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БЕЗОПАСНОСТЬ ЖИЗНЕДЕЯТЕЛЬНОСТИ

Учебное пособие

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SAFETY OF HUMAN ACTIVITIES

Manual

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Утверждено ученым советом университета в качестве учебного пособия для иностранных студентов

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В данном учебном пособии представлены фундаментальные понятия и определения дисциплины «Безопасность жизнедеятельности». Основное внимание уделено физиологии работы, здоровья и безопасности человека в техносфере, оценке влияния опасностей на человека и защите в чрезвычайных ситуациях, также предложены тестовые задания.

Учебное пособие предназначено для студентов всех специальностей и направлений бакалавров и магистров.

Данное издание публикуется в авторской редакции.

In the given edition the basic sections of discipline "Safety of human activities" are stated, the systematized minimum of knowledge opening the basic concepts and definitions is presented. Scientifically-practical knowledge in the field of physiology of work, health and safety of the person in a technosphere, an estimation of influence of dangers on the person is given, to protection in emergency situations, and also control tests.

The textbook is intended for students of all specialities and directions of training of experts and bachelors.

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Contents

INTRODUCTION

BASES OF INDUSTRIAL SAFETY, MAIN CONCEPTS, TERMS AND DEFINITIONS

The level of decision of the industrial safety problems providing in any modern state can be the most reliable and complex criterion for estimation of the economic development and stabilities degree of this state, and also for estimation of the society moral condition.

The essence of the industrial safety teaching is stipulated by the presence of the permanent influence on person of external mass energetical and information streams, part from which can have levels, exceeding possible influence on it.

Main determinations

Safety is an activity condition that excludes the danger presence and safety absence.

Industrial safety is the field of scientific knowledges that explores the dangers those threaten to a person and also rules of their appearance and methods of protection from them.

Danger (hazard) is a phenomenon, processes, objects and subjects features those are capable to injure the person's health in appointed conditions.

Dangers:

1. Probable (accidental);
2. potential (latent);
3. permanent (constant), continuous;
4. total (general and comprehensive).

Activity is necessary condition of human's society existence.

Labour is the highest form of human activity.

Biosphere is the area of life expansion on the Earth including lower atmosphere, hydrosphere and upper lithosphere those haven't tried the anthropogenic impact.

Technosphere is the habitat appeared by means of direct or indirect impact of people and technique on environment for the best equivalence of

environment to the social-economic needs of a person. Technosphere replaces biosphere in XX century.

Axiom about potential safety is the main postulate of Industrial Safety: potential danger is the universal property of interaction process between a person and environment.

Industrial Safety axioms:

1. Any activity (inactivity) is potentially dangerous.

2. There are comfortable conditions for every kind of activity that make for its maximum efficiency.

3. All natural processes, anthropogenic activity and activity objects have the tendency to the spontaneous loss of stability or continuous negative impact on the person and his habitat, i.e. have residual risk.

4. The residual risk is an original cause of potential negative impacts on the person and biosphere.

5. Safety is real if negative impacts on the person do not exceed the maximum indices for their complex impact.

6. Ecological compatibility is real if negative impacts on biosphere do not exceed the maximum indices for their complex impact.

7. Indices of anthropogenic negative impacts are supported by the adherence to the requisitions of ecological compatibility and safety to the technical systems, technologies and also systems ecobioprotection (ecobioprotection technique) use.

8. Ecobioprotection systems on technical objects and in technological processes have the priority of putting into operation and control device of operating regime.

9. Safe and ecological exploitation of technique and productions is realized on equivalence of operator's qualification and psychophysical characteristics to the requirements of engineering system designer and on the adherence of standards and safety and ecological compatibility requirements by operator.

Phases of specific safety problems solving:

1. Identification (detailed analysis) of dangers those are inherent in every specific activity;

2. development of measures on person and environment protection from ascertained dangers;

3. development of measures for liquidation of danger realization consequence.

Laws of biosphere development

1. The totality of all living organisms on the Earth has the one physicochemical composition, regardless of their systematic belonging and it is defined as living substance (the law of physicochemical unity of living substance by V. I. Vernadskiy). The mass of living substance is rather small. It is only $2{,}4 – 3{,}6 \cdot 10^{12}$ t (in dry weight).

2. *The Law of the internal dynamic balance*. Substance, energy, information and dynamic features of the separate natural systems and their hierarchy are interconnected so that any change of one of these factors causes attendant functional structural qualitative and quantitative changes, those save total amount of substantial-energy, information and dynamic features of systems, where these changes take place, or in their hierarchies.

Number of consequences of given Law functioning is established by the empirical way:

a) any change of environment (substance, energy, information, dynamic features of ecosystems) unavoidable results to the development of natural chain reactions, aimed at neutralization way of taken measurement or new natural systems formation. Formation of these systems can become irreversible on serious environment changes;

b) interaction of substantial-energy ecological components (energy, gas, liquids and etc.), information and dynamic features of natural systems quantitatively is not linear, i.e. weak influence or change of one of the factors can cause strong deflections in another ones (also in the whole system in tote);

c) changes, taken place in big ecosystems, are relatively irreversible. Passing on hierarchy upwards – from influence place to the biosphere in the whole, they change global processes and by this way transfer them into the new evolution level;

d) any local nature transformation causes recoils in global complex of biosphere and in its largest subdivisions. These recoils results in relative constancy of ecological and economical potential, increase of which is possible only by the significant increasing of energy inputs.

4. *All-or-nothing law*. Weak influences can’t cause nature system’s recoils until they accumulate and will bring to the development of impetuous dynamic process. The law is useful on ecological forecast.

5. Constancy law (V. I. Vernadskiy). The Amount of nature living substance (for given geological period) is constant. Any change of living substance amount in one of the biosphere regions inevitably involves its change of the same rate in any region, but with reversed sign. Polar changes can be used in nature management processes, but it is important to take into account that not always adequate change takes place. Usually highly developed species and ecosystems are displaced by others, those are relatively on lower level of evolution (big organisms are displaced by smaller ones), but useful forms for person are displaced by less useful, neutral or even harmful ones.

6. *Law of nature management energy efficiency decrease*. With passing of historical time on useful production getting from natural systems it is applied at the average more and more energy on its unit. With passing of historical time it is applied at the average more and more energy on its unit at useful production getting from natural systems.

SECTION 1. PHYSIOLOGY OF LABOUR

1.1. Physiology of labour and comfort conditions of life ctivity. Classification of human's activity principal forms. Physical labour and intellectual work. Difficulty and tension of labour. Methods of labour difficulty rating

Labor activity is divided on physical and intellectual work.

Physical labour is characterized by increased load on supporting-motor apparatus and its functional systems, providing its activity. Physical labour developing the muscular system and stimulating the exchange processes, at the same time has a number of negative consequences. First of all, this is the social inefficiency of the physical labour, connected with its low productivity, necessity of physical powers tension and necessity in the long rest (up to 50 % of working time).

Intellectual work joins works connected with information reception and organization that requires the sensory apparatus tension, attention, memory, and also mentation activation, emotional sphere. Hypokinesia is typical for given kind of the labour, i.e. significant reduction of person's motor activity. Reduction of person's motor activity results in worsening of organism responsiveness and increasing of emotional tension. Hypokinesia is one of the conditions of cardiovascular pathology formation of the

intellectual work persons. Long mental load oppressively influences on psychical activity: the functions of attention, memory, perception get worse.

Labour forms that require significant muscular energy.

This kind of labor operations is used on the absence of mechanized facilities and requires the raised energy expenditures from 17 to 25 MJ (4000 – 6000 kkal) and more per day.

Mechanized labour forms. On these labour forms energy expenditures of workers vary in the range of 12,5 – 17 MJ (3000 – 4000 kkal) per day.

The forms of the mechanized labour change the nature of the muscular loads and complicate the action programmes. Professions of the mechanized labour quite often require the special knowledges and skills.

In conditions of mechanized production it is observed the reduction of the muscular activity volume. Small muscles of distal segments of extremities are involved into the process, which must provide the high speed and accuracy of motions those are necessary on mechanisms control. Monotony of simple and mostly local actions, monotony and small volume of information apperceived in labour, result in the labour monotony.

Forms connected with partly automated production. The Semiautomatic production excludes the person from the process of direct treatment of labour's object that the mechanisms carry out entirely. Person's duty is limited by the maintenance of automated lines and electronic technique control. Characteristic features of this kind of work are monotony, increased rate and rhythm of work, taut nerves.

The Physiological particularity of the automated labour forms is a constant readiness of worker to action and reaction rapidity on removal of appearing defects. Such functional condition of "active waiting" is different on degree of fatiguability and depends on attitude to labour, urgency of the necessary action, responsibility of lying ahead work and etc.

Group forms of labour: conveyor. The feature of this form is lies in division of the general process on concrete operations, strict sequence of their execution, automatic giving of the details to each working place by means of moving belt of the conveyor. The conveyor form of the labour requires the synchronous work of participants in accordance with the given rhythm and rate. Herewith than less of time the worker spends on operation, that more monotonous work is and simpler its contents.

Monotony is one of the negative consequences of the conveyor labour, which is expressed in premature weariness and enervation.

Forms of labour, connected with control by production processes and mechanisms. The person is enclosed in control system as necessary operative part – than the control process less automated, that the labour of the person is used. Two main forms of production process control are distinguished from physiological aspect: in one case the control boards require the frequent active actions of the person, but in other case they require the rare active actions. In the first case continuous attention of a worker gets the relaxation in multiple motions and colloquial acts, in the second one the worker is in ready condition to the activity, his reactions are small.

Forms of intellectual (mental) labour. This labour is presented by professions, referring to the sphere of material production, for instance constructors, engineers, technologists, dispatchers, operators and others, and also outside of it: scientists, doctors, teachers, writers, actors, artists and others.

Intellectual labour is concluded in conversion and analysis of the big volume of varied information, and as the result of this – the mobilization of the memory and attention, frequency of stressful situations. However muscular loads, as a rule, small, day power inputs is 10 – 11,7 MJ (2000 – 2400 kkal) per day.

For intellectual labour the hypokinesia is typically i.e. significant reduction of motor activity of the person, resulting in deterioration of organism reactivity and increasing of the emotional voltage. Hypokinesia is a negative production factor, one of the reasons of cardiovascular pathology which have persons of the brainwork.

In conditions of scientific-technical progress the role of the creative element increases in all spheres of professional activity. At the century of computer technologies the part of mental activity increases in many professions, especially in professions of physical labour, even when the function of control is on the electronic technology.

Mental labour is connected with acceptance and conversion of information, requires the tension of the sensory apparatus, and also the activation of mental processes, emotional sphere.

Forms of mental labour are divided on operator, control, creative labour, the labour medical workers, the labour of teachers and students. They differ according to the organization of the labor process, the evenness of load, emotional tension condition.

Operator's labour. In conditions of the modern multiple factor production the function of control for functioning of technological lines by processes of turnover and service of buyers are more important. For example, the labour of dispatcher of the wholesale depot or main manager of the supermarket is connected with processing of the big information content for short time period and raised nervously-emotional tension.

Control labour is the labour of leaders of institutions, enterprises is characterized by hyper increase of information content, quick decision making, increased personal responsibility, periodic occur of conflict situations.

Creative labour is the most difficult form of labor activity, requiring the significant memory capacity, concentration of attention that arise the nervously-emotional tension. This is the labour of teachers, programmers, designers, scientists, writers, composers, actors, artists, architects, constructors.

The **labour of the teachers, trade and medical workers, workers of all spheres of service** differs by the constant contact with people, raised responsibility, often the deficit of time and information for taking the correct decision that stipulates the high degree of nervously-emotional tension.

The **labour of students** is the tension of main psychic functions, such as memory, attention, perception; presence of stressful situations (exams, tests).

Energy expenses of a person depend on intensity of the muscular functioning, information intension of labour, degree of the emotional tension and the other conditions (temperature, moisture, velocities of air moving and others). The day expanses of energy for persons of the mental labour (engineers, doctors, teachers and others) are 10,5 – 11,7 MJ; for workers of the mechanized labour and sphere of service (nurses, shop assistants, workers servicing automatic machines) – 11,3 – 12,5 MJ; for the workers, carrying out the work of the medium heaviness (the machine operators, miners, surgeons, melters, agricultural workers and others), – 12,5...15,5 MJ; for workers carrying out the hard physical work (miners, metallurgist, lumbermen, loader), – 16,3 – 18 MJ.

Energy expenses change depending on the working position. In the sitting working position the energy expenses exceed on 5…10 % the level of the main metabolism; in the standing worker position – on 10...25 %, in the forced uncomfortable position – on 40...50 %. During the intensive

intellectual work the brain necessity in energy is 15...20 % of the total metabolism in organism (brain mass is 2 % of the body mass). Increasing of the total energy expenses at mental work is defined by degree of nervously-emotional tension. So, during the oral reading in the sitting position the energy consumption increases on 48 %, during the speaking with public lecture – on 94 %, operators of the computers – on 60...100 %.

The level of energy expenses can be the criterion of heaviness and tension of the carried out work, having great meaning for optimization of the labour conditions and its rational organization. The level of energy expenses is defined with the help of the method of the full gas analysis (the volume of the oxygen consumption and isolated carbon dioxide is taken into consideration). With the increase of labour heaviness the consumption of oxygen and amount of applied energy considerably increases.

Heaviness and tension of the labour are characterized by the degree of the functional tension of the organism. It can be energy tension, depending on the labour capability, – at the physical labour, and emotional – at mental work, when information overload occurs.

Physical heaviness of labour is a load on organism at labour, requiring mainly muscular effort and corresponding energy provision. The classification of labour according to the heaviness is carried out on level of energy expenses taking into account the type of load (static or dynamic) and loaded muscles.

Static work is connected with the fixation of instruments and subjects of labour in fixed condition, and also with the giving to a person the working position. So, the work requiring the worker to stay in static pose for 10...25 % of working time is characterized as the work of medium heaviness (energy expenses 172...293 J/s); 50 % and more is the hard work (energy expenses over 293 J/s).

Dynamic work is a process of the muscles anastalsis that results in the moving of load, and also the body of person or his/her parts in space. At that the energy is put out on the keeping of the definite tension in muscles, and also on mechanical effect. If maximum mass of the raised manually loads does not exceed 5 kg for women and 15 kg for men, the work is characterized as light work (energy expenses up to the 172 J/s); 5...10 kg for women and 15...30 kg for men is characterized as medium heaviness work; over 10 kg for women or 30 kg for men is characterized as hard work.

Tension of the labour is characterized by the emotional load on organism during the labour, requiring mainly intensive cerebration on

reception and conversion of information. Besides, at the estimation of the tension degree they take into account the ergonomic factors: interchangeability of the labour, position, number of the motion etc. So if the density of perceived signals does not exceed 75 per hour, the work is characterized as light; 75...175 – of medium heaviness; over 176 is characterized as hard work. I In accordance with hygienic classification of the labour the labour conditions subdivide on four classes: 1– optimal; 2 – possible; 3 – harmful; 4 – dangerous (extreme).

Optimal conditions of the labour guarantee maximum productivity of the labour and minimum tension of the organism of the person. The optimal standards are established for microclimate parameters and working process factors. For another factors conditionally use such labour conditions, when the levels of negative factors do not exceed the adopted as the safe factors for population (within the scope of background).

The possible conditions of the labour are characterized by such levels of ambience factors and working process, which do not exceed the adopted ones by hygienic standards for work places. Changes of the functional condition of the organism are restored during the specified rest or to the beginning of the following shift, they must not influence negatively in the near and distant period on the health of worker and his posterity. Optimal and possible classes correspond to the safe labour conditions.

The harmful labour conditions are characterized by the levels of harmful production factors, exceeding hygienic standards and influencing negatively on the organism of worker and (or) his posterity.

The harmful labour conditions (3d level) are divided on four degrees of badness. The first degree (3.1) is characterized by such divergence from hygienic standard, which, as a rule, cause reversible functional changes and condition the risk of disease development. The second degree (3.2) is defined by such levels of production factor, which can cause the stable functional breaches, resulting in the increasing of diseases, temporary loss of ability to work, increasing of the frequency of general diseases, appearance of initial features of professional pathology.

At the third degree (3.3) the influence of harm factor levels results in the development of professional pathology in light forms, growing of chronic general somatic pathology, and also to increasing of diseases level with temporary loss of the ability to works. In conditions of the labour of the fourth degree (3.4) can appear the expressed forms of the professional

diseases; it is noted the significant increasing of chronic pathology and high levels of diseases with temporary loss of the ability to works.

The extreme labour conditions are characterized by such levels of production factors, influence of those during the work shift (or its part) creates the danger for life, high risk of the appearing the heavy forms of the sharp professional defeats.

1.2 Microclimate. Hygienic normalization of microclimate parameters of production and non production workplace

The normalization of microclimate parameters of production workplaces.

The standards of production microclimate are established by the system of labour safety standards of the State Standard 12.1.005-88 «Total sanitary-hygienic requirements to the working zone air» and SANPIN 2.24.548-96 «Hygienic requirements to microclimate of production workplaces». They are united for all productions and all climatic zones with some small retreats.

In these standards each microclimate component in working zone of the production workplace is separately normalized: temperature, relative humidity, velocity of the air in depending on abilities of the person organism to acclimatization in different season, type of the cloth, intensities of the produced work and type of heat generations in workplaces.

For estimation of the cloth type (heat insulation) and acclimatization of the organism in different season the concept “year period” is introduced. It is distinguished the warm and cool period of the year. The warm period of the year is characterized by average daily temperature of the outside air +10 ^{o}C and above, cool period of the year is characterized by average daily temperature – below +10 ^{o}C.

At the taking account the intensity of the labour all types of work, proceeding from the total expenses of organism energy, are divided on three categories: light, average gravity and heavy.

Works carried out in the sitting or standing position, not requiring the systematic physical tension (comptrollers’ work, work in processes of precision instrument-making, office works and others) are concerned to the light works (category I) with energy expenses up to 174 Wt. Light works are divided on the category Ia (energy expenses up to 139 Wt) and category Ib (energy expenses 140... 174 Wt).

Works with energy expenses 175...232 Wt (category IIa) and 233...290 Wt (category IIb) are concerned to the average gravity works (category, II). Works, related to permanent walking, carried out in the sitting or standing position, but not requiring loads displacement are included in category IIa, works related to walking and carrying of small (up to 10 kg) loads (in machine-assembly departments, textile production, wood processing and others) are included in category IIb.

Works related to the systematic physical tension, particularly to the permanent movement, transportation of big loads (over 10kg) (in the forge casting shop with manual processes and other) are concerned to the heavy works (category III) with energy expenses over 290 Wt.

According to the intensity of the heat generation the production workplaces are divided on the groups depending on the specific excesses of explicit heat. Explicit heat is the heat influencing on the variation of workplace air temperature. Excess of explicit heat is the difference between summary inflows of the explicit heat and summary heat loss in the workplace.

The explicit heat that was formed within workplace, but was removed from it without transmission of the heat to the air of workplace (for example, with gas from flue or with the air of local suctions from equipment) at calculation of heat excess is not taken into account. The small excesses of the explicit heat is the heat excesses not exceeding or equal to 23 Wt on 1 m^3 of internal volume of the workplace. Workplaces with big excesses of the explicit heat are characterized by heat excesses more than 23 Wt/m^3.

The intensity of the heat irradiation of workers from warmed surfaces of the technological equipment, lighting instruments, insolation on constant and changeable work places must not exceed 35 Wt/m^2 at irradiation 50 % of surface of the person and more, 70 Wt/m^2 – at irradiation 25...50 % of surface and 100 Wt/m^2 – at irradiation not more than 25 % of surface of the body.

The intensity of the heat irradiation of workers from opened sources (the heated metal, glass, open flame and others) must not exceed 140 Wt/m^2, not more than 25 % surfaces of the body must be under irradiation and it is obligatory to use the individual protection funds.

In the working zone of the production workplace according to the State Standard 12.1.005-88 the optimum and possible microclimate conditions can be established.

SECTION 2. HUMAN AND ENVIRONMENT

2.1 Negative factors in the system "person – the environment". The Classification of negative factors: natural, anthropogenic and technogenic, physical, chemical, biological, psychophysical; traumatic and harmful factors. Probability (risk) and levels of the negative factors influence. Criterions of safety.

Hazard as relates to «Accident» is defined as the potential for causing harm to persons, damage to property or environmental degradation. It will particularly cause unwanted transfer of energy and can occur in random variations of normal operations or from changes in physical or human factors. In many industrial units, safety management system revolves around minimizing the occupational injuries. In a few units the system extends to controlling the near misses. These are reactive approach. The best safety management system will be adopting a proactive approach that is hazards are controlled by minimizing the errors since it will be difficult to eliminate the 'changes' in the industrial scenario.

As per the definition, hazards are due to transfer of energy in one form or other. If the energy transferred more than the withstanding capacity at the receiving end, hazard is created. Haddon, a researcher, has enumerated a few forms of energy in the industrial situation, table 2.1.

The human system or any other object or species has tolerance levels or thresholds for each form of energy. The quantity of such energy, particularly near the threshold limit must be determined in order to decide on the control method to eliminate or reduce the impact of hazard.

The dangerous factor is a production factor, which influence on worker in determined conditions results in the trauma or sharp aggravation of health (electric current, ionizing emission and etc.).

The bad factor is a factor, which influence on worker in determined conditions results in disease or reduction of capacity to work.

Dangers:

- by descent:

1. natural,
2. technogenic,
3. ecological,
4. mixed;

– by time of the appearance:

1. pulsed (appear immediately, e. g., shock hazard),

2. cumulative (accumulating, e. g., habitation in the place of raised radioactive influence);

– by localizations:

1. lithospheric (earthquake, volcanic eruption);
2. hydrospheric;
3. atmospheric (ozone holes);
4. cosmic (solar cycles).

Table 2.1

Forms of energy transfer

Energy	Examples
Kinetic	Rotating, revolving, vibratory, reciprocating, falling objects, etc
Potential	Solid objects, physical strength, materials, stored pressure, coiled spring, etc.
Electrical	Electricity, including static charge
Chemicals	Flammables, reactive, water sensitive, asphyxiating, poisons, explosives, corrosives, toxic, etc.
Thermal	Hot surface, molten metal, Boilers / Furnaces, etc.
Acoustic	Noise, ultrasonic
Light	Inadequate quantity, poor quality, ultra violet and infra red rays, laser, etc
Ionizing radiation	Radio active substances
Non ionizing radiation	Electro magnetic waves
Biological	Micro organisms

Factors:

– Depending on the type of influence:

1. Active (energy carriers themselves);
2. actively-passive (energy reason exists too, e. g., corner of the table - a person can be injured by it);
3. Passive (functions mediately, e.g., corrosion of metals, degradation of materials).

– Depending on energy that the factors have:

1. Physical (radiations, noises);
2. Chemical;
3. Biological (predators, parasites);
4. Psychophysiological.

The notion "risk". Definition of risk.

The analytical risk expresses the frequency of realization of the dangers relating to their possible number:

$$R = \frac{N(t)}{Q(t)} \qquad (2.1)$$

Factors of the risk. The classification of the risk.

Factor (lat. – moving force) is the important circumstance in some process or phenomenon.

Factor of the risk is a factor not being a reason of dangers realization, but increasing the probability of its appearing.

Object of the risk is the thing is under the risk.

Risk types:

1. individual,
2. technical,
3. ecological,
4. social,
5. economic,
6. others.

Individual risk characterizes the danger of the certain type for a separate individual.

Social risk is a risk for group of the people, dependency between the frequency of the dangers realization and number of the victims.

Social - acceptable risk is the level of social risk, when the society is ready to die.

2.2 Negative factors of technosphere, their influence on person, technosphere and environment

Elements of technosphere create the technogenic dangers, appearing when the environment pollution by different wastes and power flows takes place. Zones of the action of technogenic dangers are spread on regions of technosphere and nearest natural zones, on territory and places of economy objects, on transport, local and residential areas. In some cases the technogenic dangers are appeared on interregional and global levels.

2.3 Environment pollution by waste

2.3.1 Air pollution

Atmospheric air always contains some amount of the admixtures, entering from natural and technogenic sources. To admixtures, selected by

natural sources are referred: dust (vegetable, volcanic, cosmic origin, appearing at erosions of ground, particles of sea salt); the mist; the smoke and gases from forest and steppe fires; gases of the volcanic origin; the different products of the vegetable, animal origin and others.

Natural pollution sources can be dispersed, for instance the fallout of cosmic dust, or local, for instance forest and steppe fires, volcanic eruptions. Level of the air pollution by natural sources is background and changes a little during the time.

The motor transport, heating energy and number of the industry branches (table 2.2) create the main technogenic air pollution.

Table 2.2

Sources of air pollution

Admixure	**Main sources**		**Annual average concentration in the air, mg/m^3**
	Natural	**Antropogenic**	
Dust	volcanic eruptions, dust storms, forest and steppe fires, etc.	firing of fuel in industrial and home plants	In towns 0,04…0.4
Sulfurs dioxide	volcanic eruptions, oxidation of sulfur and sulphates	firing of fuel in industrial and home plants	In towns to 1,0
Oxides of the nitrogen	Forest and steppe fires	Industry, motor transport, thermoelectric power stations	In regions of highly developed industrial area to 0,2
Oxides of carbon	Forest and steppe fires, excretion of the oceans	Motor transport, industrial power installations, plants of ferrous metallurgy	In towns 1...50
Volatile hydrocarbon	Forest and steppe fires, natural methane	Motor transport, oil evaporation	In regions of highly developed industrial area to 0,3
Polycyclic aromatic carbohydrates	–	Motor transport, chemical and petroleum refinery plants	In regions of highly developed industrial area to 0,01

The most wide-spread toxic materials, polluting atmosphere, are: oxides of carbon CO_2, sulfurs dioxide SO_2, oxides of the nitrogen NO_x,

carbohydrates C_nH_m and dust. Except given above materials and dust, another more toxic materials are also discharged in the atmosphere.

The high concentrations and migration of the admixtures in atmospheric air are stimulate their interaction with forming of more toxic compounds (smog, acids) or result in such phenomena, as "greenhouse effect" and destruction of ozone layer.

Suspended materials concentration and tailpipe pollution of the air. In places of the gas and dust emission the measures on dust and gas control, worked out in accordance with the determinate order must be carried out. In cases when used facilities do not provide the necessary reduction of the harmful admixtures concentration, airtight packing of the excavator cab, borers, cars and the other equipment with feeding in them the cleaned air and making the surplus pressure must be realized. On work places, where the dust concentration exceeds the established maximum concentration limits (MCL), operating personnel must be provided by individual means of protection of respiratory organs.

Methods of air clearing from harmful materials are divided on 5 main groups by the type of behavior of physic and chemical processes:

Absorption of the gaseous admixtures by hard materials is based on physical characteristics of some solids with ultramicroscopic structure, those are capable selectively extract and concentrate on their surfaces the separate components from gas mixture. Method of adsorption is widely used for air clearing from organic resins and fumes of solvents (acetone, ether and others) on enterprises of fiberglass and glass-cloth, nitrocellulose production, and also at colouration of industrial products.

Absorption of wastes by solvents of admixtures is concluded in division of the gas - air mixture on component parts by absorption of the one or several gas components of this mixture by fluid absorbent with solution forming. This method is used at the air clearing from such gases, as ammonia, hydrogen chloride or anhydrous hydrogen fluoride.

Absorption of wastes by reagents solution, bonding chemically (**chemical adsorption**) the admixtures is based on gas and fumes absorption by hard or fluid absorbents with formation of low-fugative and slightly soluble chemical compounds. This method is widely-spread for air clearing from nitrogen oxides.

Thermal neutralization of exit gases is related to ability of combustible toxic components to acidify until less toxic at the presence of free oxygen and high temperature of gas mixture. This method is used when amounts of

wastes are great, and concentrations of polluting materials exceed 300 mln^{-1}.

Biochemical method is based on the use of microorganisms, capable to destroy and convert different chemical compounds. Biochemical methods of gas purification are more applicable for clearing of exit gases of the constant composition. High effect can be reached if the velocity of biochemical oxidation gaseous materials is higher of the velocity of their entry on clearing.

Acid rains are known more than 100 years, however the problem of these rains appeared near 25 years ago.

Sources of the acid rains are the gases, containing sulphur and nitrogen. The most important of them are: SO_2, NOx, H_2S. Acid rains appear in consequence of maldistribution of these gases in the atmosphere. For instance, the concentration of SO_2 (mkg/m^3) is usually like this: in city 50... 1000, on territory near the city in radius of 50 km is 10...50, in radius of 150 km is 0,1...2, above ocean is 0,1.

Main reactions in atmosphere are:

I variant:

$SO_2 + OH \rightarrow HSO_3$; $HSO_3 + OH \rightarrow H_2SO_4$ (molecules in atmosphere quickly condense in drops); II variant: $SO_2 + h\nu \rightarrow SO^*_2$($SO^*_2$ is activated molecule sulphurs dioxide); $SO_2 + O_2 \rightarrow SO_4$; $SO_4 + O_2 \rightarrow SO_3 + O_3$; $SO_3 + H_2O \rightarrow H_2SO_4$. Reactions of both variants are carried in atmosphere simultaneously. For sulfide hydrogen the reaction $H_2S + O_2 \rightarrow SO_2 + H_2O$ is typical and further the I or II variant of reaction.

Sources of the sulphur compound entry in atmosphere are: natural (volcanic activity, activity of microorganisms and others) 31...41 %, anthropogenic (thermoelectric power station, industry and others) 59...69 %; totally enters 91...112 million tons per year.

Concentrations of the nitrogen compounds (mkg/m3) are: in city is 10...100, on territory near the city in radius of 50 km is 0,25...2,5, above ocean is 0,25.

From nitrogen compounds the main share of acid rains give NO and NO_2. There are reactions carried in atmosphere: $2NO + O_2 \rightarrow 2NO_2$, $NO_2 + OH \rightarrow HNO_3$. Sources of nitrogen compounds are: natural (soil emission, storm discharges, biomass firing and others.) 63 %, anthropogenic (thermoelectric power station, motor transport, industry) 37 %; totally enters 51...61 million tons per year.

Sulfuric and nitric acids enter the atmosphere also as the mist and fumes from industrial enterprises and motor transport. In city their concentration reaches the 2 mkg/m^3.

Hothouse effect. Condition and composition of atmosphere define the value of solar radiation in heat balance of the Earth. The main part of entering heat J/year in biosphere is related to its share : heat from solar radiation is $25 \cdot 10^{23}$ (99,8 %), heat from natural sources (from bowels of the Earth, from animals and others) is $37{,}46 \cdot 10^{20}$ (0,18 %), heat from anthropogenic sources (power plants, fire and others) is $4{,}2 \cdot 10^{20}$ (0,02 %).

Shielding role of atmosphere in heat transfer processes from the Sun to the Earth and from the Earth into space influences on the biosphere average temperature that was + 15 ^{o}C for a long time.

Calculations show that at atmosphere absence the surface average temperature of the Earth would be approximately – 15 ^{o}C.

Hothouse effect in atmosphere is rather wide-spread phenomena also on regional level. Technogenic heat sources (thermoelectric power station, transport, industry), concentrated in the cities and industrial centres, intensive entry hotbed gas and dust, stable condition of atmosphere form around the cities the spaces of the radius 50 km and more, with raised on 1...5 ^{o}C temperature and high concentration of the contaminations. These zones above the cities are well observed from outer space. They destruct only at intensive moving of big masses of atmospheric air.

Technogenic pollution of atmosphere is not limited by bottom layer zone. Certain portion of admixtures enters in ozone layer and destroys it. Destruction of ozone layer is dangerous for biosphere, because it is accompanied by significant increasing of ultraviolet radiation share with wavelength less than 290 nm, reaching the ground surface. These radiations are harmful for vegetation, especially for corn cultures. It is the source of carcinogenic danger for people, stimulates increasing of the eye diseases number.

Because of the technogenic influence on atmosphere the following negative consequences are possible:

- excess of MCL of many toxic materials (CO, NO_2, SO_2, CnHm, benzopyrene, and others) in the cities and populated localities;

- smog formation at the intensive wastes of NOx, CnHm;

- fallout of the acid rains at intensive wastes of SOx NOx;

- appearance of the hothouse effect at raised contents of SO_2, NO_x, O_3, SN_4, N_2O and dust in atmosphere that promotes the increasing of the average temperature of the Earth;

- destruction of ozone layer at entry of NO_x and compounds of chlorine in it that forms the danger of UF-irradiation.

2.3.2 Hydrosphere pollution

Usually water is polluted at the usage, and then it is wasted into natural reservoirs. Internal reservoirs are polluted by sewages of different industry branches (metallurgical, oil-processing, chemical and others), rural and housing-public facilities, and also by surface sewers. Main sources of pollution are industry and agriculture.

Pollutants are divided on biological (organic microorganisms), causing the fermentation of water; chemical, changing the chemical composition of water; physical, changing its transparency (turbidity), temperature and other indexes.

Biological contaminations fall into reservoirs with home and industrial sewers, basically of enterprises of food, biomedical, cellulose-paper industry. For instance, cellulose-paper factory pollutes the water in the same way, as the city with population of 0,5 million people does.

Biological contaminations are estimated by the biochemical consumption of the oxygen – BCO. BCO_5 is an amount of the oxygen, consumed during the 5 days by microorganisms – destructors for full mineralization of organic materials, contained in 1 l of water. Normative value of BCO_5 = 5 mg/l. Real pollution of the sewages require the BCO values in ten times more.

Chemical contaminations enter the natural reservoirs with industrial, surface and home sewers. They are: oil-products, heavy metals and their compounds, mineral fertilizations, pesticides, cleansers. Lead, hydrargyrum, cadmium are the most dangerous.

2.3.3 Ground pollution

Crippling of the crust top layers occurs at: mining of mineral products and their enrichment; burial of domestic and industrial waste; military exercises and test carrying out. Soil cover is greatly polluted by sediments in the zones of different wastes diffusing in atmosphere, arable lands – at fertilizing and pesticide usage.

Technogenic influence on ground is accompanied by:

- rejection of arable lands or reduction of their productive capacity. According to UN data, is annually disabled about 6 million hectares of fertile grounds;

- exceeding saturation of plants by the toxic materials that inevitably results in the food stuff of phytogenous and animal genesis pollution. Nowadays food stuffs are up to 70 % of toxic influence on a person;

- biocenosis disfunction in consequence of death of insect, birds, animals, some type of plants;

- pollution of ground waters, especially in zone of dumps and sewage disposal.

2.4 Energy pollution of technosphere

Transport pathways, radiation zones of radio- and television transmitting systems, industrial zones and so on are the zones of significant technogenic danger. Danger development is possible at using on production and at home of technical devices: power grids and devices, tools, manual instrument, gas bulb and gas networks and so on. Occurrence of dangers in such cases is related to the presence of the faults in technical device or wrong action of the person during their use. The level of dangers is defined by their energy indexes of technical devices, which are greatly increased in XX century because the person have got the powerful technology, great stores of hydrocarbon raw material, chemical and bacteriological materials.

Industrial enterprises, objects of energy and transport are the main sources of the energy pollution of industrial regions, urban environment, homes and natural zones. Vibratory and acoustic influence, electromagnetic fields and radiations, influences of radioactive nuclides and ionizing radiations are referred to energy pollution.

Vibrations in urban environment and residential buildings are spread on the ground. The source of these vibrations is the technological equipment of the shock action, rail transport, building machines and heavy motor transport. Extension of the zone of vibration influence is defined by the value of their decay in the ground that is1 db/m, as a rule, (in water saturated grounds it is a little more). Mostly the vibrations decay on the distance of 50...60 m from pathways of the rail transport. Technical devices (pumps, elevators, transformers and so on) those are located in the residential buildings can produce significant vibrations and noise.

Noise in urban environment and residential buildings is produced by the vehicles, industrial equipment, sanitary-technical plants and devices and others.

Infrasound sources can be natural (blowing by wind of buildings and water surface), and also technogenic (the moving mechanisms with wide surface – vibroplatform, shakers; jet propulsion, gas turbines, vehicles).

Main sources of electromagnetic fields (EMF) of the radio frequencies are radio technical objects (RTO), television and radar stations (RLS), hardening plants and areas (in the zones joined with enterprises). The influence of EMF of industrial frequency is mostly related to high-tension electrical lines (HTL), constant magnetic field sources used on industrial enterprises. Zones with raised level of EMF are up to 100...150 m. The source of these zones can be RTO and RLS. At that even inside the buildings, located in these zones, density of the energy flow, as a rule, exceeds possible values.

EMP of industrial frequency are basically absorbed by ground so at the short distance (50... 100 m) from electric lines the electric tension of the field falls from group of ten thousands volt on metre up to the normative level. Magnetic fields, appearing in zones around electric lines of currents of the industrial frequency, and in zones, adjoining to electrified railways are the significant danger. Magnetic fields of high intensity are discovered in buildings located near these zones.

At home the source of EMF and radiations are TV sets, display, microwave ovens and other devices. Carpets, curtains and etc. produce the electrostatic fields in conditions of lowered moisture (less than 70 %).

2.5 Vibrations and acoustic vibrations

Mechanical vibrations, produced by working machines, moving liquids and other sources and transmitted by constructions of production buildings, equipment, person, are identified as vibration.

In construction the main sources of vibration are machines for preparation, distribution and vibration compaction of concrete mixture: concrete mixers, batching plants, vibroplatform, also building machines, compressors, bulldozers and others.

Total vibration damages the nervous and cardiovascular systems, gastrointestinal tract, musculoskeletal system. At continuous work without effective protection measures the vibrating disease can develop – fatal

disease, which is accompanied by the change in blood vessels of upper or lower extremities, arterial pressure reduction, blood supply disturbance of internals, reduction of cardiac beat frequency.

The reduction of fingers sensitivity, arthropathy and hands neurosis is observed at the continuous influence of local vibration.

By the direction of effect the vibration is considered more harmful if it effects lengthways of body axis, than perpendicular to it.

For description of vibrations the following characteristics are used:

– amplitude of vibration displacement, i.e. maximum deviation of oscillating point from equilibrium position;
– the oscillatory velocity;
– the vibration acceleration;
– the oscillation period;
– the oscillation frequency

Classification of vibration.

a. by the method of transmission on a person it is found out the general vibration, transmitted through the supporting surface of a person in the sitting or standing position;

b. by the sources of origin it is classified only general vibration, dividing it on the following categories:

– transport vibration, influencing on the operators of the moving machines and vehicles at their movement on the territory and roads, and also at their construction (agricultural and industrial tractors, self-moving agricultural machines (including combines); the trucks (including tractors, road scraper, graders, paving compactor and etc.); the snowplows);

– transport and technological vibration, influencing on the operators of machines with limited displacement only on specially prepared surfaces of the working areas, industrial areas or mine workings (excavators, industrial and building cranes, mine loading machine, tow-to-yarn machines, concrete pavers);

– technological vibration, influencing on the operators of the stationary machines or are dispatched on working places, not having the sources of vibration (metal-working and woodworking machine, equipment for bore-hole drilling, equipment of building materials industry (except concrete pavers).

c. By frequency composition the vibrations can be:

– low-frequency vibrations (with prevalence of maximum levels in octave-frequency band 1-4 Hz – for general vibrations, 8-16 Hz – for local vibrations);

– middle-frequency vibrations (8-16 Hz – for the general vibrations, 31,5-63 Hz – for local vibrations);

– high-frequency vibrations (31,5-63 Hz – for general vibrations, 125-1000 Hz – for local vibrations)

2.6 Noise

Noise is a disorderly combination of sounds of different frequency and intensity (power), appearing at mechanical oscillations in solid, fluid and gaseous mediums.

Classification of noise, influencing on a person.

1. By the character of the spectrum:

– broadband noise – with continuous spectrum by the width of more than one octave;

– tone noise – there are showed tones in the spectrum. Tone character of noise for practical goals is determined by the measure in 1/3 octave-frequency band on level excess in one band on nearby ones not less than on 10 db.

2. By temporary characteristics:

– constant noise, which sound level for 8-hours workday or for the time of measure changes not more than on 5 dBA at measures on time characteristics of sound level meter "slowly";

– inconstant noise, sound level for 8-hours workday or for the time of measure changes more than on 5 dBA at measures on time characteristics of sound level meter "slowly".

3. Inconstant noises are divided on:

– oscillating noise in the time, sound level continuously changes in the time;

– discontinuous noise, which sound level changes stepply (on 5 dBA and more) moreover the interval duration, during of which the level stays the constant, is 1s and more;

– pulsed noise, consisting of one or several sound signals, each of duration less 1s differ not less than on 7 db.

The sound wave is characterized by sound pressure (P, Pa), intensity (I, W/m^2), frequency (f, Hz).

The sound pressure shows the difference between instantaneous value of pressure and average pressure in quiet ambience. Our acoustic organ reacts exactly on changing of air pressure. Than more the pressure, that stronger the irritation of acoustic organ and the feeling of sound volume.

At spreading of the sound wave in space the energy transport occurs; the amount of transported energy is defined by the intensity of the sound.

The intensity of the sound is an amount of sound energy, passing at one second through the unit of area, perpendicular to the direction of the sound wave spreading.

$$I = \frac{W}{S} \ , \qquad (2.2)$$

where: I – intensity of the sound, W/m^2;

W – sound energy, W;

S – area, m^2.

Between intensity of the sound and its sound pressure exists the definite dependency:

$$I = \frac{P^2}{\rho \cdot c} \ , \qquad (2.3)$$

where: I – intensity of the sound, W/m^2;

P – sound pressure, Pa;

ρ – density of the ambience, kg/m^3;

c – speed of the sound in the same ambience, m/s.

For characteristics of the noise level it is used not direct values of the sound intensity and sound pressure, by those it is uncomfortably operate, but their logarithmic values, defined as the level of sound intensity or level of sound pressure.

The level of sound intensity is defined by the formula:

$$L_I = 10 \ \lg \ \frac{I}{I_0} \ , \qquad (2.4)$$

where L_I – level of intensity in decibel (dB);

I – sound intensity, W/m^2;

I_0 – sound intensity, corresponding to the edge of audibility of human ear (I_0 – constant value; $I_0 = 10^{-12}$ W/m^2 on frequency 1000 Hz).

The human ear, and also some acoustic instruments react not on sound intensity, but on sound pressure, which level is defined by the formula:

$$L_p = 20 \lg \frac{P}{P_0}, \qquad (2.5)$$

where P – sound pressure, Pa;

P_0 – edge of sound pressure (P_0 – constant value; $P_0 = 2 \cdot 10^{-5}$ Pa on frequency 1000 Hz).

The acoustic organs of the person perceive the sound waves with frequency 20-20000 Hz. The oscillations with frequency below of 20 Hz (infrasound) and above of 20000 Hz (ultrasound) do not cause the auditory feelings, but biologically influence on organism.

The perception of the sound by a person depends on its frequencies, intensity and sound pressure. The least intensity (I_0) and the least sound pressure (R_0), perceived by the person on given frequency, is identified as the edge of audibility. At f = 1000 Hz $P_0 = 2 \cdot 10^{-5}$ Pa and $I_0 = 10^{-12}$ W/m^2.

If P = 20 Pa and I = 10 W/m^2 then person feels the pain – an ear-ache edge.

Between these edges is the area of audibility.

2.7 Electric current

Electric shock is a sudden stimulation of the nervous system by flow of electric current through a part of the body. It is a threat to life. Shocks are caused by direct contact or flashover. Primary shock is a shock of such a magnitude as to produce direct physiological harm. The results of primary shocks are: Fibrillation – irregular heart beat, respiratory – continuous contraction of muscles Secondary shock is a shock of such magnitude that it will not produce direct physiological harm, but it is annoying and cause involuntary muscle reaction. Results of secondary shock are annoyance, alarm and loss of balance due to involuntary muscle spasm.

Types of electric current effects:

– Thermal. The result of effect is burns, skin heating.

– Electrolytic. The result of effect is the decomposition of organics inside the person (blood).

– Biological. The result of effect is a spasm (contraction) of muscles.

– Electrodynamic (mechanical), results in myorrhexis (muscles rupture). The presence of the voltage source and closed circuit results in current rush.

Electrical injury is an injury got because of the effect of electric current or electric arc. **Types of electrical injuries:**

– Local electrical injury (probability 20 %);
– Electric shock (25 %);
– Mixed (55 %).

Types of local electrical injuries:

Burn. It is got because of the effect of electric arc. The symptoms are the redness, vesication, skin necrosis, carbonization.

Electric signs. The skin and internal organs resistance results in the skin rupture as the circlet in the place of passing of electric current through the skin.

The skin metallization. At the becoming of the short circuit occurs the melting of electric parts, and flying in different sides parts of metal are hit on skin.

Mechanical damages.

Electrical autonomous. At the becoming of the electric arc occurs the bright flash and effects on retina (bright electric sparks at welding).

Mixed.

Degrees of electric shock effect on body of a person:

1 degree – convulsive, perceptible a little the contraction of muscles;

2 degree – convulsive contractions of muscles without loss of consciousness;

3 degree – loss of consciousness with the retention of breathing and heart work;

4 degree – loss of the consciousness with breathlessness and heart work;

5 degree – apparent death.

Factors effecting on the result of electric injury:

1.Electric resistance of the body of a person. The person is stroked by current, which depends on voltage and resistance of the body:

$$I = \frac{U}{R}, \tag{2.6}$$

where I – current, A

U – voltage, V

R – electrical resistance, Ohm·m.

2. Parts of body of the person, damaged at **electric injury** of the person:
skin in place of the current entering;
internal organs;
skin in place of the current leaving.

3. The resistance of internal organs is insignificant. The resistance of the skin depends on its conditions (clean and dry or humid (sweated)).

Types of current:

- perceptible current (1 mA for variable voltage);
- continuous current 10-15 mA;
- mortal current 0,1 A.

Duration of the current is defined: heart in weakened condition 1 sec. (where in 0,5 sec. occurs the heart fibrillation).

The mortal way of the current passing: head - left hand (left leg).

The ways of current passing, (fig. 2.1.):

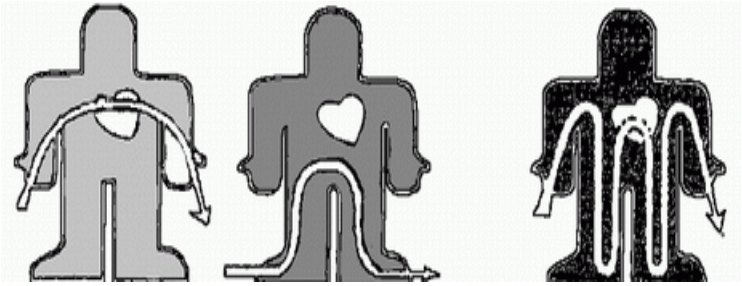

Fig. 2.1. The ways of current passing

2.8. Anthropogenic dangers

Activity of a person is important, necessary section, providing the interaction of technical systems. At this the person, operating by energy and information flows, solves the problems, consisting from the row of stages: perception of information; its estimation, analysis and generalization on the base of beforehand given and stated criteria, taking a decision about the further actions, realization of taken decision. However, on all stages of activity it is possible the wrong actions of a person.

Analysis of data on technogenic accidents and catastrophes shows that significant part of dangers appears because of wrong, incorrect taken decisions, when he himself becomes the source of dangers. According to

statistics about 45 % of emergencies on nuclear power plants, over 60 % of accidents on objects with raised risk, 80 % of air disasters and catastrophes on the sea, and also 90 % of car accidents occurs because of wrong action of people.

The error is defined as nonfulfillment of the given problem (or carrying out by the person of forbidden action) that can be the reason of heavy consequence – traumas, death of people, damage of equipment or property or irregularity of the normal current planned operations. The errors due to the fault of person can occur in different spheres and conditions of its vital activity:

- *on rest, during the journey, at going in for sport:* at vehicles driving; careless treatment with fire, sharp subjects, weapons; at bathing in water reservoirs; during the trips in mountains; on training and competition on different types of sport;

- *at home*, at the usage of appliances, domestic gas, open fire, pesticides, instrument and devices; at treatment with the home wastes, the boiling liquids, with subject containing mercury; the consumption of the bad products, alcohol, medicine and etc;

- *in the field of production activity*: at irregularity of stated working regimen and inaction at the moment, when its participation in process of activity is necessary;

- *in emergency situations natural and technogenic kinds*, related, as a rule, to unpreparedness of the people to actions in emergency situations; to their inability to foresee, for instance at treatment with combustible and explosive agents or control of complex technical systems; at avalanching, descent of torrents and so on;

- *at contact of the people between themselves*: the sources of errors can be dishonourableness, negligence, revenge, jealousy, insults, religious and national conflicts and so on;

- *at control of economy and state activity* – errors is often are caused by tendency of people to break laws of the nature: for instance, construction pulp and paper mill on Baikal, projects of turning of the North rivers to the South and others.

The feature of the person to mistake is a function his psychological condition and intensity of mistakes in mostly depends on conditions of surrounding ambience and effecting loads on the person. It is determined that dependence of the mistakes occurrence frequency from effecting loads is nonlinear. So, at very low level of loads the majority of operators work

inefficient (the task seems boring and does not cause the interest), and quality of work does not correspond to necessary. At moderate loads the quality of the operator's work turns out to be optimum so the moderate load can be considered as conditions sufficient for ensuring of the attentive work of the person-operator. But at further increase of the loads the quality of work of the person becomes worse that is explained, mainly, by such demonstrations of the physical stress, as fear, nervousness, rapidness of pulse and frequency of breathing, increasing of temperature, ejection of adrenaline in blood and so on.

In the system "person – environment" person is the most changeable component. His behaviour is defined by lots of individual factors. Often, the different operators the similar tasks execute in the different actions.

The main particularities of personality and conditions of the organism of the person, inciting him to carrying out of mistakes, can be divided on innate particularities and temporary conditions.

The physiological features of the person and his heredity, including sense organs (ear, vision, smell, touch, taste), support-locomotion (muscular power, velocity of the motion, co-ordination etc.) and psychomotor systems (reflexes, reactions and etc.), intellect (level of knowledges, ability to orientate) are concerned to innate particularities.

The temporary conditions such as physical and psychological tiredness, resulting in the reduction of attention and muscular power, worsening of health and capacity to work, contribute to occurrence of mistakes. As factors, detracting attention, can be temporary functional disturbance of the organism (for instance, unexpectedly appeared headache, dizziness, spasm of muscle and so on), temporary switching over of attention to some event or subject, not connected with work; the fatigue, sudden external effect (noise or bright flash of the light).

The reasons of mistakes are divided on direct, main and contributory.

The direct reasons of mistakes depend on psychological structure of operator's action (the mistakes of the perception – has not recognized, has not found; the mistakes of memories – has forgotten, has not remembered, wasn't able to restore; the mistakes of thinking – has not understood, has not provided, has not generalized; the mistakes of decision taking, return reaction ,etc.) and type of these actions i.e. from psychological regularities, defining the optimum activity – the discrepancy to psychic possibilities of information organization (size or speed of the information reception, attitude to the edge of the distinguishing, small duration of the signal and

etc.) from lack of the skill (the standard actions in non-standard situation) and structures of attention (didn't concentrated, didn't not switch over, quickly tired).

2.9. Production ambience

Production ambience is a part of technosphere that has the raised collection of negative factors. Main bearers of injury and harmful factors in production ambience are machines and other technical devices, chemical and biologically active subjects of the labour, the sources of energy, unregulated actions of workers, breaches of regimens and organization of activity, and also departure from possible parameters of microclimate of working zone.

Injury and harmful factors are divided on physical, chemical, biological and psychophysiological.

The physical factors – moving machines and mechanisms, raised levels of noise and vibration, electromagnetic and ionizing radiations, insufficient luminosity, increased level of the static electricity, raised value of the voltage in electric circuit and others; chemical – materials and compounds those different on the aggregate condition and have toxic, irritating, sensitizing, carcinogenic and mutagenic influence on organism of the person and influencing on his reproductive function; biological – pathogenic microorganisms (bacteria, viruses and others) and products of their vital activity, and also animals and plants; psychophysiological – a physical overloading (static and dynamic) and nervously-psychic (mental overstrain, overstrain of analyzers, monotonicity of the labour, emotional overloading). Injury and harmful factors of the production ambience those are typical for majority of modern productions, are showed in tabl. 2.3.

Table 2.3

Injuring and harmful production factors

The sources of harmful factors	**The coverage of factor**
Physical factors	
Dust level in working zone	Zones of discrete material processing, welding and plasma treatment, plastic, glass fiber plastics and others fragile materials treatment, zones of materials crushing and so on

Продолжение табл. 2.3.

The sources of harmful factors	**The coverage of factor**
Vibrations: Total Local	Vibroplatforms, vehicles, building machines
	Vibroinstrument, horns of transport machines control
Acoustic vibrations:	
Infrasound	Zones next to the vibroplatforms, powerful explosion engines and other high energy systems
Noise	Zones next to the technological equipment of the shock action, devices for gas testing, vehicles, energy machine
Ultrasound	Zones next to the ultrasound generators, crack detectors: bathes for ultrasound treatment
Static electricity	Zones next to the electrical equipment on the constant current, zones of coloring by spray, synthetic materials
Electromagnetic fields and radiation	Zones next to the power lines, electrolamp generators, screens, displays, antennae, magnets
Infrared radiation	Heated surfaces, melted materials, emission of the flame
Laser emission	Lasers, reflected laser emission
Ultraviolet radiation	Zones of welding, plasma treatment
Current	Electric mains, electric installations, distributors, transformers, equipment with electric drive and etc.
Ionizing radiations	Atomic fuel, sources of radiations used in instruments, crack detectors and at the researches
Movable machines, mechanisms, materials, products, parts of destroying constructions	Zones of land transport moving, conveyors, underground mechanisms, moving parts of machines, instrument, zones near the systems of the raised pressure, reservoirs with compressed gas, line tubes, pneumohydroelectric power plants
Height, felling objects	Building and erecting works, machines and plants support
Sharp edges	Cutting and pricking tool, rough edges, roughened surfaces, metallic cutting waste, pieces of brittle materials
Increased or decreased temperature of equipment and materials surface	Steam pipes, gas pipelines, cryogenic systems, chilling equipment, melts
Chemical factors	
Gas pollution of working zone	Loss of toxic gas and steams from unpressurized equipment, evaporations from opened reservoirs and at sheddings, outbreak of materials at the seal failure of equipment, coloring by spay, drying of colored surfaces

Продолжение табл. 2.3.

The sources of harmful factors	The coverage of factor
Dust level of working zone	Welding and plasma treatment of materials contained the Cr_2O_3, MnO, sprinkling and transportation of disperse materials, coloring by spay, bonding by plumbous welding alloys, bonding of beryllium and by welding alloys containing beryllium
Poison ingress on skin and mucous tunics	Galvanic production, reservoirs filling, liquids spraying (douching, surfaces coloring)
Poison ingress in gastrointestinal tract	Errors at the liquids usage, deliberate actions
Biological factors	
Liquid coolants	Materials treatment with the emulsols usage
Psychophysiological factors	
Physical overloads:	
Static	Continuous work with displays, the work in uncomfortable position
Dynamic	Lifting of the loads, manual labour
Neuropsychic overloads:	
Mental stress	Labour of scientific workers, professors, students
Analyser stress	Technical systems operators, airline operators, the work with displays

The concrete working conditions are characterized by collection of negative factors, and also are differed on level of harmful factors and risk of the demonstration of injury factors.

CHAPTER 3. EMERGENCY SITUATIONS

3.1. *Basic concepts and definitions*

Any human activity is potentially dangerous, and the dangers have permanent character. Potential danger is a hidden danger which is not determined in time and space.

Emergency situation (ES) is a situation happening in a certain area, as a result of an incident, dangerous natural phenomenon, accident, natural or any other disaster, which can result in or have already resulted in victims, damage to people's health or to the environment, serious material releasees and disturbance of people's life conditions.

Emergency event is *a deviance from normal processes or phenomena***.**

Accident is an emergency situation of technogenic type, occurred because of constructive, industrial, technological or maintenance reasons or because of accidental external impacts. They result in breakdown, destruction of technical devices or structures.

Industrial or traffic accident is a serious accident which has involved human victims, serious material damage and other serious consequences.

The dangerous natural phenomenon is a spontaneous event of a natural origin which by its intensity, area distribution and duration can cause negative consequences for people's life activity, economics and environment.

Natural disaster is a catastrophic natural phenomenon (or process) which can cause numerous human victims, large material damage and other heavy consequences.

Ecological catastrophe (ecological disaster) – extremely large scale emergency caused by change (under the influence of anthropogenic factors) in soil, atmosphere, hydrosphere and biosphere state, which is accompanied by mass mortality of living organisms and economic damage.

3.2. Classification of emergency situations

All emergency situations (ES) can be classified by three basic principles – distribution area, rate of growth and origin.

Local (individual) emergency situations which in terms of territory and formally do not extend beyond the area of a workplace or a site, a small piece of road, housing estate or an apartment . Local emergency situations are emergency situations resulting in no more than 10 people injured, or no more than 100 people have been influenced by disturbance of their life conditions, or material damage does not exceed the amount of more than 1 thousand of minimum wages rate . If the consequences of an emergency situation are limited by the area of a particular industrial or other site, so they are defined as in-site emergency. Emergency situations, with the consequences distribution limited to a populated locality, city (region), republic and are eliminated by local forces, are defined ***as local***. Local emergency situations include emergency situations as a result of which more than 10, but not more than 50 people suffered, or life conditions were disturbed for more than 100 , but no more than 300 people, or material damage is more than 1 thousand, but not more than 5 thousand of minimum wages rate.

Regional emergency situations are those situations, which cover the area of several administrative areas or economic regions. Joint local efforts and also participation of federal forces are necessary for the liquidation of consequences of such ES. ES resulting in 50 to 500 persons suffered or 500 to 1000 persons have been influenced in terms of life conditions, or the material damage is from 0,5 to 5 million minimum wage rates.

National (federal) emergency situations cover extensive territories of the country, but do not leave its borders. Forces, means and resources of the entire state are involved. Assistance from abroad is often required. The national ES are referred to emergencies resulting in 500 people suffered, or in disturbance of life conditions of more than 1000 people, or material damage is over 5 million minimum wage rates.

Global (transboundary) emergency situations go beyond the country borders and extend to other states. Their consequences are eliminated by forces and efforts both of the states suffered, and the international community.

Each type of emergency situations has its own rate of danger distribution, being essential intensity component of an emergency and specifying the sudden exposure degree of the damaging factors. From this point of view such events can be subdivided into the following:

– ***unexpected*** (explosions, road accidents, earthquakes etc.);

– ***vigorous*** (fires, emission of gaseous strong poisonous substances (SPS), hydrodynamic accidents with formation of waves of break, mudflow, etc.),

– ***moderate*** (emission of radioactive substances, accidents on municipal systems, volcano eruptions, flood);

– ***gradual*** (treatment facilities breakdown, droughts, epidemics, ecological deviations, etc.). Gradual (slow) emergency situations can last for many months and years, for example, consequences of anthropogenous activity in a zone of Aral sea.

3.3 Emergency situation of technogenic character

3.3.1. Transport accidents:
– freight trains;
– passenger trains;
– river and sea cargo vessels;
– on the trunk pipelines, etc.

3.3.2. Fires, explosions, threat of explosions:

– fires (explosions) in buildings and structures on communications and technological equipment on industrial sites, etc.

– fires (explosions) on transport;

– fires (explosions) in residential, social, cultural buildings and structures;

3.3.3. Accidents resulting in emission (or emission threat) of chemically hazardous substances (CHS):

– accidents resulting in emission (or emission threat) CHS during their production, processing or storage (burial);

– release of sources CHS;

– accidents with a chemical ammunition, etc.

3.3.4. Accidents resulting in emission (emission threat) of radioactive substances:

– accidents at nuclear power stations;

– accidents of road and space vehicles with nuclear installations;

– accidents with a nuclear weapons in places of their storage, operation or installation;

– release of radioactive sources, etc.

3.3.5. Accidents with emission (emission threat) of biologically hazardous substances (BHS):

– accidents resulting in emission (emission threat) of biologically hazardous substances at industrial and research facilities;

– release BHS, etc.

3.3.6. A sudden collapse of buildings, constructions:

– a collapse of elements of transport communications;

– a collapse of industrial buildings and strucures;

– a collapse of residential, social and cultural buildings and structures.

3.3.7. Accidents on electric power systems:

– accidents on independent power stations with a long interruption period of electric supply to all consumers;

– breakdown of transport electric contact networks, etc.

3.3.8. Accidents on municipal life–support systems:

– accidents in sewer systems with mass emission of polluting substances;

– accidents on thermal networks in a cold season;

– accidents in potable water supply systems;

– accidents on municipal gas pipelines;

3.3.9. Accidents on treatment facilities:

– accidents on wastewater treatment facilities at industrial enterprises with mass emission of polluting substances;

– accidents on treatment facilities for industrial gases with mass emission of polluting substances.

3.3.10. Hydrodynamic accidents:

– breach of dams (dams, guad locks, etc.) with the formation of breakout waves and catastrophic flooding;

– breaks of dams with the resulting in floodflow, etc.

3.4. Emergency situation of natural character

The geophysical dangerous phenomena:

– earthquakes;

– volcano eruptions.

The geological dangerous phenomena (the exogenous geological phenomena):

– landslips;

– mudflow;

– dusty storms;

– collapses, taluses, erosion, slope runoff , etc.

The meteorological and agrometeorological dangerous phenomena:

– storms (9–11 points), hurricanes (12–15 points), tornadoes, squalls, vertical whirlwinds;

– large hailstones, a strong rain (downpour), a strong fog;

– a strong snowfall, strong ice, severe frost, heavy snowstorm, frosts;

– strong heat, a drought, a dry wind.

The sea hydrological dangerous phenomena:

– tropical cyclones (typhoons), a tsunami, strong (5 and more points), strong fluctuation of a sea level;

– an early ice cover, ice pressure, intensive ice drift, impassable ice;

– a separation of coastal ice, etc.

Hydrologically dangerous phenomena:

– high level of waters (flooding), high water;

– jams, low levels of waters, etc.

The hydrogeologically dangerous phenomena:

– low levels of subsoil waters;

– high levels of subsoil waters.

Natural fires:
– forest fires;
– range fires and grain field fires;
– peat fires, underground fires of combustible minerals.
Contagious diseases of people:
– single cases of exotic and specially dangerous contagious diseases;
– group contagious dangerous diseases, etc.
Contagious diseases of farm animals:
– single cases of exotic and specially dangerous contagious diseases;
– contagious diseases of unknown etiology, etc.
Plant infections and insect attacks:
– mass distribution of plant pests;
– infections of unknown etiology, etc.

3.5 Emergency situation of ecological character

Emergency situations connected with the change of condition of land (soil, subsoil, landscape):

– catastrophic subsidence, landslips, collapses of a terrestrial surface resulting from mining operations and other human activities;

– presence of heavy metals (including radioactive nuclides) and other harmful substances in the soil (ground) over maximum permissible concentration;

– intensive soil degradation, desertification of vast areas due to erosion, salinization, swamping , etc.;

– the critical situations connected with exhaustion of non renewable natural resources;

– the critical situations caused by overload of storehouses (dumps) by industrial wastes and household refuse, causing environmental pollution.

Emergency situations connected with the change in structure and properties of the atmosphere (ambient air):

– sharp changes in weather or climate caused by anthropogenous activity;

– excess of maximum concentration limit of harmful emissions into the atmosphere;

– temperature inversions over urban areas;

– "oxygen" hunger in cities;

– considerable excess of maximum noise permissible level in the city;

– formation of an extensive zone of acid rainfall;

– destruction of the ozone layer of the atmosphere;

– considerable changes of atmospheric transparency .

Emergency situations connected with change in a condition of the hydrosphere (the water environment):

– lack of potable water caused by exhaustion of water sources or their contamination;

– exhaustion of water resources needed for household water supply and maintenance of technological processes;

– Disturbance of economic activities and ecological balance caused by pollution of zones of internal seas and the world ocean.

Damaging factors of emergency situations

The basic consequences of emergency situations are as follows: destructions, diseases, fatality, various kinds of exposure (radioactive, chemical, bacterial), etc.

In addition, people, who experience extreme conditions of an emergency situation, are influenced by ***psychological factors***. Their mental activity is misbalanced in the form of (psychogenic) conditions. People, staying away form the area of an emergency situation also experience psychogenic influence. In itself, this is expecting an emergency situation and its consequences.

If the range of dangerous and harmful factors of emergency situations can be estimated, the range of psychological impact can be unpredictable. ***The phobia*** (from Greek phobos – fear), i.e. obsession, fear of something which does not stop.

Dangerous and harmful factors of an emergency situation, influencing a particular area with its population, structures, flora and fauna, form ***the defeat centre***.

The following are distinguished:

– the simple centre of defeat is the centre of the defeat which have arisen under the influence of one amazing factor (for example, destructions from explosion or a fire);

– he difficult centre of defeat is the centre of defeat formed as a result of action of several amazing factors (for example, owing to explosion there were the destructions of the designs which have caused a fire and depressurization of capacities with chemically dangerous substances).

More often the defeat centres difficult. For example, earthquakes bring not only destructions, but also fires, infectious diseases and mental frustration of the survived inhabitants.

Forms of the centres of defeat depend by nature a source, for example, at earthquake – the round form, hurricane forms the form in the form of a strip, and the fire or a landslip form the centre of defeat of the wrong form.

3.6. Stages of emergency situations development

Researches in the field of emergency situations allow to draw a conclusion, that the great consequences of emergency events results:

– influences of the natural factor (natural processes owing to gravitation, terrestrial rotation, a difference of temperatures, etc.);

– environment influences on constructions and technics (corrosion, change of technical indicators, etc.);

– occurrence or developments because of the person (for example, at infringement of service regulations) refusals and defects in constructions, cars, etc.;

– influences of technological processes (temperatures, vibration, aggressive steams and the liquids, the raised loadings and so forth) on constructions, cars, mechanisms, etc.;

– military activity, etc.

Irrespective of a classification accessory, in development of emergency situations allocate four stages.

1. Origin – occurrence of conditions or preconditions for emergency a situation (strengthening of natural activity, accumulation of deformations, defects, etc.). To establish the moment of the beginning of a stage of origin it is difficult. Use of statistics of design refusals and accidents is thus possible, data of seismic supervision, meteorological estimations, etc. are analyzed

2. Initiation – the beginning of an emergency situation. At this stage the human factor as the statistics testifies is important, that to 70 % of technogenic accidents and accidents occurs owing to personnel errors. More than 80 % of air crashes and accidents on the sea are connected with the human factor. Better preparation of the personnel is necessary for decrease in these indicators.

So, for example, in the USA for preparation of the operator for the atomic power station it is spent to 100 thousand dollars. It is necessary to lift prestige of work of the dispatcher and the operator.

3. The culminations – a stage of liberation of energy or substance. At this stage the greatest negative influence on the person and environment of harmful and dangerous factors of an emergency situation is marked. One of features of this stage is explosive character of destructive influence, involving in process toxic, energy and other components.

4. Attenuations – localisation of an emergency situation and liquidation of its direct and indirect consequences. Duration of the given stage days, months, years and are various, possible decades.

As an example the following sequence of events is offered:

– approach of the fire risk period in wood can be estimated as a stage of origin of an emergency situation;

– left not extinguished the fire in wood has caused a stage of initiation of an emergency situation;

– forest fire is a stage of the culmination of an emergency situation;

– the attenuation stage begins with the capture moment under the fire control, i.e. its localisation (restriction). The termination of a stage of attenuation is connected with fire extinguishing and the further works on рекультивации the earths and to restoration of wood plantings.

3.7. Fires

As burning is called the transient chemical transformation of substances accompanied by allocation of a considerable quantity of warmth and a bright luminescence (flame).

In usual conditions burning represents process of intensive oxidation or connection of combustible substance with air oxygen. Hydrogen and some metals can burn in chlorine atmosphere, copper – in sulphur steams, magnesium – in carbon dioxide etc. The compressed acetylene, chloride nitrogen, ozone and some other can blow up and without oxygen.

Burning subdivides into full and incomplete. Full – proceeds at enough of oxygen and comes to an end with formation of the substances not capable to the further burning. If it is not enough oxygen, there is the incomplete burning accompanied by formation of combustible and toxic products – carbon dioxide, spirits, aldehydes.

Depending on speed of distribution of a flame distinguish normal

burning, explosion and a detonation. At normal burning speed of distribution of a flame makes from several centimetres to several metres per second.

When burning occurs in the closed space or the gas exit is complicated, the subsequent layers of a gas mixture heat up not only by heat conductivity, but also for the account, increases of pressure owing to them adiabatic compression. It promotes increase in speed of distribution of a flame and can lead to explosion.

Fire and explosion hazard of substances, i.e. The comparative probability of their burning in equal conditions, is defined by their properties: combustibility and temperatures of flash, ignition and spontaneous ignition.

On combustibility all substances are subdivided on

– uninflammable,

– Average inflammable,

– Combustible.

Nonflammable substances are what are not capable to burn in air of normal structure at temperature to 200 ^{o}C.

Average inflammable substances can light up under the influence of an ignition source in air of normal structure, but are not capable to burn independently. Nonflammable and average inflammable substances represent danger only as sources of toxic and combustible gases. Some of them at decomposition can allocate a warmth considerable quantity.

Combustible substances are capable to light up from an ignition source in air of normal structure and to continue to burn after its removal. They are subdivided on

– highly inflammable – are capable to ignite from short–term influence of a source of ignition with low energy (a flame of a match, a spark, etc.),

– average inflammable – from long influence of a source of ignition with low energy,

– uninflammable – only under the influence of a powerful source of ignition.

Combustible liquids usually more fire dangerous, than firm combustible substances as they ignite is easier, burn more intensively, form explosive steam–air mixes and badly give in to suppression by water.

As flash temperature is called the least temperature at which formed over a surface of combustible substance of pair and gases flash on air from an ignition source, but do not form steady burning because of small speed of

their formation.

As ignition temperature is called the temperature of combustible substance at which it allocates combustible gases and steams with such speed, that after their ignition from an ignition source there is a steady burning.

As spontaneous ignition temperature is called the least temperature at which speed of exothermic reactions which are coming to an end with ardent burning sharply increases.

If in technological process apply combustible substances and there is a possibility of their contact to air danger of a fire and explosion can arise both in equipment, and out of it, indoors and on the open areas.

So, the big danger is represented by devices, capacities and tanks with combustible liquids as they do not happen are filled to a limit and in space over liquid level the steam–air explosive mix is formed. Painting sites and цехи the enterprises where as solvents use inflammable liquids are dangerous in the fire relation.

As cause of the explosion or a fire presence in a combustible dust and fibres can serve.

Distinguish thermal, chemical and microbiological sources of ignition – impulses. The thermal impulse which possess is most extended: an open flame, a spark, electric arches, heated surfaces, etc.

For ignition of a gas mixture of gases and steams with air it is enough to heat up to ignition temperature only 0,5...1 mm^3 this mix. From an open flame the gas mixture almost always is lighted.

Spark usually name a dot source of ignition. Sparks can be formed at a friction, blow or to be caused by the electric category. Operations of machining concern sources of their formation (grinding), and also tool sharpening, etc.

Sources of open fire – technological heaters of the furnace, devices and processes of gas welding also are sharp, installations for burning of a waste, etc.

Fires can arise from electroinstallations at which there are heating up conductors of an electric current and combustible substance (isolation of these conductors). At short circuits electric conductors are quickly warmed up to heats.

In order to avoid occurrence of fires to smoke it is authorised only in specially taken away places.

The chemical impulse is caused by that the temperature raises for the

account exothermal chemical reactions of interaction of those or other substances, and microbiological – is connected with ability to live of the microorganisms influencing increase of temperature. Their distinctive feature consists that the processes causing these impulses, begin at usual temperatures and lead to self-ignition.

Special danger represent oiled special clothes and the materials combined in heaps. Under condition of a bad heat–conducting path the heating which has begun at normal temperature, through 3... 4 h can end with self-ignition.

3.8 An estimation of zones of defeat at explosions

For calculations the knowledge of physical and chemical properties of explosive, such as density, speed of a detonation, warmth of explosion, tab. 1 is necessary.

Calculation of a zone of defeat at explosion is made in the following sequence.

1. Superfluous pressure at explosion of charge explosive on an earth surface define under M. A. Sadovsky's equation:

$$\Delta P_{\phi} = 95\frac{\sqrt[3]{G}}{R} + 390\frac{\sqrt[3]{G^2}}{R^2} + 1300\frac{G}{R^3}, \qquad (3.1)$$

where ΔP_{φ} – superfluous pressure, kPa;

G – weight of a trotyl charge, kg;

R – distance from the centre of explosion to object, m.

The equation (1) is fair for land explosion and air at $R > 8H$, H – explosion height, m.

For explosion of any explosive (except trotyl) G define under the equation:

$$G = \alpha \cdot M_e, \qquad (3.2)$$

where α – a specific trotyl equivalent;

M_e – weight of explosive.

Value of G is also called the TNT (trotyl) equivalent.

Table 3.1

Properties of explosives

Explosive	Warmth of explosion Q_m, kJ/kg	Coefficient of equivalent kJ, α,	Density ρ, , g/sm^3	Energy, GJ /m^3	Speed of a detonation $V_Д$, km/s	Pressure of detonation GPa	$\rho_э / P_Д$
Individual matter							
Trinitrotoluene, TNT	4190	1,0	1,66	7,23	6,73	21,0	0,344
Hexogen	5440	1,2	1,81	8,84	8,70	34,0	0,260
Octogen	5680	1,3	1,90	10,79	9,11	38,7	0,279
Nitroglycerine	6700	1,5	1,59	10,65	–	–	–
Tetryl	4815	1,1	1,73	7,82	7,85	26,0	0,301
Fulminate of mercury	1790	0,395	4,43	7,93	5,40	–	–
Mixture							
Ammatol	2650	0,586	1,60	4,24 ,	5,20	–	–
Torpex	7540	1,67	–	–	–	–	–
Dynamite (60 %)	2710	0,6	–	–		–	–
Plastid	4520	1	–	–	–	–	–

2. On tables 3.2 define degree of defeat by a shock wave of not protected people.

Table 3.2

Defeat degree of people in dependence on pressure ΔP_φ

ΔP_φ, **kPa**	**Defeat degree**
>100	Fatal (irretrievable)
60–100	Hard defeat (contusion)
40–60	Medium defeat (bleeding, dislocation, concussion of the brain)
10–40	Light defeat (injury, hearing release)
<10	Safe distance

On table 3.3 is defined degree of the destruction element engineering-technical complex.

Table 3.3

Defeat degree of people in dependence on pressure ΔP_{φ}

Objects of the destruction	Degree destructions, %		
	Strong	Average	Slight
Shop with light metallic framework	50 – 30	30 – 20	20 – 10
Brick buildings	30 – 20	20 – 12	2 – 8
Tanks	90 – 60	60 – 40	40 – 20
Lorries	> 50	50 – 40	40 – 30
Lines of the electric transmissions	120 – 80	80 – 50	50 – 20
Pipe lines overland	> 130	13 – 50	50 – 20
Reservoirs GSM:			
overland	100 – 50	50 – 30	30 – 10
underground	200 – 100	100 – 50	50 – 30
Heat electric stations	25 – 20	20 – 15	15 – 10
Water towers	60 – 40	40 – 20	20 – 10
Wooden buildings	30 – 18	18 – 10	< 10

If explosion occurs in air at height from the ground, equal *H*, (*H*>> *R*) that M.A. Sadovsky's formula looks like:

$$\Delta P_{\phi} = 47,5\frac{\sqrt[3]{G}}{R} + 195\frac{\sqrt[3]{G^2}}{R^2} + 650\frac{G}{R^3}. \qquad (3.3)$$

For calculations of radiuses of zones of full, strong, average, weak destructions in view of influence of a spreading surface it is possible to use estimated formulas:

– Radius of a zone of m full destruction, R, of m:

$$R_{n.p} = 3,1 \cdot \sqrt[3]{G}; \qquad (3.4)$$

– Radius of a zone of strong destructions R, of m:

$$R_{c.p} = 4,2 \cdot \sqrt[3]{G}; \tag{3.5}$$

– Radius of a zone of average destructions R, of m:

$$R_{cp.p} = 5,5 \cdot \sqrt[3]{G}; \tag{3.6}$$

– Radius of a zone of weak destructions R, of m:

$$R_{сл.p} = 8,3 \cdot \sqrt[3]{G}. \tag{3.7}$$

Safe distances at explosions expect under the formula, R, of m:

$$R_{n.p} = 15 \cdot \sqrt[3]{G}. \tag{3.8}$$

Range of scattering of splinters, R, of m:

$$R_{n.p} = 240 \cdot \sqrt[3]{G}. \tag{3.9}$$

The probability of defeat splinters depends on many factors and to calculation apply models in which take into account parameters of an explosive. We shall assume, that quantity of splinters proportionally capacities of an explosive, and at explosion of standard explosive of 1 *kg* is formed *N* splinters. We shall carry out calculation of density of splinters n_s on 1 m^2 of a surface on the distance equal *R* (of m) from the center of explosion:

$$n_s = \frac{NG}{4\pi R^2}. \tag{3.10}$$

Believing, that at explosion of a charge in 1 *kg* 400 splinters are formed, we shall define density of splinters on distance *R*:

$$n_s = \frac{33G}{R^2}. \qquad (3.11)$$

Estimating the area of a body of the person of 0,6 - 1 m^2 we shall define probability of defeat (*W*):

– if n_s <1, $W \sim 33G/R^2$;

– if n_s> 1, high probability (W ~ 0,95-0,99).

The offered model is simple and allows to receive numerical values of probability of defeat of people splinters on distances up to 3000 m.

Calculation of a zone of defeat at explosion physical explosives

Explosion of the capacities which are under pressure concerns group of physical explosions at which capacity destruction is accompanied by fast expansion of gas and formation of a shock wave and a field of splinters. The most frequent reasons – tank falling, ruptures of seams.

1. Energy of explosion is defined under formula *E,* J:

$$E = \frac{P_\Gamma \cdot V_0}{\gamma - 1}\left[1 - \left(\frac{P_0}{P_\Gamma}\right)^{\frac{\gamma-1}{\gamma}}\right], \qquad (3.12)$$

where P_g – pressure of gas in capacities, Pa;

P_0 – atmospheric pressure, Pa;

V_0 – Capacity volume, m^3;

γ – values of an indicator of an adiabatic curve, table 3.4.

Table 3.4

Values of an indicator of an adiabatic curve of some gases

Gas, medium	$\gamma = C_p/C_V$	Gas, medium	$\gamma = C_p/C_V$
Air, hydrogen, carbon monoxide, nitrogen, oxygen	1,4	Acetylene	1,24
Methane, carbonic acid (gas)	1,3	Chlorine	1,36
Fume of water	1,135	Sulfur dioxide gas	1,29
Argon, helium	1,67	Hydrogen sulphide	1,34

2. We define (taking into account parity $E_{y0.6} = 0,6E$ weight of equivalent charge G, kg):

$$G = \frac{0,6 \cdot E}{Q_{THT}}, \qquad (3.13)$$

3. Superfluous pressure ΔP_φ of shock wave front on distance R is defined under M. A. Sadovsky's equation:

$$\Delta P_\phi = 95\frac{\sqrt[3]{G}}{R} + 390\frac{\sqrt[3]{G^2}}{R^2} + 1300\frac{G}{R^3}, \qquad (3.14)$$

Comparing values ΔP_φ, we find amazing action of a shock wave.

CONTROL TEST

1 Harmful production factors are:
a) excessed noise
b) discomfort microclimate
c) electric trauma
d) insufficient light
e) acid burn.

2 What is referred to social dangers?
a) terrorism
b) alcoholism and smoking
c) production work
d) hooliganism
e) sport.

3 According to the locality protective constructions are classified on:
a) built-in constructions
b) constructions for factory workers and people protection
c) constructions, erecting in advance
d) constructions standing separately
e) quickly erecting.

4 Harmful production factors are:
a) vibration
b) moving machines and mechanisms
c) air dustiness
d) rebounding particles of treated material
e) rolling mechanisms.

5 What is referred to the quantity indexes of light?
a) contrast of the object with background
b) luminance
c) coefficient of luminance pulsation
d) light intensity
e) brightness.

6 Maximum permissible concentrations are established for:
а) gas
б) water
в) dust
г) sugar

7 Production noise can be:
a) fluctuating
b) jerky
c) discontinuous
d) impulsive
e) continuous

8 The following categories of work difficulty are established:
a) light works
b) moderate works
c) works of increased difficulty
d) works of medium difficulty
e) difficult works

9 Difficult works are the works with energy expenses more than:
a) 150 J/s
b) 183 J/s
c) 200 J/s
d) 250 J/s
e) 293 J/s

10 Forms of intellectual labour on organization of working process , type of load, level of emotional tension are divided into:
а) operator's labour
б) administrative work
в) labour of professors and medical workers
г) labour of students
д) creative work

11 What is referred to microorganisms?
a) bacteria
b) animals
c) plants
d) water plants

12 Vibration impacts negatively on:
a) nervous system
b) cardiovascular system
c) gastrointestinal tract
d) respiratory organs
e) vestibular apparatus

13 Octave is an interval of frequencies where the highest frequency:
a) in 1,5 times more of bass frequency
b) in 2,5 times more of bass frequency
c) in 2 times more of bass frequency

14 Ultrasound is a sound with the frequency:
a) below 16 Hz,
b) above 20 kHz,
c) from 16 to 20 kHz.

15 According to the influence on organism chemically harmful materials are divided into:
a) generally toxic,
b) irritating,
c) sedative,
d) sensitizing,
e) cancerogenic,

16 Choose the classes of labour conditions taking into account the exceeding of hienic standards:
a) optimal,
b) normal,

c) permissible,
d) harmful,
e) dangerous,
f) real.

17 Safety of vital activity is a …… about comfort and safe interaction of a person with environment:
a) fiction,
b) mystics,
c) science,
d) supposition.

18 Rupture of eardrum is possible at noise influence more than:
a) 70-90 dB,
b) 140-145 dB,
c) 90-110 dB,
d) 110-120 dB.

19 In dependence of particles size dust can be:
a) visible dust,
b) heavy dust,
c) microscopic dust,
d) ultramicroscopic dust,
e) invisible.

20 There are 4 methodical approaches to the risk defining:
a) engineering approach,
b) constructive,
c) expert approach,
d) sociological approach,
e) model approach,
f) economical.

21 Main forms of labour activity of a person are classified on:
a) physical labour,
b) mechanized forms of labour,

c) collective labour,
d) automated and semi-automated labour.

22 Unit of brightness measurement is:
a) lux (lx),
b) candela per square meter (cd/m^2),
c) candela (cd),
d) lumen (lm).

23 The level of sound pressure is measured in:
a) paskal (Pa),
b) bel (B),
c) decibel (dB).

24 Spectrum of noise is a dependence of sound pressure level on:
a) sound frequency,
b) sound intensity,
c) pressure,
d) oscillation amplitude.

25 Rated parameters of microclimate are:
a) light,
b) relative humidity,
c) temperature,
d) pressure,
e) speed of air motion.

26 According to the influence on organism harmful materials are divided into 4 types:
a) abnormally dangerous,
b) maximum dangerous,
c) high dangerous,
d) low dangerous,
e) moderately dangerous,
f) low-hazard.

27 Production light can be of the following types:
a) natural,
b) combined,
c) artificial,
d) united,
e) joint.

28 For natural light the normative index of light is:
a) coefficient of illumination pulsation,
b) blindness measure ,
c) coefficient natural illumination.

29 During the analysis of traumatism we take into account the following indexes:
a) coefficient of traumatism seriousness,
b) coefficient of traumatism duration,
c) coefficient of traumatism frequency,
d) general coefficient of traumatism,
e) coefficient of traumatism with fatal outcome,
f) coefficient of traumatism danger.

30 Means of individual protection are divided into:
a) isolating,
b) protecting,
c) wraparound,
d) filtering,
e) preserving.

31 According to the direction of air flow moving ventilation can be:
a) forced ventilation,
b) come running ventilation,
c) exhaust ventilation,
d) outflow ventilation,
e) forced and exhaust ventilation.

32 Heat emission by the human organism into environment is carried out by:

a) radiation
b) inversion
c) conduction
d) water loss,
e) convection
f) isothermia

33 There are the following groups of agents:

a) combustible,
b) easy combustible,
c) low combustible,
d) hard combustible,
e) noncombustible.

34 There are two main sources of atmosphere pollution:

a) nature,
b) anthropogenic,
c) artificial.

35 For work control and guaranteeing of exploitation safe conditions reservoirs, functioning under pressure are equipped by:

a) sound level meter,
b) back valves,
c) manometers and thermometers,
d) liquid level indexes,
e) luxmeter,
f) lock valves.

36 The result of electric shock depends on:

a) type and current magnitude,
b) ways of current passing,
c) lay of land , where the injury happened,
d) individual features of organism,
e) parameters of environment,

f) man’s humour.

37 Dust is the disperse system consisting from the finest solid particles, those are in:

a) gaseous medium,

b) liquid,

c) solid substance.

38 What is referred to the means of individual protection from noise?:

a) protective suit,

b) «earplugs»,

c) earpieces,

d) pneumohelmet,

e) special shoes.

39 Sound pressure at the limit of audibility is:

a) 200 Pa,

b) 0.00002 Pa,

c) 0.02 Pa,

d) 200000 Pa.

40 According to the classification on the danger of electric shock of a person premises can be:

a) premises without increased danger,

b) premises of low danger ,

c) premises with moderate danger,

d) premises with increased danger,

e) especially dangerous premises.

41 According to the influence on a person dust is divided into:

a) toxic,

b) low toxic,

c) nontoxic,

d) extremely toxic.

42 Light control in production premises is carried out by:

a) Wattmeter,
b) Luxmeter,
c) Voltmeter.

43 There are two main sources of atmosphere pollution: natural and anthropogenic. What is referred to anthropogenic sources of atmosphere pollution?
a) forest fires,
b) metallurgic plants,
c) heat electric stations,
d) processes of plants and animals decomposition,
e) transport,
f) industrial enterprises.

44 Halogen lamps is the kind of:
a) gas-discharge lamps,
b) incandescent lamps,
c) luminous tube lampы.

45 Ultraviolet rays in moderate doses:
a) positively influence on organism,
b) negatively influence on organism,
c) have no any influence on organism.

46 Lightning protection is a complex of measures and devices used for people protection, protection of buildings, constructions, equipment and materials from….., possible at lightning effect:
a) explosions,
b) fires,
c) floods,
d) landslides,
e) torrents,
f) destructions.

47 What is referred to the dust diseases of the lungs?
a) pneumoconiosis,

b) dust bronchitis,
c) hearing loss,
d) hypokinesia,
e) diseases of upper air passages.

48 Pitch of sound is a quality of sound defined subjectively by a person and depending on its…:
a) intensity,
b) frequency,
c) pressure,
d) sound pressure level.

49 For electric traumatism prevention the preventive posters are used. These posters are divided into 4 groups:
a) preventive,
b) guiding,
c) prohibitive,
d) prescriptive,
e) indicating.

50 Chemically dangerous object is an object of economics,
a) using chemical technologies;
b) using chemical weapons;
c) using chemically dangerous materials in technological processes.

51 Toxic dose is:
a) the concentration of agent in the air, not influencing harmfully on a person;
b) quantity characteristics of agent toxicity, corresponding to the definite level of injury at its influence on the live organism for the definite period of time;
c) quantity of the cloud agent per unit of volume of this cloud.

52 Dangerous factor of habitat is a factor which influence can result in:
a) professional disease;
b) trauma;

c) aggravation of health.

53 Sensitizing materials are the harmful materials causing …
a) workability decrease;
b) allergic reactions;
c) irritation of upper air passages.

54 Harmful factor of habitat is the factor which influence can results in:
a) trauma;
b) disease;
c) area contamination.

55 More dangerous dust particles for respiratory organs are the dust particles of the size:
a) from 0,5 to 10 mkm;
b) from 10 to 20 mkm;
c) from 5 to8 mkm.

56 Electromagnetic oscillations with wave length …… are referred to optical area of radiation
a) from10 to 300 nm;
b) from380 to 470 nm;
c) from10 to 340000 nm.

57 What is referred to quantity indexes of room illumination?
a) light flux;
b) illuminance;
c) spectral composition.

58 What is used for quality of natural light estimation:
a) coefficient of natural light;
b) index of blindness;
c) illuminance.

59 Standard specifications of artificial light are determined according to the index of:

a) light intensity;
b) illuminance;
c) coefficient of pulsation.

60 We perceive elastic vibrations as a sound in the frequency range:
a) 16Hz-50 Hz;
b) 20 Hz -20 kHz;
c) 50 Hz -100 Hz.

61 Pain limit of sound level is equal to:
a) 90 dB;
b) 100 dB;
c) 130 dB.

62 Characteristics of vibration is not the:
a) frequency;
b) amplitude;
c) dose limit.

63 Relative humidity is …
a) ratio of water vapors mass to air mass expressed as percentage
b) ratio of absolute physical air humidity to maximum possible humidity at temperature of dry-bulb thermometer
c) ratio of temperature of wet bulb thermometer of wet-and-dry-bulb thermometer to the temperature of dry thermometer expressed as percentage

64 In what medium the speed of sound propagation is higher?
a) in solid
b) in liquid
c) in gaseous

65. At explosion of 3 kg trinitrotoluene (TNT) on distance 20 m are observed defeats of people by a shock wave
a) Fatal (irretrievable)
b) Hard defeat (contusion)
c) Medium defeat

d) Light defeat (injury, hearing release)
i) Safe distance

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