy particles consisting of protons and neutrons, for example, and practically it, is not able to penetrate the outer layer of the skin, formed by dead cells. Therefore, it does not pose a danger until the radioactive substances releasing alpha particles enter the body through an open wound, with food or with inhaled air; then they become extremely dangerous. Beta-radiation has a greater penetrating power: it passes through the tissues of the body to a depth of one to two centimeters. The penetrating ability of gamma radiation, which propagates at the speed of light, is very high: it can only hold a thick lead or concrete slab. Damage caused by radiation in the living organism will be the greater, the more energy it will transfer to the tissues; the amount of such a transferred body of energy is called the dose (this term was originally related to the dose of the drug, that is, a dose that benefits, and not to the detriment of the body). The radiation dose the body can receive from any radionuclide or their mixture, regardless of whether they are outside the body or inside it (because of exposure to food, water or air). Doses can be calculated differently. Taking into account the size of the irradiated area and where it is located, whether one person was exposed to irradiation or a group of people and for how long it was happening [30].

For all his life, a person receives a dose of radiation from natural sources, and in normal conditions of habitat, such exposure does not cause any changes in human organs and tissues.

However, by its very nature radiation is harmful to life. Small doses can "run" not yet fully established chain of events, leading to cancer or genetic damage. At high doses, radiation can destroy cells, damage tissues of organs and cause a rapid death of the body [16].

Damage caused by large doses of irradiation, usually manifested within a few hours or days. Cancer, however, is manifested many years after irradiation, usually not earlier than in one or two decades. In addition, birth defects and other hereditary diseases caused by damage to the genetic apparatus, by definition, are manifested only in the following or subsequent generations: these are children, grandchildren and more distant descendants of the individual who was exposed to irradiation [16].

While the identification of the rapidly detected ("acute") effects of exposure to large doses of irradiation is not difficult, it is usually difficult to detect long-term effects from small doses of irradiation. This is partly because they need to take a lot of time to detect them. However, even having detected some effects, it is still necessary to prove that they are due to the effect of radiation, since both cancer and damage to the genetic apparatus may be caused not only by radiation, but also by a multitude of other causes [16].

To cause severe damage to the body, the radiation dose must exceed a certain level, but there is no reason to believe that this rule applies in the case of effects such as cancer or damage to the genetic apparatus. At least, in theory, for this very small dose. However, at the same time, no dose of radiation does not lead to these effects in all cases. Even with relatively high doses of irradiation, not all people are doomed to these diseases: in the human body, reparative mechanisms usually eliminate all the damage. Similarly, anyone exposed to radiation does not necessarily have to get cancer or become a bearer of hereditary diseases; however, the probability or risk of such an effect is greater than that of a person who has not been exposed. In addition, the risk is the greater the larger the dose of radiation [16].

Of course, if one dose of radiation is large enough, the irradiated person will perish. In any case, very large radiation doses of about 100 grams cause such a serious damage to the central nervous system that death usually occurs within a few hours or days. At doses of 10 to 50 grams in irradiation of the entire body, the central nervous system defeat may not be so severe as to lead to a fatal outcome, but the irradiated person is likely to still die after one to two weeks from hemorrhages in the gastrointestinal tract. At even lower doses, there can be no serious damage to the gastrointestinal tract or the body cope with them, and yet death can come in one or two months from the time of irradiation, mainly due to the destruction of red bone marrow cells - the main component of the hematopoietic system of the body: from Doses of 3-5 Gy for irradiation of the whole body dying about half of all irradiated [16,17].

Cancer - the most serious of all the effects of human exposure at low doses. At least directly for those people. Who have been exposed to radiation. In fact. A large survey of about 100,000 people who survived the atomic bombing of Hiroshima and Nagasaki in 1945 showed that cancer is the only cause of increased mortality in this population group [17].

The problem of protecting people from harmful, dangerous acts of ionizing radiation has been developing for a long time. In 1905, the first Congress of German radiologists raised the issue of the legislative protection of work radiologists. In the Soviet Union there was a sanitary legislation regulating the rules for the use of sources of ionizing radiation in hygiene, which is a scientific and methodological center for the development of radiation hygiene issues.

Artificial sources of ionizing radiation, according to the United Nations assessment of the effects of radiation, generate an average of about 40 mrad per day on the gonads; while from natural sources, this dose is 100 mrad, ie 2.5 times more [17].

Thus, the increase in radiation exposure due to artificial radiation sources is relatively small. Given the variation of the natural background radiation and the ability of the body to adapt to increase the radiation background in some limits, it is necessary to recognize such changes in the values of radiation in a sufficiently safe for health. However, it should be noted that these doses are average for the entire population. In some cases, there may be significant deviations. Therefore, if each person because of using ionizing radiation for therapeutic purposes receives an average of 10 mrad per year, a patient undergoing radiotherapy can receive thousands and tens of thousands of radium.

Protection from internal radiation is to eliminate direct contact of workers working with radioactive substances and prevent them from entering the air in the working zone. The rules of radiation safety, which contain the categories of exposed persons, dose limits and measures for protection, and sanitary rules that regulate the placement of premises and installations, the place of work, the procedure for obtaining, recording and storing radiation sources, ventilation requirements, dust removal, disinfection, should be guided by radiation safety standards. Radioactive waste, etc. [1].

All living organisms, including humans, are constantly in the radiation field of low intensity. Every six seconds our body permeates the high-energy quanta of gamma radiation throughout life, bombarded by elementary particles of high energies. The irradiation of our organism is due to cosmic radiation, radiation of radionuclides, scattered in the surrounding rocks, waters and atmosphere, radionuclides, incorporated into our tissues and organs. Radiation from natural sources of radiation has increased over the past decade due to the use of air transport, nuclear weapons testing, and introduction into the system numerous nuclear power plants, the widespread use of X-ray diagnostics in medicine, the use of radioisotopes and electronic devices in everyday life. The radiation dose received by a person from all these sources is small. To compare the contributions of various sources to the overall average dose for the entire population of the Earth, they were compared to the natural radiation background, which was taken at 100 mrad / year [16, 17].

Everyone living on Earth is exposed to many chemical and physical factors that act simultaneously with radiation. What will be the consequences of the simultaneous action of ionizing radiation and radio waves of different ranges, ultraviolet and infrared radiation? How will radiation affect the hot climate at the equator and at low temperatures of the Far North? Will synergy be manifested in the mutagenic action of radiation with the simultaneous effect of chemical mutagens, every day more and more polluting the environment surrounding us? How will the effect of small doses of radiation in the conditions of large industrial cities, in which exhaust gases of cars, oxides of nitrogen and sulfur chemical plants, contaminate the air? There is currently no data for an exhaustive answer to similar questions, but everything we know about the phenomenon of synergy makes it all the more serious to treat them and deploy research in this direction [16,17].

All this is an exciting and important task for scientific research and the production of new experiments, for reflection and reflection. These are tasks that are called upon to solve the squads of young scientists who are interested in the area of "invisible rays" around us - an area studied by radiobiology. Solving these problems is very important for all humanity in the present and future [18].

All chemical elements consist of atoms. Most of the atoms are stable, which means that they are immutable. However, some of the heaviest atoms that decay and transform into others. Such a dissociation is called radioactivity. Radioactivity is by no means a new phenomenon; the novelty lies only in how people tried to use it. In addition, radioactivity, and its associated ionizing radiation existed long before the birth of her life and was present in space before the Earth itself [16-18].

Each radioactive element at decay releases certain rays with a certain frequency. This frequency can neither be accelerated nor slowed down in any way. Some elements break up quickly, others slowly, but in any case, this phenomenon is not subject to man [16-18].

In the nucleus there are particles called neutrons, because they are electrically neutral. The kernels of atoms of the same element always contain the same number of protons, but the number of neutrons in them may be different. Atoms having nuclei with the same number of protons, but differing in the number of neutrons belonging to different varieties of the same chemical element, are called isotopes of this element. The nuclei of all isotopes of chemical elements form a group of "nuclides [34].

Some nuclides are stable, that is, in the absence of external influence, never undergo any transformation. Most nuclides are unstable; they all turn into other nuclides. As an example, we will take the atom of uranium-238, in which the nucleus of protons and neutrons are barely held together by the forces of grip. From time to time, a compact group of four particles breaks out of it: two protons and two neutrons (an alpha particle). Uranium-238 is transformed into thorium-234, in which nuclei contain 90 protons and 144 neutrons. However, thorium-234 is also unstable. His transformation, however, is not the case, as in the preceding case: one of his neutrons turns into a proton, and thorium-234 turns into protactinium-234, in which the nucleus contains 91 proton and 143 neutrons. This metamorphosis, which occurred in the nucleus, also affects electrons moving in orbits: one of them becomes unpaired and flies out of the atom. Prolactin is very unstable, and it takes very little time to transform ...

Further, there are other transformations accompanied by radiation, and all this chain eventually ends with a stable lead nuclide. There are many such chains of spontaneous transformations (decays) of different nuclides according to different conversion schemes and their combinations [34].

At each such act of decay, energy is released, which is further transmitted in the form of radiation. We can say that the particles produced by the nucleus, consisting of two protons and two neutrons, are alpha radiation; the emission of an electron, as in the case of the collapse of thorium-234, is beta radiation. Often, an unstable nuclide is so excited that the emission of a particle does not lead to a complete removal of arousal; then he ejects a portion of pure energy, called gamma ray (gamma-quantum). As in the case of X-rays (in many respects similar gamma rays), there is no release of any particles [34].

The entire process of spontaneous decay of an unstable nucleus is called radioactive decay, and such a nuclide is radionuclide itself. However, although all radionuclides are unstable, some are more volatile than others are. For example, protactinium-234 dissolves almost instantly, and uranium-238 - very slowly. Half of all atoms of protactinium in any radioactive source decompose in time, just over a minute, while half of all atoms of uranium-238 will turn into thorium-234 for only four and a half billion years [34].

The bulk of the radiation of the world's population is derived from natural sources of radiation (Fig. 1). Most of them are such that it is completely impossible to avoid exposure to them. Throughout the history of the existence of the Earth, various types of radiation fall on the surface of the Earth from outer space and come from radioactive substances in the earth's crust, the natural radioactivity present in food and air. Every person is more or less exposed to natural radiation, and for most of the population, this radiation is a source of radiation [16].

Any inhabitant of the Earth exposes irradiation from natural sources of radiation, but some of them receive higher doses than others. It depends, in particular, on where they live. Normal to human habitation is considered the level of gamma background in 20 microspheres per hour. However, this is rather conditional, because in principle, normal radiation cannot be normalized. It depends on the particular area, its relief: in the mountains, for example, higher than in the plain. In some parts of the globe, where radionuclides are found especially radioactive, the level of radiation is much higher than the average. However, many people live where they are accustomed, and nothing happens to them. Verhovovintsy, for example, live in conditions where the level of natural radiation is two to three times higher than average and long-lived among them more. Tens of thousands of people in the Far North eat mostly m 'Long-tailed deer (Caribbean), in which there is a fairly high concentration of nuclides of lead-210 and polonium-210. These isotopes fall into the body of deer in the winter when they feed on lichens, which accumulate both isotopes. Doses of human exposure to polonium-210 in this case can be 35 times higher than the average level. In addition, in another hemisphere, people living in Western Australia in places with high concentration of uranium receive radiation doses that are 75 times higher than the average, because they eat meat and the intestines of sheep and kangaroo. The above-mentioned nuclides are highly concentrated in fish and shellfish, so people who consume many fish and other gifts of the sea can receive relatively high radiation doses these isotopes fall into the body of deer in the winter when they feed on lichens, which accumulate both isotopes. Doses of human exposure to polonium-210 in this case can be 35 times higher than the average level. In addition, in another hemisphere, people living in Western Australia in places with high concentration of uranium receive radiation doses that are 75 times higher than the average, because they eat meat and the intestines of sheep and kangaroo. The above-mentioned nuclides are highly concentrated in fish and shellfish, so people who consume many fish and other gifts of the sea can receive relatively high radiation doses these isotopes fall into the body of deer in the winter when they feed on lichens, which accumulate both isotopes. Doses of human exposure to polonium-210 in this case can be 35 times higher than the average level. In addition, in another hemisphere, people living in Western Australia in places with high concentration of uranium receive radiation doses that are 75 times higher than the average, because they eat meat and the intestines of sheep and kangaroo. The above-mentioned nuclides are highly concentrated in fish and shellfish, so people who consume a lot of fish and other gifts of the sea can receive relatively high radiation doses Doses of human exposure to polonium-210 in this case can be 35 times higher than the average level. In addition, in another hemisphere, people living in Western Australia in places with high concentration of uranium receive radiation doses that are 75 times higher than the average, because they eat meat and the intestines of sheep and kangaroo. The above-mentioned nuclides are highly concentrated in fish and shellfish, so people who consume a lot of fish and other gifts of the sea can receive relatively high radiation doses Doses of human exposure to polonium-210 in this case can be 35 times higher than the average level. In addition, in another hemisphere, people living in Western Australia in places with high concentration of uranium receive radiation doses that are 75 times higher than the average, because they eat meat and the intestines of sheep and kangaroo. The above-mentioned nuclides are highly concentrated in fish and shellfish, so people who consume a lot of fish and other gifts of the sea can receive relatively high radiation doses consuming a lot of fish and other gifts of the sea, can receive relatively high doses of radiation consuming a lot of fish and other gifts of the sea, can receive relatively high doses of radiation

The dose of radiation also depends on the way people live. The natural radiation background is constantly changing because of restless human activity, the spread of technologies for the processing of natural products containing radionuclides [16-18].

Recently, the radon problem is becoming urgent. Radon is formed in the natural radioactive decay of radium practically everywhere, including in the soil under the buildings, in underground drinking waters. Radon is isolated from building materials used in industrial and civil engineering. Since radon is a heavy gas, its concentration in the living rooms of the ground floor and basements is always higher [18].

Before getting into the human body, the radioactive substances pass through the complex routes in the environment, and this has to be taken into account when assessing radiation doses received from any source [16-18].

Artificial radionuclides are formed because of human activity.

Testing nuclear weapons - one of the most dangerous sources of radioactive contamination of the environment. When testing nuclear weapons in the atmosphere, radioactive substances fall into the upper atmosphere, from which they are slowly transferred to the lower atmosphere and then to the ground. Since the adoption of the Treaty on the Limitation of the Testing of Nuclear Weapons in 1963, only a few tests were carried out in the atmosphere, the latter being held in 1980 in a state that did not sign this treaty. The concentration of radionuclides formed during the testing of nuclear weapons in air, rainwater and food significantly decreased compared to the maximum values in the early 60's and is currently at the lowest levels recorded during all measurements performed since 1953 [16 -18].

Of greatest interest are radionuclides that produce a large dose of irradiation, such as carbon-14, strontium-90 and cesium-137. These radionuclides are transmitted through food chains to human food, and thus lead to a dose of internal radiation, which is now mainly caused by carbon-14. Deposits of radionuclides producing gamma radiation result in external radiation.

On April 26, 1986, a sudden overload of power in a reactor at the Chernobyl Nuclear Power Plant (Ukraine) caused an explosion, resulting in a significant amount of radionuclides released into the atmosphere for ten days. Once in the air, they spread throughout Europe, reaching May 2 in Great Britain, where heavy rain in North Wales, Cambrian and Southeast Scotland has led to high levels of radionuclides in these areas [16].

Emissions of radionuclides into the environment occur also in some processes in the non-nuclear industry. As a result, for the most part of these emissions, there are insignificant individual doses that make a small contribution to the collective dose. However, one branch of industry deserves attention in this regard - it is getting electricity at power stations working on coal. Irradiation occurs both when inhaled into the air and when transferred to these radionuclides in food chains. Coal, like most other natural materials, contains small amounts of primary radionuclides. In the process of extraction and processing of ore, radon is isolated, the fertilizers themselves are radioactive, and the radioisotopes contained therein penetrate from the soil into food crops. Radiation pollution in this case is usually insignificant, but increases if fertilizers are introduced into the earth in liquid form or fed to the cattle substances containing phosphates. Such substances are widely used as feed additives, which can lead to a significant increase in the content of radioactivity in milk. All these aspects of the use of phosphates give an estimated collective effective equivalent dose per year, equal to approximately 6000 people-Zv.Medical devices. Radionuclides enter the human body with fluorography, tooth roentgen graphs, lung x-ray, radioisotope surveys, and radiation therapy. Other sources of radiation include flights to the plane, TV, computer, granite structures [16].which can lead to a significant increase in the content of radioactivity in milk. All these aspects of the use of phosphates give an estimated collective effective equivalent dose per year, equal to approximately 6000 people-Zv. Medical devices. Radionuclides enter the human body with fluorography, tooth roentgen graphic, lung x-ray, radioisotope surveys, and radiation therapy. Other sources of radiation include flights to the plane, TV, computer, granite structures [16].which can lead to a significant increase in the content of radioactivity in milk. All these aspects of the use of phosphates give an estimated collective effective equivalent dose per year, equal to approximately 6000 people-Zv.Medical devices. Radionuclides enter the human body with fluorography, tooth roentgen graphs, lung x-ray, radioisotope surveys, and radiation therapy. Other sources of radiation include flights to the plane, TV, computer, granite structures [16].granite buildings [16].granite buildings [16].

Radionuclides are both natural (relatively small) and artificial origin. The last (for all elements of the Mendeleev table) physicists have already received more than 2000. Dozens of types of such active nuclei are generated during the operation of nuclear research or power reactors [34].

The most important characteristics of radionuclides include [16, 34]:

1) The number of Z protons (charge of the nucleus), which determines the isotope of which chemical element is this radionuclide. Relying on the data of chemistry and knowing Z, there is much to say about the chemical properties of atoms with radioactive nuclei;
2) Number of neutrons N and atomic number a (total number of particles in the radioactive nucleus). Kernels with the same Z and different N (they are called isotopes) have different degrees of stability;
3) types of their radiation and particle energy;
4) The half-life Tm is the number of years (days or hours) for which half of the initial amount of radionuclides decays with the release of ionizing radiation.

The stability of the nuclei is higher, the greater the half-life. The latter for different unstable nuclei can vary greatly. For some, the half-life can be considerably less than a second, for others can (like for uranium or thorium) it can exceed one billion years. The table shows some radionuclides of a certain ecological significance, as well as half-life and their radiation patterns. In this table, the (+) sign is marked with low energy radiation. A particle with such energy up to a stop ionizes 500-1500 molecules of living matter. The sign (++) corresponds to greater energy and the formation of up to 6 thousand pairs of ions by each particle with such energy. However, for energy (+++) the number of ionized molecules reaches 10 thousand or more. The greatest energy (++++) has particles that can create up to 100,000 pairs of ions before the stop [34].

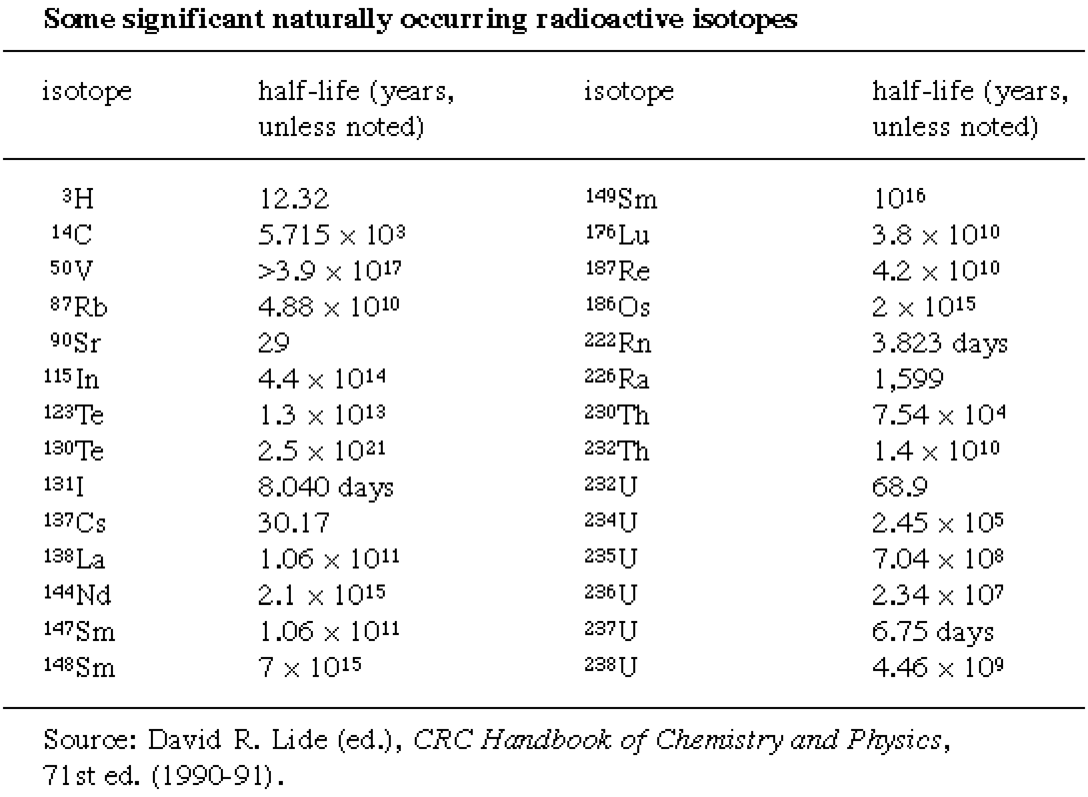
If the number of ionized molecules directly indicates the level of harmfulness for a certain specific radiation, then this cannot be said about its "mileage" (distance of braking). The distance of the run in the soft tissues of humans is the smallest (about 30 mm = 0.03 mm), the largest number of damaged molecules. In β-particles, the average run distance is 23 mm, in the gamma rays 30-50 cm. If the source of ionizing radiation is located inside us, the greatest damage is from α-particles, 10-12 times less - from β-particles and even less (because they will partly depart from us without absorption) - from γ-rays.

The situation turns out to be the opposite if the source of radiation is outside of us and distant at a distance of several tens of centimeters or 1-2 meters. This air layer does not almost absorb at the rays, they become the most dangerous. Significantly better β-particles are absorbed, the intensity of the flow decreases (moderate danger). The air will not pass to us α-particles, excluding the danger on their part. If the source of radiation is located on or near the skin, then the dead cells of the upper layer (or clothing) absorb all α-particles (which are found to be harmless). The body absorbs almost all β particles (the most harmful in this situation) and a significant part of γ-quanta (somewhat less harm than β) [34].

It has been proved that many radionuclides inherited the Earth from the remnants of supernovae. The explosion of one of them could have been a stimulus to the formation of the solar system from the cloud of space dust. Only isolated species of retro radionuclides have been preserved and distilled from that remote to billions of years: potassium-40, uranium-238, uranium-235 and thorium-232. They are the products of the decomposition of heavy nuclei and constitute the majority of natural radionuclides, forming a natural field of radiation.

The second (lower) portion of natural radionuclides with a small mass of nuclei is continuously born (mainly in the upper atmosphere) as products of the collision of the flux of cosmic particles with nuclei of atoms of the atmosphere and soil (carbon-14, tritium, and others). Their contribution to the natural radiation background is negligible, and, of course, it cannot be neglected. They are few, but they belong to those elements that are part of the living substance. Therefore, they are easier than heavy elements, "embedded" in the molecule of proteins, DNA and harm, like saboteurs [16, 34].

Table 5.2. - Characteristics of ecologically important radionuclides [34]



Some significant naturally occurring radioactive isotopes

isotope	half-life (years, unless noted)	isotope	half-life (years, unless noted)
^{3}H	12.32	^{149}Sm	10^{16}
^{14}C	5.715×10^{3}	^{176}Lu	3.8×10^{10}
^{50}V	$>3.9 \times 10^{17}$	^{187}Re	4.2×10^{10}
^{87}Rb	4.88×10^{10}	^{186}Os	2×10^{15}
^{90}Sr	29	^{222}Rn	3.823 days
^{115}In	4.4×10^{14}	^{226}Ra	1,599
^{123}Te	1.3×10^{13}	^{230}Th	7.54×10^{4}
^{130}Te	2.5×10^{21}	^{232}Th	1.4×10^{10}
^{131}I	8.040 days	^{232}U	68.9
^{137}Cs	30.17	^{234}U	2.45×10^{5}
^{138}La	1.06×10^{11}	^{235}U	7.04×10^{8}
^{144}Nd	2.1×10^{15}	^{236}U	2.34×10^{7}
^{147}Sm	1.06×10^{11}	^{237}U	6.75 days
^{148}Sm	7×10^{15}	^{238}U	4.46×10^{9}

Source: David R. Lide (ed.), *CRC Handbook of Chemistry and Physics*, 71st ed. (1990-91).

Of all the natural and artificial radionuclides, the group of environmentally significant ones included [16, 34]:

1) those that are isotopes of "elements of life", members of a group of elements with small and medium masses of nuclei, from which the living matter (including the human body) is constructed: 1-5, 7-11;
2) products of artificial division of the heaviest and most unstable nuclei into two parts of the near masses in the process of the operation of all nuclear reactors and during the testing of nuclear weapons: 13-15, 18, 19, 23. They are released into the environment during nuclear explosions in the air or in the water and as a result of serious accidents on nuclear reactors of all types and constructions (example of the explosion of a reactor at the Chernobyl Nuclear Power Plant in 1986);
3) A group of radioactive inert gases that emit into the air all nuclear reactors in the process of their normal operation: 6, 7, 12. Not involved in chemical reactions, cannot enter into a living substance, but irradiate our tissues when they fall into the lungs along with air;

4) A group of heavy retro radionuclides (22, 24) and their decay products (20, 21), which account for a small proportion of the natural background radiation.

Ionizing radiation is radiation (electromagnet, magnetic, corpuscular), which, when interacting with a substance, or indirectly, cause ionization and violation of its atoms and molecules. The atom of any chemical element consists of two main parts: a positively charged nucleus and negatively charged electrons, which rotate around it in different orbits. The nucleus of an atom has a complex structure, it consists of positively charged particles - protons having the same mass, and electrically neutral neutrons. Varieties of one element having different atomic mass (due to different neutrons), but the same charge of atomic nuclei and identical chemical properties, were called the isotopes, or nuclides [34, 42, 43].

Physical properties of ionizing radiation are given in Table 5.3 [34, 42, 43].

Table 5.3 Physical properties of ionizing radiation

Physical properties	Type of radiation			
	Alpha	Beta	Gamma	Neutrons
Radiation energy, MeV	1-10	0.1-2.0	0.1-20	0.05-10
Distribution velocity in vacuum, km / s	20000	280 ·	300000	1 · -1 ·
Runtime in air	Up to 20 cm	Up to 15 cm	Hundreds meters	Hundreds of meters
Runway length in the tissues	Up to 50 microns	Up to 1 cm	Dozens centimeters	Centimeters - meters
Ionizing ability	(10-20) · pairs / mm	5-10 pairs / mm	1 pairs / cm	Hundreds-tens of thousands pairs / mm

Ionizing radiation, passing through a substance, spends its energy on ionization and excitation of the atoms and is absorbed by this substance. The energy consumed by a charged particle or a photon of electromagnetic radiation per unit length of their run in a substance is called a linear energy transfer (LPE). In the SI system, it is expressed in Joule per meter. In radiobiology, special units are often used to measure the energy of ionizing radiation - electron-volts (eV). One electron volt (1 eV) corresponds to the energy received by an electron in a field with a voltage of 1 volt. 1 eV = 1.60 · J. Therefore, the LPE is expressed in kilo electron volts (keV, eV) per micrometer of the path in water (1 keV / mm is 0.16 nJ / m) [16-18].

The mileage depends on the energy of photon radiation, charge, mass and particle velocity; this dependence increases sharply with decreasing speed and increasing particle mass [34].

Gamma - (γ-) radiation is the flux of photons (quanta) of electromagnetic radiation with energies above 100 keV [34].

The energy of the gamma quanta produced by the nuclei after the α-decay is usually not greater than 5 MeV, after the electron decay of 2.0-2.5 MeV. At annihilation of antiparticles, it is 0.511 MeV. On average, the energy of the γ-radiation of various radioactive elements varies in the range 0.1-3 MeV and rarely reaches 10 MeV [34].

γ-quanta with energy up to 1 MeV form radiation called the [34] soft, and with energies more than 1 MeV - hard radiation. γ-quanta, with the rare exception, form a linear spectrum of radiation, constant for each element. The monoenergetic radiation spectrum has only some γ-emitting isotopes, therefore, usually indicate their average energy (E).

Due to the small probability of encounters of γ-quanta with atom electrons, they have a high permeability. In the air, γ-quanta pass through a few hundred meters, in the wood - up to 25 cm , in lead - up to 5 cm , in concrete - up to 10 cm , in water - dozens of meters, and they live through organisms through them, giving them significant a threat as a source of external radiation. The LPE in water of γ-quanta with an energy of 1.3 MeV is 0.3 keV / mm, and at an energy of 0.25 MeV, it is 2 keV / mm [16, 34].

X-ray radiation is an electromagnetic radiation consisting of a braking and characteristic radiation whose energy range ranges from 0.12-200.0 keV, which corresponds to wavelengths of 50-0.01 nm. In the spectrum of electromagnetic waves, they border with ultraviolet rays, the length of which is 50-2000 nm [34].

Braking radiation is a photon emission with a continuous spectrum that arises when the kinetic energy of charged particles (electrons with an energy greater than 15 keV) is reduced due to their inhibition in the field of the core of an atom of heavy elements. The main sources of X-ray radiation are X-ray machines, which are widely used for experiments with plants and animals, as well as in X-ray diagnostics and radiation therapy. X-ray machines have the ability to regulate the energy of braking radiation, which depends on the voltage on the anode of the X-ray tube, and the intensity of the radiation, which depends on the current strength of the cathode [34].

Brain radiation sources can be some radioactive isotopes, whose β-particles, when braking them in the field of nuclei of heavy-element atoms, are converted into braking radiation impulses whose energy is equal to the energy of β-particles. The intensity of such radiation is much lower than in X-ray machines [34].

The characteristic radiation is a photon radiation with a discrete spectrum that occurs when the energy state of electron atoms under the influence of fast electrons and β-particles is changed [34].

The absorption of the energy of a fast electron by electron shells, for example a tungsten or molybdenum atom, from which the anode of an X-ray tube is made, leads to the knocking out of one of the electrons of its inner layers outside the atom. At the same time ionization of the atom occurs. At the place of the electron, knocked out of the inner layer, an electron from the more distant layers of the nucleus immediately passes. This transition is accompanied by the emission of a number of photons with different energy values characteristic of each particular atom. The energy of these photons can be in the visible spectrum, the ultraviolet and infrared spectra, depending on the energy of the particles and the serial number of the element. Therefore, this type of radiation is called characteristic [34].

γ-quanta lose energy when it passes through a substance due to three effects: photoelectric absorption (photoelectric effect), Compton scattering (Compton Effect), and the formation of electron-positron pairs. The relative magnitude of each of these effects depends on the atomic number of the absorbing material and the photon energy [34].

The photoelectric absorption effect occurs at low energies of γ-quanta, usually up to 10,000 eV [34].

In the photoelectric effect, the γ-quantum, knocking out an electron (more often than a K-layer), passes all its energy to it and disappears, and the electron receives energy of its energy, minus the energy of the electron bond in the atom [34].

At higher energies of γ-quanta (100-200 keV), there is a Compton Effect, which is still called "Compton scattering". At the same time, the γ-quanta, knocking out the electrons, conveys to them only some part of their energy, after which the direction of motion changes, that is, dissipate. This process continues until the γ-quantum completely transfers its energy to the electron that is knocked out and ends with the photoelectric effect [34].

γ-quanta with energy from 1,022 MeV to 20 MeV in a substance under the action of a strong electric field near the nucleus become a pair of "electron-positron". In this case, electromagnetic radiation is converted into corpuscular particles. After that, the pair of "electron-positron" disappears (annihilates), turning into two secondary γ-quanta with energy equal to the energy equivalent of the resting mass of particles of 0.511 MeV [34].

γ-radiation with an energy of more than 20 MeV can interact with nuclei of atoms (nuclear effect), but the probability is very small [34].

Interaction of corpuscular particles with matter. Charged particles, passing through a substance, gradually spend their energy on ionization, i.e., the separation of the electron from the atom (ionization charges) and the excitation of atoms and molecules (radiation losses), which then appear in the form of braking radiation [34].

Charged particles of different types but with equal energy form almost the same number of ion pairs (the same total ionization).

Alpha - (α) - radiation is a stream of positively charged α-particles or helium atom nuclei. A-particles consist of two protons and two neutrons, having a double positive charge, an atomic mass of 4,003 a.m. (6,664 · 10- 27 g), the speed of their movement in a vacuum is 9-25 · 103 km / s. Their energy varies in the range from 2 to 11 MeV. The energy spectrum of α-particles is monochromatic or close to it and is characteristic of each α-emitting element.

A-particles release unstable nuclei of heavy Tran's uranium elements, which are in the periodic system DI the Mendeleev serial numbers, are above 82. At the same time, the nucleus loses two protons and two neutrons and turns into the nucleus of another element placed on two cells to the left of the parent (α-decay). The excess energy of the daughter nucleus is released from γ-radiation [34].

The run of the α-particle in a substance is directly proportional to its energy and inversely proportional to the density of matter. The energy of the α-particles is spent on ionization and excitement of the atoms of the medium, forming a 1 cm path in the air of 116000-254000 pairs of ions. The density of ionization of the medium dramatically increases at the end of the run - there is the so-called Brigg Peak. The α-particle's LP in water is up to 260 keV / mm. The length of the run, which is carried out by the α-particle until the total energy loss, reaches 10 cm in air , 0.10-0.15 mm in water and soft biological tissue . After losing energy, the α-particle joins two electrons and turns into a helium atom [34].

Beta - (β) - radiation is a stream of negatively charged electrons of nuclear origin, which is called β-particles. β-particles are produced by nuclei of radioactive elements with excess in their nuclei of neutrons (electron decay). In this case, the neutron turns into a proton with the release of the β-particle and antineutrino. In the case of electron decay, daughter products that are in a metastable state and have an excess of energy released in the form of γ-quanta are formed. There are pure β-emitting radioactive elements and mixed, with the decay of which β particles are released and 20-80% γ-quanta [34].

The mass of the β-particle is equal to the mass of the electron (0.00548 a.om or 9.11 · g). The energy of β-particles of various natural and artificial radioactive isotopes has a huge range: from 0.0015-0.05 MeV (soft β-radiation) to 3, less than 12 MeV (rigid β-radiation). With an electron decay, the antineutrino is released along with the β-particle, and the nucleus binding energy is arbitrarily distributed between them. Therefore, the energy of the β-particles of the same element is uneven; their energy spectrum is continuous, or continuous. The average energy of β particles in the spectrum is approximately 1/3 of their maximum energy and is denoted by ( ) [34].

When interacting with the medium, the β-particle spends its energy on ionization and excitement of the atoms (ionization energy consumption) and the formation of braking radiation (radiation energy expenditure), which increases with the increase in the atomic mass of the irradiated substance. Their path in the material is winding, as they easily change the direction of motion under the influence of electric fields of opposing atoms [34].

The run of β-particles reaches 25 m in air, 0.85 cm in biological tissue. They form 50-100 pairs of ions per 1 cm of the path in the air. The LPE of β-particles in water with an average energy of 0.4 MeV is 0.25 keV / mm, at the end of the run it is increased to 0.70 keV / mm [34].

The length of the run of β-particles increases with increasing energy.

The β-particles of medium energies are almost completely absorbed by a layer of aluminum and a Plexiglas with a thickness of five mm. Due to the scattered type of ionization, there is no complete protection when working with sources of β-radiation. With external exposure to a large number of β-particles, β-burns of the skin and plant leaves, damage to the lens of the eye can occur. Particularly dangerous are they when they enter the body [34].

5.9.1. Radiation pollution, its sources and objects, measures of protection.

Because of human activity in the external environment, artificial radionuclides and radiation sources appeared. Natural radionuclides, which are extracted from the earth's interior, together with coal, gas, oil, mineral fertilizers, building materials, began to flow into the natural environment. These include geothermal power plants that generate an average emission of about 41014 Bq of the isotope 222Rn per 1 GW of electricity produced; phosphorus fertilizers containing 226Ra and 238U (up to 70 Bq / kg in Kola apatite and 400 Bq / kg in phosphorus); coal, burned in residential buildings and power plants, contains natural radionuclides 40K, 232U and 238U in equilibrium with their decay products. Over the past few decades, people have created several thousand radionuclides and began to use them in scientific research, in technology, for medical purposes, and others. This leads to an increase in the dose of radiation received by both individuals and the general population [14, 16].

At present, the main contribution to the dose from sources created by man, also contributes to the radiation exposure in diagnosis and treatment. In developed countries, every thousand people account for 300 to 900 such surveys per year, not counting massive fluorography and x-ray examination of teeth [14].

To study the various processes occurring in the body and for the diagnosis of tumors are also used radioisotopes that are introduced into the human body. In industrialized countries, approximately 10 to 40 surveys per million inhabitants per year are projected. Collective effective equivalent doses are 20 people-Z per 1 million residents in Australia and 150 people-in-USA. The average effective equivalent dose, obtained from all sources of radiation in medicine, in industrialized countries is 1 mSv per year per inhabitant, that is, approximately half of the average dose from natural sources [14].

5.9.2. Nuclear cycle. Nuclear reactor. Safety of the NPP. Chernobyl Accident.

The radiological consequences of testing nuclear weapons are determined by the number of tests, the total energy output and the activity of fragments division, types of explosions (air, land, underwater, surface, underground) and geophysical factors of the environment during the test period (district, meteorological conditions, migration of radionuclides, etc.). Testing nuclear weapons, which was particularly intensive in the period 1954-1958 and 1961-1962, has become one of the main causes of increasing the earth's radiation background and, as a result, a global increase in the doses of external internal radiation of the population [41].

In the US, the USSR, France, Great Britain and China, a total of at least 2060 tests of atomic and thermonuclear charges in the atmosphere, under water and in the bowels of the Earth, of which they are directly in the atmosphere of 501 trials. Atmospheric tests in the USSR were completed in 1962; underground explosions at the Semipalatinsk Test Site - in 1989, on the North Landfill - in 1990, France and China continued to test nuclear weapons until recently. According to estimates, in the second half of the 20th century, due to nuclear testing, 1.811021 Bq of nuclear fission products came into the environment, of which 99.84% was attributed to atmospheric testing. The spread of radionuclides has become planetary scale.

Nuclear fission products (NAPs) represent a complex mixture of more than 200 radioactive isotopes of 36 elements (from zinc to gadolinium). Most of the activity is short-lived radionuclides. Therefore, after 7, 49 and 343 days after the explosion, the activity of PYD decreases accordingly, at 10, 100 and 1000 times, in comparison with the activity one hour after the explosion. In addition, the radioactive contamination is due to radionuclides of the induced activity (3H, 14C, 28Al, 24Na, 56Mn, 59Fe, 60Co, etc.) and an inseparable part of uranium and plutonium. Especially large role of the induced activity in thermonuclear explosions [41].

At nuclear explosions in the atmosphere, a significant part of precipitation (at ground explosions of up to 50%) falls near the test area. Part of the radioactive substances is delayed in the lower part of the atmosphere and under the influence of wind moves over long distances, remaining at about the same latitude. While in the air for about a month, radioactive substances during this movement gradually fall on the Earth. Most of the radionuclides are thrown into the stratosphere (at a height of 10- 15 km), where their global scattering and largely decay occurs. Unsuspended radionuclides fall down all over the Earth.

The source of radiation, which is surrounded by the most intense controversy, is the nuclear power plant. The advantage of nuclear power is that it requires significantly less quantities of raw materials and land than heat stations, does not pollute the atmosphere with smoke and soot. The danger lies in the possibility of catastrophic reactor accidents, as well as in the unresolved problem of utilization of radioactive waste and leakage into the environment of a small amount of radioactivity [41].

By the end of 1984, 345 nuclear power reactors were operating in 26 countries. Their capacity was 220 GW or 13% of the total power of all power sources. By 1994, the world had 432 nuclear reactors; their total capacity was 340 GW.

In the process of working nuclear reactors, they accumulate a huge amount of nuclear fission products and Tran's uranium elements [41].

In the conditions of normal operation of NPPs, radionuclide emissions into the environment are insignificant and consist mainly of iodine radionuclides and inert radioactive gases (He, Cr), whose half-life periods (with the exception of the isotope 85kg) generally do not exceed several days. These nuclides are formed in the course of the distribution of uranium and can penetrate through the micro cracks in the shells of the telescopes (fuel elements containing uranium). The entire dose of radiation, which is possible due to emissions at the nuclear power plant and caused by short-lived isotopes (iodine, IWG), is received during the year after the release, 98% - within 5 years. Almost the entire dose falls on people living near the nuclear power plant [41].

The first major accident at the nuclear power plant occurred in Ontario, Canada on Dec. 12, 1952. Because of overheating and partial melting of the active zone, a huge amount of fission products came into the environment, and radioactive contaminated water was thrown straight to the ground near the Ottawa River. Because of leakage of radioactive materials from the laboratory for the production of plutonium (Liverpool, UK), they fell ill and killed 39 people [41].

In 1969, a significant leakage of radiation occurred in Switzerland at an underground nuclear reactor. In the same year in France, when the fuel was overloaded at a working reactor at the Sainte-Lauren NPP, the operator by mistake in the fuel channel did not load the fuel cell. For this reason, about 50 kilograms of molten fuel hit the inside of the reactor housing and there was a release of radiation into the environment. The reactor was stopped for one year.

At the Czechoslovak nuclear power station in Yalovskiy-Bogunitsa, there were just two accidents in 1976 and 1977. The first accident occurred due to fuel overload, the second - when the nuclear fuel was loaded on the first power unit.

After these accidents, the power plant was closed. Because of malfunctions in the equipment and error of operators on the second unit of the Three Vile Island nuclear power plant in Harrisburg, the United States was the worst accident. There was a melting of 53 percent of the active zone of the reactor and into the atmosphere got radioactive gases - xenon and iodine. In the adjacent river was abandoned 185 cubic meters slabordioaktivnykh waters, were evacuated 200 thousand people from the surrounding areas. At the nuclear power, plant TVA Sequoyah, 40,000 liters of radioactive material was leaked [41].

In 1981, after a crash at the Stagira power plant in Japan, 56 workers received various radiation doses, and another 278 employees of the nuclear power plant received an increased dose of radioactive exposure during emergency repair works. People have suffered damage to the radioactive contamination container at the Kerr-McGee power plant in the United States. However, perhaps, the most terrible accident occurred at the nuclear power plant in Chernobyl. Because of two powerful explosions on the fourth block of the nuclear power plant, part of the reactor unit and engine room collapsed.

The tragedy happened on April 26, 1986. About 190 tons of radioactive substances were thrown into the environment. Tens of thousands of people received various doses of radioactive contamination, many of whom subsequently became invalids, immediately killed 28 people (firefighters and station workers); more than 400 thousand people were evacuated from the infection zone. Huge areas (over 160 thousand square kilometers) were subjected to severe radioactive contamination [41].

It is believed that this accident is the largest in the history of the development of nuclear energy. In addition to the death of people and environmental pollution, the country lost the largest power station. At that moment, it was really the largest in the USSR. As a result, an energy crisis could not be solved for a long time.

Two more accidents at the Chernobyl Nuclear Power Plant occurred in the same year - a fire at the emergency unit four and east of the rails of a special wagon with spent nuclear fuel.

The accident at the Fukushima-1 nuclear power plant is a major radiation accident (according to a statement by Japanese officials - level 7 on the INES scale), which took place on March 11, 2011 because of the earthquake and subsequent tsunami in Japan's history. An earthquake and tsunami blow disrupted external power supply and backup diesel generators, which caused the failure of all systems of normal and emergency cooling and led to the melting of the reactor core at units 1, 2 and 3 in the first days of the accident [41].

Effects of radiation on humans are usually divided into two categories:

Somatic (bodily) - arise in the body of a person who was exposed to radiation. Genetic - associated with damage to the genetic apparatus and manifested in the next or subsequent generations: these are children, grandchildren and more distant descendants of the person who was exposed to radiation [19].

There are threshold (deterministic) and stochastic effects. The first occurs when the number of cells that died as a result of irradiation, which lost the ability to reproduce or normal functioning, reaches a critical value, which significantly affects the functions of the affected organs.

Chronic irradiation has a weaker effect on a living organism than a single exposure in the same dose, which is associated with the ongoing process of restoring radiation damage. It is estimated that about 90% of radiation damage is restored.

Stochastic (probable) effects, such as malignant neoplasms, genetic disorders, can occur at any dose of radiation. As the dose increases, the complexity of these effects increases and the probability (risk) of their appearance increases [16-18].

5.9.3. Migration of radionuclides in the atmosphere.

Radioactive substances migrate in different ways. These are the main factors leading to the redistribution of primary radioactive contamination of the territories.

The main sources of radioactive contamination of the surrounding
The environment is [13]:

1. Induction of chemical elements by cosmic radiation;
2. Nuclear explosions and other tests, military activities;
3. Thermal Power Stations;
4. Industrial Complexes with Full Nuclear Fuel Cycle, Nuclear Industry;
5. Uncontrolled use of radionuclide materials and materials;
6. Extraction of radioactive ores;
7. Volcanic activity of the planet;
8. Forest fires, peatlands, etc.

Usually these sources are uneven in terms of pollution, isotopic and phase state of pollutants. For example, cosmic radiation is ionizing radiation that continuously and eternally enters Earth's surface from the world of space. As a result of the interaction of primary cosmic radiation (neutrons, photons) with nuclei of oxygen atoms, nitrogen, and argon atmosphere, cosmogonic radionuclides are formed, which then enter the earth's surface with atmospheric precipitation. This group is represented by 20 radionuclides with periods of half-life from 32 minutes to 7.4 years [13].

Especially large amounts of radioactive substances are released into the atmosphere when testing atomic and thermonuclear weapons in the air. This is the first important source of radiation pollution of the environment. In a nuclear disruption, about 250 isotopes of 35 elements are formed as direct "fragments" of the separation of nuclei of heavy elements and of products of their decay with periods of half-life from a few seconds to millions of years. Most of these radionuclides carry beta and gamma radiation at the same time; some are sources of beta or gamma radiation. During ground and overland trials, radioactive particles rise to a considerable height, creating unique currents moving above the Earth at a speed of up to 200 km / h. The radioactive cloud formed during the bombing of a nuclear bomb may in two weeks get around the entire Earth. A danger to people arises then when radioactive particles from the atmosphere with precipitation fall on the ground, and when, where and to what extent they fall out after the explosion, it is impossible to predict precisely. Part of the radioactive products falls near the test site, some of them are delayed in the troposphere, picked up by the wind and transported over huge distances. Being in the air for about a month, radioactive substances during these displacements gradually fall to the ground. Most of the radioactive products are thrown into the stratosphere at a height of more than 10-Being in the air for about a month, radioactive substances during these displacements gradually fall to the ground. Most of the radioactive products are thrown into the stratosphere at a height of more than 10-Being in the air for about a month, radioactive substances during these displacements gradually fall to the ground. Most of the radioactive products are thrown into the stratosphere at a height of more than 10- 50 km. There they remain for many months, slowly descending and scattering all over the surface of the Earth [13].

In today's most advanced nuclear devices, the charge utilization rate is about 20%. Part of the elements of charge (uranium, plutonium) that did not react, spray by force of the explosion on the smallest particles containing atoms with the properties of the original radionuclides, create radioactive clouds and spread by the wind on vast territories. Because of the activation, reaction in the area of the explosion there is an additional source of radioactive contamination.

Today there is no product of the biosphere, where radionuclides of "bomb" origin would not be present. The average effective equivalent radiation dose due to radionuclides of nuclear tests is about 20-25 ncSv per year. Significant inflows of radionuclides into the environment are from the use of coal to fuel. The annual need for coal in the world is several billion tons, of which 70% is burned at power plants, 20% - in coke production and 10% - used for heating homes [13].

In structure of coal, as in other earth's rocks, there are natural radionuclides.

The size of the radioactive contamination of the atmosphere during the combustion of coal depends on a number of factors: the content of radioactive isotopes in the coal used the amount of combusted coal, the technology of combustion, the efficiency of ash content containment systems and other combustion products. For example, under the existing purification technologies, up to 10% of volatile ash is introduced into the atmosphere [13].

At all stages of the closed nuclear fuel cycle, from the extraction of uranium raw materials, its enrichment, and the processing of spent fuel, the dumping of high-level waste, the release of artificial radionuclides into the environment, as well as the acceleration of the rate of migration of heavy natural radionuclides [41].

At present, nuclear power engineering is developing mainly for the production of electricity, which accounts for about 20% of the total energy consumption, and in some countries - up to 80%, and in Ukraine - up to 40%.

The magnitude and intensity of the migration of radionuclides in the atmosphere are determined by the following: the effective height of their emissions into the atmosphere, the phase state of emissions, the shape and dispersion of aerosol particles, geographic coordinates of the place of emission, atmospheric conditions. Depending on the influence of these factors, local, tropospheric (the lower layer of the atmosphere up to 8-10 km) and stratospheric (the layer of the atmosphere lying above the troposphere from 10 to 80 km) is isolated - global losses [13].

Local departures are observed in the area up to several hundred kilometers from the source. Radioactive substances of local falls occur in the lower atmosphere. The duration of the fall depends on the season and latitude/

Tropospheric falls are observed in nuclear explosions and major accidents at the NPP. Explosions, with a capacity of several kilowatts of TNT, pollute the troposphere mostly. Powerful explosions, mega-ton power, pollute the stratosphere [41].

Conditional pollution of the territory of Ukraine, Belarus and Russia are divided into four "traces": western, northern, southern and northeast. The most complex nature of radioactive contamination, both in intensity and in the composition of the main nuclides, is observed on the western, northeastern and southern tracks, covering virtually the territory of the Ukrainian Palissy and significant areas south of Kiev [41].

Thus, the migration routes can be divided into the following [13]:

- Areal loss from the atmosphere (dry and wet);
- Water migration;
- Surface and inland-ground drains;
- In the process of repeated redistribution as a result of the movement of air;
- Anthropogenic;
- The vital functions of different living systems.

5.9.4. Migration of radionuclides in reservoirs.

In a water year, which originates in the mountains, radionuclides can come from rocks that in various quantities contain radioactive elements and products of their decay (uranium, thorium, potassium-40, radon, etc.). The radioactivity of surface water is always much lower than that of underground. Most uranium, I am glad, thorium is found in underground waters of uranium deposits. With an increase in the depth of underground water sources, the concentration of radionuclides in them increases [13].

In the water of underground sources used for drinking humans and animals, the content of radionuclides of natural origin is allowed and in quantities not exceeding the maximum permissible standards for open water bodies [13].

In the water, radionuclides of artificial origin coming from the atmosphere, with rain and melt water, with atomic reactor waste, from the enterprises of the radiochemical industry and various other radioisotopes, can be found.

Hydrobionts (micro - and microorganisms) accumulate and deposit radionuclides in themselves. Therefore, the consumption of water containing significant amounts of hydrobionts and silt increases the possibility of radiation damage to animals and humans who consume water containing a lot of silt and hydrobionts [13].

Radioactive substances to the reservoirs can come from the atmosphere, from the soil, through flushing and discharges.

Migration of radionuclides in reservoirs is provided by currents, zoo-hydro bodies, which eat phytohydrobionts contaminated with radionuclides. There is now a specific use of contaminated water for irrigation in agriculture and industry. Especially significant migration of radionuclides is carried out in the reservoirs of fluid. In reservoirs can occur tritium, cesium, zirconium, strontium, etc. [13].

Radionuclides accumulate in the surface layer of water. Thus, in reservoirs in the surface layer, the concentration of radioisotopes can reach 370 mBq / l, and in the water column - 185 mBq / liter. As of 1965-1966 in the waters of the Pacific Ocean, the concentration of strontium-90 in the surface water layer was observed at 1.5 higher than at a depth of 1000 m [13].

The natural factor of self-cleaning of water bodies is microorganisms. It Established in researches conducted on Lake Baikal.

At the bottom of the reservoirs, the concentration of radionuclides is tens of times higher than in water due to their adsorption on the surface of mineral and organic matter. Therefore, hydrobionts that lead to a benthic (bottom) or peribentous lifestyle are more affected by radiation contamination than pelagic ones (those that live in the water column). Depending on the intensity of irradiation, radiation can act on hydrobionts by stimulating, suppressing, damaging or lethal effects [13].

As a rule, with increasing levels of organization of hydrobionts, their radio sensitivity increases. The most resistant bacteria are radiation. Some of them withstand irradiation over 1 million X-rays. Water plants are more resistant to irradiation than animals [13].

The dose of radiation causing the death of 50% of irradiated during 30 days of organisms is as follows [13]:

- for aquatic plants - 0,1 ... 0,5 Gy;
- for invertebrates -0.01 ... 2 Gy;
- for fish - 5 ... 40 Gy (at high temperatures, the radio sensitivity of fish increases significantly);
- For water-repellent mammals - 2 ... 5 Gy.

5.9.5. Distribution of radionuclides in the marine ecosystem.

The role of seas and oceans in maintaining the stability of the entire biosphere is enormous. To understand this role, consider the phenomenon of the transport of radionuclides, trays (tags) or markers characterizing ecosystems.

The largest inflow of radionuclides to the sea and the oceans was during the testing of nuclear weapons in the 1950-1960 pp. Additional local pollution of marine ecosystems comes from discharges and emissions of nuclear reactors, nuclear fuel fabrication plants, radioactive waste disposal in the seas, accidents, etc. Natural radionuclides fall into the sea due to erosion of rocks [13].

Most nuclear military tests were conducted on the continental shelf and the islands of the Pacific Ocean in 1946-1962 pp. Therefore, Britain conducted several nuclear tests in the Pacific in 1952-1958, and Russia carried out nuclear tests at landfills in the polar seas near the Kola Peninsula and on Novaya Zemlya.

Nuclear tests in the Pacific have led to localized radionuclide pollution. Researchers believe that due to such tests, more radionuclides were found in the oceans and seas than on land. Part of radionuclides that fell on land, gets into the ocean through wind and surface runoff [13].

The most important part of the surface runoff of radionuclides in marine ecosystems is the year of drainage. Thus, the runoff of the Dnieper is crucial in assessing the deposition of radionuclides caused by the Chernobyl accident in the Black Sea and the World Ocean. According to the estimates, the activity of the runoff of radionuclides in the Black Sea is (185-740) · Bq (50-200 Ky) per year [13].

In seawater, there are also natural radionuclides. This is primarily potassium-40, uranium, thorium, radium and rubidium. Artificial radionuclides are represented by products of the separation of uranium and radionuclides formed from stable elements after activation by neutrons [13].

Another important factor in the migration of radionuclides in seas and oceans is the chemical composition of water. It was found that the content of H, O, Na, C1 reaches 10-19 g / l, and K and Ca - 380-400 mg (in the fresh water, their content is about 10-8 g). As a result, freshwater organisms, including fish, absorb significantly more Cs-137 and Sr-90 than marine organisms [13].

Another reason for the less accumulation of these radionuclides in marine organisms is that the sea, unlike freshwater reservoirs, contains a huge amount of water for radionuclide breeding. The radionuclides Cs-137 and Sr-90 in seawater are contained in a soluble form, and due to the high concentration of chemical analogues (carriers) in a small amount, they form part of the marine biota. In the open ocean, where biota is low, radionuclides are redistributed between water and various suspensions. Studies on the distribution of radionuclides in depth showed that a significant proportion of radionuclides are located at a depth of less than 100 m, and the rest - up to 1000 m [13].

The biota also influences the migration of radionuclides. The degree of biotic effect depends on radionuclides and other environmental factors. Therefore, plankton and higher organisms accumulate large amounts of radionuclides and burrow them through excretion. Small-scale populations, such as phytoplankton, which are characterized by rapid metabolic processes, carry significant amounts of radionuclides into deep-water layers and sediments after extinction [13].

5.9.6. Migration of radionuclides in the soil.

The main receiver of radioactive fallout on the Earth is the soil. However, the soil is largely covered with plants; the total area of the leaves can many times exceed the area of the soil on which they grow.

If radioactive substances have already fallen into the atmosphere, it is impossible to reduce them on a large scale to the soil and plants.

Regardless of the type of soil, a large number of nuclides are retained in the upper part of the soil profile (0-10 cm). The content of radionuclides gradually decreases with depth.

The migration of radionuclides in the soil depends on the chemical properties of the radioactive elements, the state and the form of their placement: diffusion in the soil solution and transferring with the gravitational flow of water. During the convective transfer of moisture, radionuclides migrate in the soil not only in the dissolved state, but also in a solid state [13].

Migration of radionuclides in the soil can be carried out by surface and ground water drains, deflation processes (transfer of groundmasses by water), wind erosion (the transfer of earth masses by wind), and animals. The anthropogenic factor, in particular, agriculture, transport, construction, coal mining, mining, mining, etc., has a certain place.

Vegetation and animals are an important regulatory factor in the redistribution of radionuclides in the soil. There are reports that, for example, rape elevates radionuclides of depth to the surface of the soil, carrying out the vertical migration of radionuclides in the soil.

To a certain extent, the migration of radionuclides depends on the type of soil, as well as the isotopic composition of radioactive particles, relief. Yes, radionuclides, like most elements of mineral nutrition of plants, have increased mobility and ability to enter plants in acidic environments. Soils Palissy belong to acid and weakly acid (pH = 3.5 - 6) [13].

Under certain conditions, radioactive particles from the ground can rise in the air and settle on the soil, plants; reservoirs are already in another place. They can be washed off from the surface of the soil by rain and melting waters from the catchment areas in the reservoir, contaminating them further.

With the remnants of plants, livestock wastes, radioactive substances fall into the soil again and begin to feed their chains again.

5.9.7. Migration of radionuclides in the forest.

Among the natural and climatic zones, the forest is the one that most Accumulates radionuclides, besides, the forest keeps them the longest. The most intense radionuclides accumulate in the growing parts of the body of plants and animals. Therefore, the plants to such parts include leaves, fruits, berries, young shoots, and the inner part of the bark, spines, and the least radionuclides in the wood [13].

Plants are the main carriers of radioactive substances from the soil in the body of animals and humans. Although on the transition soil - a plant can significantly affect the accumulation of radioactive substances Agricultural plants. Radionuclides enter the plants when they pass into soil solutions. This process, like in general the mobility of substances, is accelerated in the acidic medium [13].

Radioactive contamination of crop production depends not only on the degree of soil contamination, but also on its ability to bind and retain radionuclides. This ability is determined by the physical, chemical and agrochemical properties of soils. For example, in Palissy it is the weakest, much higher - in gray forest, even higher - in the black soil of the forest-steppe [13].

Accumulation of radionuclides also depends on photomasks. Yes, radionuclides are always higher in the terrestrial part of the plant, and among the terrestrial - in berries, fruits. As for animals, then they are mostly in wool, skin, red bone marrow, in the parenchyma of the glands of the internal secretion [13].

Accumulation of radionuclides is more intense in the conditions of a humid climate. The amount of rainfall, humidity of the soil affect the migration of radionuclides.

Migration of radionuclides to the full corresponds to the law of V.I. Verna sky on the biogenic migration of atoms, which is formulated as follows: the migration of chemical elements on the earth's surface and in the biosphere as a whole is carried out either with the direct participation of living matter (biogenic migration), or flows in an environment whose geochemical features are caused by living matter, as the one now inhabits the biosphere, and the one that acted on Earth throughout the geological history. This law with particular force is manifested in a natural arena, which includes forest [13].

Mushrooms occupy a special place in the ecosystem of the forest. The contribution of fungi to the 137Cs biological cycle is several times higher than the contribution of the tree and grass-bush tier. Mushrooms are one of the main factors determining the role of litter as a biochemical barrier in the path of vertical migration of radionuclides in forest ecosystems [13].

Significant danger in the redistribution of radioactive particles is forest fires, resulting in a sharp decline in radioactivity of forest ecosystems, as radioactive particles in aerosols and gaseous compounds are carried into the air. According to the generally accepted classification of forest fires (upper, lower, underground), most of the radionuclides are placed outside the forest biogeocoenosis in the event of a fatal, sustained fire. In underground fires in peat bogs, when the peat burns completely, all the radionuclides contained in it can go into an aerosol state. In lowland fires, a dry ground cover burns, with 5-20% of the total stock of radionuclides of the forest massif released. Forest fires violate the safe deposition of radioactive particles in forest ecosystems and lead to the redistribution of primary radio contamination of the territory [13].

Bio indicator of plant pollution is the response to bees.

CHAPTER 6. RADIATION POLLUTION OF FOOD PRODUCTS AND METHODS OF CONTROL

6.1. You select food contaminants

Radioactive materials have become part of the Earth since its inception. Even a person is slightly radioactive, because in any living tissue there are traces of radioactive substances. A person is exposed to radiation in two ways: radioactive substances can be outside the body and irradiate it from the outside; in this case, it is an external radiation. Alternatively, radioactive substances may be in the air that the person breathes, in food, or in water, and get into the body. Before getting into the human body, radioactive substances pass through a complex path in the environment. The emergence in the biosphere of products of fission and their inclusion in the food chain resulted in the receipt radionuclides in living organisms and has caused additional irradiation of plants, animals and humans. It is possible to distinguish the following routes of exposure of radionuclides to the human body through food: a plant - a person; plant - animal - milk - man; plant - animal - meat - man; atmosphere - precipitation - reservoirs - fish - man [46].

Distinguish surface and structural contamination of food products with radionuclides. When surface contamination of radioactive substances carried by the air are deposited on the surface of products, partially penetrating into the plant tissue. More efficiently radioactive substances are kept on plants with napped cover, in the folds of inflorescences leaves. At the same time delay not only soluble forms of radioactive compounds, but also insoluble. However, surface contamination is easily removed even in a few weeks. The physical and chemical properties of radioactive substances, the composition of soil, and the physiological characteristics of plants cause structural pollution. When radionuclides come from the soil through the root system of plants, because of the sorption forces of the soil absorption complex, separation of radionuclides occurs. Some of them are found in the soil in a relatively accessible condition for plants, therefore a large number of them enters the terrestrial parts of plants, and the part that is firmly fixed by the solid phase of the soil is not readily available to plants [46].

One of the ways to include radionuclides in the biological and food chains may be eating animals, along with food, of soil particles that contain radionuclides when grazed. The main channels for radionuclide withdrawal from the mammalian body are the gastrointestinal tract and the kidneys, and in the lactating animals, in addition - the mammary glands. A part of the fission products that came into the body of lactating animals is excreted along with milk. In experiments on lactating goats and cows, it has been proved that the concentration of radionuclides in milk is always 5 to 10 times higher than in plasma. The highest concentrations of radionuclides in milk of cows are observed in the winter and spring months, which is explained by the decrease in thyroid gland iodine requirements and increased absorption by its mammary gland [46].

Reducing the amount of radionuclides entering the body with food can be achieved by reducing their amount in food products through various technological and culinary processing of food raw materials. Due to processing of food raw materials - thorough washing, cleaning of products, and separation of low-value parts it is possible to remove from 20 to 60% of radionuclides. Before washing some vegetables, it is necessary to remove the upper, more polluted leaves (cabbage onions and others). Potatoes and root crops must be washed twice: before cleaning the skin and after [46].

The most effective method of culinary processing of raw materials in conditions of increased contamination with radionuclide substances is cooking, in which a significant part of radionuclides passes into a decoction. To use such a decoction in food is inappropriate. To get broth you need to cook the products in water for 10 minutes. Then drain the water and continue cooking in a new portion of water [46].

Meat before cooking should be cut into pieces, soaked for two hours in cold-water, and then drain water, pour second water and cook for 10 minutes, then water should be drained and cooked in a new portion of water until ready. When frying meat and fish on the surface there is a crust that prevents the removal of radionuclides and other harmful substances. Therefore, with the probability of food contamination, boiled meat and fish dishes, as well as steamed dishes should be preferred [46].

Reducing the composition of radionuclides in dairy products can be achieved by obtaining fat and protein concentrates from milk. In the processing of milk in the cream is not more than 9% cesium and 5% strontium, in cheese - 21% cesium and 27% strontium, in hard cheeses 10% cesium and 45% strontium. In butter, about 2% of cesium is from its composition in milk [46].

Beans washing and stewing (10 minutes at 96 ° C) reduces the amount of strontium by 56%. When treating tomatoes from the skin after immersion in hot water (90 ° C for 3 minutes), the content of the same radioisotope decreases by 39%. Sterilization of beans under home conditions leads to a reduction of strontium by 50%. Washing green and salads with a 2% solution of citric acid reduces the amount of cesium by 57% and strontium by 19% [46].

Fruits and vegetables, in addition to cooking at home, are processed in large quantities in industrial conditions. Of particular interest is the impact of the technological regime of production on fruit and vegetable canned goods. At normal processing of basic fruits and vegetables, the content of strontium in the finished product is reduced by almost 6 times compared with the raw material. The content of radioisotope decreases with canning in the following order: young peas - in 3, 5 times, carrots - in 1, 3, tomatoes - 1, 5 and peaches in 2 times. When processing in industrial conditions of fruits and vegetables contaminated by radionuclides from outside only, it is recommended the following pre-treatment [46]:

- Flushing for 1-2 minutes with water to eliminate the bulk of mechanically detained radionuclides;
- Treatment for 10 minutes with desorbing solution of hydrochloric acid (1%);
- repeated washing with water for one minute to remove the rest of the solution from the surface of fruits and vegetables.

Therefore, in order to prevent contamination of food products, their radiation control is necessary. This process is quite complex, requires a certain minimum of parameters.

6.2. Terms and definitions. Scope of application

Food control methods (ICHP) are used for hygienic control, as well as for assessing the radiation safety of food products. With the help of (MKHP) set requirements for sampling, the method of laboratory research. Designated for organizations of the state sanitary and epidemiological service that perform food quality control in cities and districts, regions and zones by water and air transport [46].

Food products are products that humanity uses in natural or processed food. Any foods come in batches. A party is a reliably identified quantity of homogeneous food or food of one name, packaged in homogeneous containers intended for a single delivery, sale or storage in one capacity. There are the following types of containers [46]:

Transport packaging - a package for the placement of products that forms an independent transport unit (flask, box, barrel, tank, etc.);

Consumer packaging - a package for the placement of products that enters the consumer and does not constitute an independent transport unit (a bottle, a bank, a package, a briquettes, etc.).

Unit of production - the quantity determined in the established order is the quantity of artificial or non-tangled products (mass of products in a barrel, a box, etc.). Not all foods that enter the consumer pass quality control - this happens selectively. Sampling is a set of product units selected for party control. There is also the concept of sampling volume - the number of units of transport or consumer packaging with the sampled product. Distinguish the following types of samples [46]:

Spot sample - the minimum quantity of products that is selected from one place in one treatment from the product of this batch in order to make a combined sample;

Combined test - set of point samples, which are intended for the compilation of the average sample;

Average sample - part of the combined test, which is intended for research;

Counter sample is a specified amount of substance obtained from a point or combined test according to an established method and is intended to measure its radiation parameters at a radiometric installation in accordance with a regulated research methodology.

The activity of radionuclide is the ratio of the number of unauthorized transformations of nuclei of a given radionuclide occurring over a certain period. Specific activity of radionuclide is the ratio of radionuclide activity in a radioactive sample to the mass of a specimen. To measure activity, a radiometric device is used - a technical device that measures the activity of radionuclides in the sample. The minimum measuring activity of the sample when measured in one hour should be 50% (P = 0, 95) of relative statistical error [46].

The limit of the annual effective dose is the effective dose of anthropogenic radiation, which should not exceed it per year [46].

The control level is the numerical values of controllable values set by the authorized bodies for radiation control, securing the achieved level of radiation hazard, ensuring further reduction of personnel and population radiation, radioactive contamination of the environment [46].

Radiation control - radiation measurements that are performed to determine the degree of compliance with the principles of radiation safety and compliance with standards, including not exceeding the established basic dosage limits and control levels [46].

6.3. The content of radionuclides in food products

In developing the permissible levels of specific activity of radionuclides in food products relied on the following provisions [46]:

Annual effective dose of radiation from the population from fabricated sources should not exceed 1 move / year;

The appropriate limits for ingestion of radionuclides with food are for strontium-90 - 3.6x10 Bq / h and 100 Bq / d; for cesium-137 - 7.7 x 10 Bq / h and 210 Bq / d;

The structure of the diet, studied by the actual materials of the State Statistics Committee, reflects the nutritional habits of the population and includes the main food components that are suppliers of radionuclides in the human body. To calculate, the only one for all administrative formulas of the diet with a mass of 1860 g / d was taken and real levels of food contamination by strontium-90 and cesium-137 were taken into account at present.

Standards are mandatory for domestic and imported food products at enterprises of production, storage, transportation and sale, regardless of ownership, including in the regions contaminated because of the Chernobyl disaster and other industrial accidents.

Radiation control of food products takes place in accordance with the requirements of the Law "On radiation safety of the population" and "Rules of certification of food products and food raw materials. Radiation control of food products under export-import operations is carried out according to the same rules as for domestic products.

When conducting radiation control of food products, the basic procedures are performed: sampling of foodstuffs; preparation of counter samples; measurement of the activity of strontium-90 and cesium-137 in counter samples; calculation of measurement results and research errors; Hygienic assessment of food products according to radiation safety criteria.

The hygienic assessment of a food product is based on the results of measurements using the compliance indicator. Personnel who carry out radiation monitoring of food products must undergo appropriate training in order to familiarize themselves with legal and regulatory documents on food research, sampling and measurement rules [46].

Organizations conducting food research on the content of radionuclides should be accredited to technical competence and independence in accordance with the established procedure.

6.4. Sampling procedure for food products

The number of average samples that are selected for research depends on the size of the lot of an object. Sampling is performed in accordance with established standards. From the point samples of artificial products, the square method is a combined test, the volume of which must be sufficient for the formation of the average sample, but not more than three times its amount [46].

Before sampling milk in tanks and other containers, mix thoroughly. Then, from each capacity, sample points of the same number are taken. The volume of spot samples should be 0.1 to 0.5 liters. When sampling milk, packaged in consumer packaging, sample samples are packed data. From dairy products, which are packed in bottles, packs, packages, as a dot sample, select the following number of units of packets [46]:

- From the batch to 100 units - 2 packing;
- From 101 to 200 units - 3 packages;
- From 201 to 500 units - 4 packing;
- From 501 to 1000 units - 5 packets;
- But not less than 2 liters for milk, etc.

From point samples, a spot sample is formed and a mean sample is taken, which falls on laboratory tests. The volume of the average milk sample should be at least 2.0 liters [46].

Spot samples of cream, liquid dairy products, ice cream, etc. are taken with a sampler or a probe after thorough mixing of the product. Form the combined test, heat up to 20 ° C and sample the average sample. The volume of the average sample must be at least 1.0 liter [46].

From sour cream, which is packed in large containers, the sample is selected and opened for 10% of the total number of packages. In the presence of less than 10 units of packages, open only one. After opening the tare, mix the sour cream with a knife. The volume of the spot sample is from 0.05 to 0.1 l . Spot samples are combined in one clean container, forming a combined test. Before taking the average sample, the sour cream is thoroughly mixed, and if it has a dense consistency, it is preheated in a water bath to 30-35 ° C., after which it is cooled to 20 ° C. The volume of the average sample is not less than 1.0 kg [46].

From cheese and cheese mass packed in large containers, they select 10% of the total number of packages. Three open samples are taken from each open packaging: one from the center and two others at a distance of 3 to 5 cm from the sidewall of the container. The volume of the spot test should be 0.05 to 1.0 kg. The point samples are transferred in a clean dry container, mixed and a medium sample is taken from the combined sample. The volume of the average sample is not less than 1.0 kg [46].

Condensed milk cans are mixed before sampling. If two cans of condensed milk canned with sugar are precipitated, then the jar is heated to a temperature of 28 ° C. and stirred until a homogeneous mass is obtained. As a controlled site, 3% of the total number of units of packaging are selected and opened, but not less than two units. Spot samples are taken from different places. The mass of the average sample is not less than 1.0 kg [46].

For selection of samples of oil are selected and open 3% of the total number of units of packages, but not less than two. Spot samples are taken with a probe heated to a temperature of 38 ° C. For assembling a combined sample from a column of oil taken by a probe from each unit of the transport packaging with the product, the spot samples of the oil are weighed each about 50 g with a knife . The combined sample of oil is placed in a water bath with a temperature of 30 ° C. When constantly stirring, the sample is heated to a softened mass and an average sample for laboratory examination is isolated. The mass of the average sample is not less than 0.5 kg [46].

In meat processing plants and refrigerators, each consignment of homogeneous batches includes 10% of cattle, 5% of carcasses of sheep and pigs and 2% of frozen or chilled blocks of meat and offal, but not less than three. The point samples are taken from each of the meat carcasses included in the selection, or a part thereof, with a whole piece of mass not less than 200 g from the following places: near the animal's slaughter, opposite the 4-5-th cervical vertebrae, in the area of the shoulder blade, in the thigh and thick portions muscles Samples from frozen and cooled blocks of meat and offal are also taken as whole pieces of mass not less than 0, 2 kg. From the obtained point samples, a combined test is formed. Mass of combined test not less than 2, 0 kg. For the formation of an average sample, the meat is thoroughly mixed, for which it is cut into small pieces, or passed through a meat grinder [46].

Birds' carcasses are taken from the batch put on sale by random sampling. The number of samples depends on the number of units of transport packages per batch. The volume of the bird sample in Table 6.1.

Table 6.1.

umber of units of transport packages in batch	umber of selected transport packages	umber of selected samples (half-carrots, carcasses)	umber of selected samples (fourth part of the carcass)
p to 20			
1 - 100			
01 - 400		0	
01 - 800		4	
01 - 1500 and more	0	0	0

To study chicken eggs from a batch of eggs, they make a selection of packaging units in accordance with Table 6.2. [46]

Table 6.2.

Number of units of transport packages in batch	p to 10	1 - 50	1 - 100	01 - 500	01 or more
Number of selected transport packages				5	0
Number of samples selected for the study of eggs	0	0	0	5	50
Standard transport packaging - a box that holds 360 pieces of eggs					

Fish samples are taken from different places by random sampling. The sample includes 10% of the packages. From different places of each open packaging of the product, take 3-point samples, from which then form a combined and average sample. The study is subject to all species of fish separately. Fish is cleaned of mechanical contaminants and scales, frozen fish are thawed to a temperature of 1 ° C [46].

Before choosing natural honey from each batch, make a selection of packaging units, as shown in Table 6.3. [46]

Table 6.3.

Number of packaging units per batch	Number of selected packaging units	Number of packaging units per batch	Number of selected packaging units
o 3		1 - 60	
- 20		1 - 80	
1 - 30		1 and more	0%
1 - 40			

Samples of liquid honey are taken by tubular aluminum samplers with a diameter of 10 - 12 mm, plunging them to the full depth of the package, if the honey is thick - a probe for oil from different layers. A conical probe, immersing it in honey at an angle, takes off crystallized honey. When investigating cell honey from one stormy take part of a cell with an area of 25 cm2. After removing the wax caps, the samples are placed on a mesh filter inserted in a glass, and heated in a thermostat at a temperature of 40-45 ° C [46].

6.5. Preparation of samples for measurement

The primary preparation of samples for measurement involves the usual processing of food products at the first stage of cooking and grinding them in order to increase the mass of the sample that can be placed in the measuring cuvette. The choice of measuring cuvette is determined by the method of measuring radionuclide, the permissible levels of activity of radionuclides in food products. To determine the measuring sample, the cuvette is weighed before and after filling [46].

If it is necessary to increase the sensitivity of measuring methods of research, it is possible to use methods approved by the established procedure for thermal concentration or partial or complete radiochemical allocation of a specified radionuclide [46].

It is also possible to use methods of concentration and radiochemical allocation.

6.6. Measurement of activity of radionuclides in food products

As radiometric devices, when measuring cesium-137, it is recommended to use scintillation and semiconductor gamma-spectra with detecting units in lead protection [46].

Proceeding from the sensitivity of currently released domestic and imported gamma spectra (the minimum measuring activity is 3-10 Bq), when measuring cesium-137 in food products in order to determine their compliance with established norms, it is expedient to use a method of measuring native samples. In those cases where the sensitivity of gamma spectra is not sufficient to obtain a reliable result in native samples, conduct thermal concentration of samples with subsequent measurement of the concentrate obtained [46].

Activity measurement is carried out in accordance with the instructions and guidelines for the use of the gamma spectrometer. If, in the gamma-spectrometric measurement, in addition to cesium-137 and potassium-40, other radionuclides are detected, then the sample should be measured repeatedly according to a program that offers measurements of a wider radionuclide composition [46].

It is recommended to use beta spectrometers ("Progress-beta-M", "Gamma-plus", etc.) to measure the activity of strontium-90, which is characterized by a value of a minimum measuring activity of 0.1-1.0 Bq [46].

Measurement of strontium-90 using a beta spectrometer in the native mode using the Progress software occurs in samples after the determination of cesium-137 and potassium-40 by gamma-spectrometry in samples. In cases where the sensitivity of the beta spectrometer is not sufficient to measure strontium-90 in native samples, concentrations are made by heat treatment or by special radiochemical techniques. The precipitate formed after evaporation or chemical concentration of samples [46] determines determination of the content of strontium-90 in drinking water, mineral water and other beverages.

Radiochemical methods of concentration are also used for products whose thermal concentration is complicated and labor-intensive, such as dairy products, condensed milk, fats, and the like. The basis of such methods is the methods of chemical decomposition (denaturation of protein, fooling of fats, etc.) followed by the combination of strontium-90 and yttrium-90 with calcium oxalates or other non-isotopic carriers [46].

In the absence of spectrometric plants, when determined strontium-90 and cesium-137 in food products, it is necessary to apply radiochemical techniques, the use of which is recommended by SanPiN 2.3.2.560-96 / 9, 10, 11 /, as well as other methods that have been metro logically certified and approved in the established order. The next measurement of the activity of the selected drugs is performed on low background radiometers such as UMF-1500, UMF-2000, RUB-01P, RKG-01A, etc. [46].

6.7. Determination of compliance of food products with radiation safety requirements

In order to determine the conformity of food products with the criteria for radiation safety, the indicator of conformity B and the error of its definition, DELTA B, are used, the values of which are calculated on the basis of measurements of the specific activity of strontium-90 and cesium-137 in the sample [46].

Food products can be recognized as complying with the relevant radiation safety criterion if the sum of the compliance indicator and the error of its definition is less than or equal to one. Food products must be recognized to be inadequate to radiation safety criteria, if the difference between the compliance indicator and the error of its determination is greater than one. Food products cannot be recognized as complying with the radiation safety criteria when: the amount of the indicator of conformity and the error of its determination is more than one. However, in this case: the difference between the index of conformity and the error of its definition is equal to or less than one, then it should be borne in mind that when conducting more accurate measurements there is a chance to get instead of one another. Then it may turn out that, based on the results of more accurate measurements, the food data can be recognized, as meeting the criteria of danger [46].

In the absence of a product, the results of measurements of the specific activity of radionuclides in the sample must satisfy the conditions of accuracy, that is, the determination error must be less than or equal to 0, 3 [46].

The hygienic assessment of the food product is based on the results of measurements using the compliance index and is made in the form of a hygienic conclusion [46].

The Department of State Sanitary and Epidemiological Surveillance of the Ministry of Health can resolve controversial issues that arise in assessing the suitability of food products. Food products whose quality does not meet the established standards are withdrawn from circulation. Their owner in consultation with the bodies of state sanitary and epidemiological service of Ukraine in accordance with the established procedure [46] carries out substantiation of possible ways of using, disposing or destroying food products declared unsuitable for food purposes.

Importation into the state, storage and sale to the population of food products that do not meet the established standards is prohibited.

6.8. Preventive measures

Considering measures of prevention of radioactive contamination of the environment, including food products, the following directions of work should be noted [46]:

Protection of the atmospheric layer of the Earth as a natural screen that protects against the destructive cosmic influence of radioactive particles;

Control over the content of radioactive elements in the air, building materials, water and other objects of the environment;

Observance of global safety in the extraction, use and storage of radioactive elements that are used by a person in the process of his life;

Exceptions to the use of food and water substances with high content of radioactive elements;

Prohibition of the use of building materials that have high content of radionuclides when building housing

Permissible levels of radionuclide content are determined for food and drinking water. In connection with the accident at the Chernobyl Nuclear Power Plant, Temporary Allowable Levels (VDU-91) of the content of cesium and strontium-90 radionuclides in food and drinking water were established. Based on the actual radiation situation and economic opportunities, some republics have the right to set control levels of radionuclide content for their territories, but not to exceed the numerical values of VDU-91.

It is not recommended to produce baby food from products obtained in contaminated areas [46].

An important factor in preventing the accumulation of radionuclides in the human body, working or living in areas contaminated with emergency emissions, is the use of certain foods and their individual components. This is especially true for the protection of the organism from long-lived radionuclides (for example, strontium-90) that can migrate through food chains, accumulate in organs and tissues, to subjected to chronic irradiation of bone marrow and bone tissue, increasing the risk of developing malignant neoplasms [46].

It was established that the enrichment of the diet with fish mass, calcium, bone meal, fluorine, luminaria contributes to the reduction of the risk of oncological diseases. Of greater interest in this issue are non-digestible carbohydrates, which are used to enrich the food products of therapeutic and prophylactic purposes [46].

Important in the prevention of radioactive exposure is beta-carotene and foods with high content of this provitamin. Reducing the population's exposure can be achieved through targeted optimization of the agricultural production structure, using the fact that in products of animal husbandry, radionuclides contain 2-4 orders of magnitude less than in crop products. The main contribution to the total intake of radionuclides with the diet is carried out at the expense of vegetable products (cabbage, potatoes) [46].

According to the recommendations of Dr. Gayle "On safety measures in the conditions of high radiation for residents of Belarus and Ukraine" (1989)

Needed [46]:

- good food;
- Daily emptying of the intestine;
- Decks of flax, nettles, laxatives;
- Abundant drink, sweat more often;
- Vitamins P, C, B, beet juice, carrots, red wine (3 tablespoons daily);

- Radish grated (in the morning to rub - eat in the evening and vice versa)
- Walnuts, 4-5 pcs. Daily;
- Horseradish, garlic;
- Buckwheat, oatmeal;
- Bread kvass;
- Ascorbic acid with glucose (2 times a day)
- Activated charcoal (1-2 pcs before meals);
- Vitamin A (no more than 2 weeks)
- From dairy products is better cheese, cream, sour cream, butter;
- Vegetables and fruits clean up to 0, 5 cm, remove cabbage at least 3 leaves
- Meat is better to eat pork and poultry, cook: 1 st broth to merge, fill with water and cook until ready (meat broths are excluded)

Products with ant radioactive action

- Carrot,
- Vegetable oil,
- Cheese
- Calcium tablets

Cannot:

- Coffee
- jelly, bones, bone fat,
- Cherries, apricots, plums;
- The most infected beef;
- It is not recommended to eat boiled eggs, because the shell contains strontium, which turns into protein during cooking.

Despite the fact that the above recommendations are more general, they nonetheless constitute certain principles of protection and are in that capacity as such.

In general, under the technologies here understand the complex measures, which include engineering, physical, medical, and biological measures of human security. Of course, both of these and others are preventive in nature and require more knowledge-intensive system support.

SUBMITTED INDICATOR

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Навчальне видання

ГЕРАСИМОВ ОЛЕГ ІВАНОВИЧ
ТЕХНОЛОГІЇ ЗАХИСТУ НАВКОЛИШНЬОГО СЕРЕДОВИЩА

Навчальний посібник
англійською мовою

***Підписано до друку* ________________**