

OCCUPATIONAL SAFETY

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OCCUPATIONAL SAFETY

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O18

Подано методичні основи сучасної безпеки життєдіяльності, охорони праці та цивільної оборони. Розглянуто найбільш поширені проблеми цих наук і наведено основні методи їх вирішення. Описано джерела шкідливих небезпечних і шкідливих факторів для людини, а також заходи захисту від них як на роботі, так і в процесі життєдіяльності.

Для студентів денної та заочної форми навчання вивчають англійську мову всіх спеціальностей.

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The methodological foundations of modern safety of vital activity, labour protection and civil defence are presented. The most widespread problems of these sciences are considered and the basic methods for their solution are given. Sources of harmful dangerous and damaging factors for a person are described, as well as measures of protection from them both at work and in the process of vital activity.

For students of full-time and part-time study in English of all specialties.

Fig. 24. Tab. 55. Ref.:10 titels.

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INTRODUCTION

Questions of protection always remain determining for any human society. The solution to these questions is a basis for further development of mankind. Consideration of safety of a person is impossible without consideration of interaction of a person with the environment. From ancient times mankind defines any danger as an undesirable event coming from the outside.

It is obvious that a required level of protection against dangers surrounding a person is directly connected with a level of interaction of a person with the environment (natural, household, industrial, etc.). For many years this level changed extremely slowly, because of minor alterations in people's household and industrial environment. Thus, the natural environment also remained practically constant. Therefore, a set of dangers, which the person faces, changed very little. The basic dangers, the person was protected from, were connected with the natural environment (natural disasters, wild animals, poisonous plants, etc.), a life (various mechanical injuries, burns, etc.), interrelations between people (military, religious and other conflicts), and also diseases of people themselves. The knowledge concerning protection against dangers passed from father to son, was got by practical consideration and provided a comprehensible level of safety.

Occurrence of mechanical means of labour and industry development which followed it, became a reason for a rush change of the industrial and household environment surrounding a person and, as a consequence, occurrence of new dangers. It caused appearance of the applied discipline "Labour safety" whose purpose is study of safety of new mechanisms, machines, manufacturing processes and development of necessary protective actions on manufacturing.

At the industry development its harmful influence on natural environment and, hence, on a person increased. Environment protection needed new knowledge which was combined with the science "Ecology".

Further development of the society caused still the big and intensive changes of an environment. These changes were caused basically by:

- growth of consumption and concentration of power resources;
- intensive development of industrial and agricultural manufacturing;
- mass use of automobiles;
- a high rate of the population growth on the Earth and its urbanization;
- growth of expenses for military purposes and a series of other processes.

– Occurrence of new dangers and their sources became the result of it. The greatest danger thus is abnormal accidents (industrial, environmental, natural, military, etc.) as a result of which the big number of victims is observed. Prevention and reduction of consequences of such accidents is a primary goal of the discipline "Civil Defense".

– Thus, the applied disciplines, incorporated by protection of a person, were created. Naturally, with their development there was a question of an establishment of interrelation between these disciplines that demanded ordering of knowledge and development of the uniform approach to safety. "Safety of Vital Activity" is a complex discipline studying opportunities of protection of a person. It is a base for further study of the disciplines "Basis of ecology", "Labour safety", "Labour safety in branch" and "Civil defense".

– The given abstract of lectures is written according to the program of normative discipline "Safety of Vital Activity" authorized by the Ministry of Education of Ukraine on December 4th, 1998.

– The basic attention is given to the system approach to the analysis of the system "person – environment" and to support of safety of vital activity. The given edition does not include questions of "Safety of vital activity in extreme situations" and "Organization and management of safety of vital activity". Students studying safety of vital activity can find these data in the educational editions given in the list of recommended literature. In the second part of the abstract there will be given the questions revealing essence of support of a person vital activity safety at interaction with various dangers.

1. THEORETICAL BASIS OF SAFETY OF VITAL ACTIVITY

1.1. System "person – environment"

Vital activity is a daily activity and rest. It is a way of existence of a person. Forms of activity can be various. They cover the practical, intellectual and spiritual processes proceeding in a life, public, cultural, industrial, scientific and other spheres of life.

The model of an activity process in the most general view can be presented consisting of a person and environment, having direct connections and feedback (fig. 1.1.). Thus, environment can be industrial, household, natural, etc.

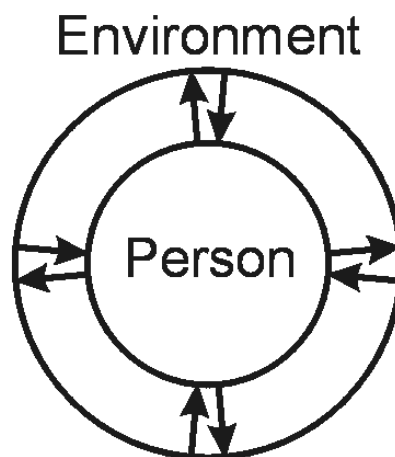


Fig. 1.1. Model of "person – environment" system balance.

At vital activity the person and the environment constantly interact with each other. Thus, "life can exist only during movement of streams of substance, energy and information through a living body".

A changing value of any stream from minimally significant up to greatest possible is able to pass a series of characteristic conditions of interaction in the system "person – environment":

- Comfortable (optimum) one, when streams meet optimum conditions of interaction, guarantee preservation of health of a person and integrity of environment;
- Allowable one, when streams do not influence health negatively, but result in discomfort and thus reduce efficiency of a person's activity;
- Dangerous one, at which streams exceed allowable levels and influence a person negatively, causing disease and (or) degradation of the natural environment at its long duration;
- Extremely dangerous condition, when streams of all levels may injure, result in a lethal outcome or cause destructions in the natural environment in a short period of time.

Thus, interaction of a person with environment can be positive or negative. The character of interaction is determined by streams of substances, energy and information.

1.2. Dangers. Classification of dangers

Danger is a phenomenon, a process or an object, which are capable in the certain conditions to damage health of a person directly or indirectly, causing undesirable consequences.

Dangers are constantly present in the environment. Their sources are any activity or condition of the environment, which are capable to result in realization of danger as an occurrence of dangerous factors in an environment. Dangers are contained in all systems having energy, chemically or biologically active components, etc.

Danger can be considered as a consequence of impact of some factors on a person. Thus, we separate dangerous and harmful factors.

A harmful factor is a negative influence on a person, which results in health state deterioration or a disease.

A dangerous factor is a negative influence on a person, which results in an injury or a lethal outcome.

Now the list of acting negative factors (or dangers) is significant and totals more than 100 kinds. Therefore classification of dangers is necessary for their effective revealing.

There are several ways of classification of dangers, depending on:

- the nature of origin: natural, technical, anthropogenous, environmental, mixed;
- localization: connected with lithosphere, hydrosphere, atmosphere, space;
- caused consequences: exhaustion, disease, injury, lethal outcome, etc.
- influence on a person: dangerous and harmful manufacturing factors; lesion factors – "extreme forms" of influence on a person, characterized by essential adverse consequences for the society, mass lesions of people.

According to the official standard, dangers are divided into physical, chemical, biological, psychophysical.

Physical dangers are moving machines and mechanisms, increased dustiness of air in a working zone, abnormal air temperature, increased noise level, vibrations, sound oscillations, etc. (fig. 2).

By character of impact on an organism of a person chemical dangers are pantotoxic, irritating, cancerogenic, mutagen, etc. Depending on occurrence the basic of them are products of burning and pyrolysis, products of metabolism and household gases, emissions from synthetic materials, harmful substances used or formed during manufacturing, etc.

Biological dangers are pathogenic microorganisms and products of their vital activity, macroorganisms (plants, animals).

Psychophysical dangers are physical overloads, static and dynamic loadings, hypodynamia, nervous-emotional loadings, intellectual overstrain, overfatigue, overstrain of analyzers (skin, visual, acoustical analyzers, etc.), monotony of work and emotional overloads.

The given classifications have a particular character as each of them is only followed to one attribute. Therefore, it is expedient to divide all dangers into three more extended groups (the factors resulting in occurrence of danger), depending on an object of influence, time and space:

- 1) dangers directly influencing the person, their degree of influence can accumulate or relax in time, so called factors of an incubatory action;
- 2) factors of instant action having a casual character, whose influence is spread to the operator or located by noxosphere;
- 3) factors of environmental influence, as a rule, mediate one, acting outside a person, outside the given manufacturing, but being a consequence of a particular manufacturing process at the given enterprise.

Such classification is more convenient at the analysis as it allows revealing, predicting and giving a quantitative assessment to possible dangers at early stages of manufacturing process engineering.

1.3. Safety. The purposes and tasks of safety of vital activity

Safety is a condition of an object, at which influence of all streams of substance, energy and information on it do not exceed maximum allowable values.

Realization of the purposes and tasks of safety of vital activity includes the following stages:

- revealing and describing of dangers and sources of their occurrence;
- development and realization of the most effective systems and methods of protection against dangers;
- forming of danger monitoring systems and management of a condition of safety of an environment;
- development and realization of measures on liquidation of consequences of dangers;
- organization of the population training in the basis of safety and preparation of experts on safety of vital activity.

The main task of safety of vital activity is the analysis of sources and causes of occurrence of dangers, as well as forecast and estimation of their influence in space and time.

1.4. Principles, methods and ways of protection

Protection is a complex process in which it is possible to separate elementary components, initial positions, and ideas so called principles.

Theoretical and cognitive importance of principles is that with their help the level of knowledge of dangers of an environment is determined, and, hence, requirements for accomplishment of protective actions are formed. These principles are very important in practice as they allow finding optimum solutions of protection against dangers on the basis of comparison of various variants.

Principles of protection should be considered in interrelation, i.e. as the elements supplementing each other.

Principles of protection are conditionally divided on the basis of their realization into four classes: orienting, technical, organizational, administrative.

Orienting principles represent the basic ideas determining a direction of search of safe solutions. These are principles of a system approach, of liquidation and decrease of danger, of operator replacement, information, classification, normalization.

Technical principles are aimed at direct prevention of action of dangerous factors and based on use of physical laws. These are principles of protection in distance and time, of shielding, durability, a weak link, blocking, pumping out, hermetic sealing, inaccessibility.

Organizational principles are those ones, which help to realize positions of scientific organization of work. These are principles of incompatibility, of rational work organization, selection of the staff, ergonomicity, compensation.

Administrative principles are those determining interrelation between separate stages of a protection process. These are principles of a planned character, of control, management, a feedback, responsibility, stimulation, efficiency, selection of the staff.

Some principles concern several classes simultaneously. Principles of protection form a system.

At the same time, each principle has relative independence.

A method is a way of achieving a goal. Methods of protection are based on use of the principles mentioned above.

Let us introduce the following concepts:

Noxosphere is a space in which dangers constantly or periodically exist.

Homosphere is a space (a working zone) where a person is located during activity.

Overlapping of homosphere and noxosphere from a position of safety is inadmissible, however in most cases it is not possible to separate noxosphere and homosphere.

By analyzing possible dangers and their consequences, it is possible to reveal the general laws on the basis of which three of the most general methods of protection against dangers are formulated:

1. Spatial and (or) time division of homosphere and noxosphere. It is achieved by means of remote control, automation, robotization, special organization, etc.

2. Normalization of noxosphere parameters by exception or decrease of quantitative characteristics of danger. It is a set of the actions protecting the person from noise, gas, dust and also other means of collective protection.

3. Adaptation of people to conditions of noxosphere and increase of their safety. The method realizes opportunities of professional selection, training, psychological influence, application of means of an individual protection.

In real conditions, the combination of all three factors is frequently realized.

Means of protection are distinguished according to means of collective and individual protection. In turn, they are divided into groups depending on the character of dangers, design, field of application, etc.

2. BASIC CONCEPTS OF THE SYSTEM ANALYSIS OF SAFETY OF VITAL ACTIVITY

The main task of safety of vital activity as a branch of scientific-practical activity is to support the set level of safety of the system "person – environment".

The solution to the given problem for any object of environment, which the person interacts with, is connected with revealing and estimation of all dangers acting on an object, and also to a choice of system of the actions providing the required level of safety.

Thus, studying of the questions which concern safety is not reduced to consideration of any element of object or any danger separately, but requires a complex (or system) analysis.

2.1. System analysis of safety

A system is a set of objects (or elements) naturally or artificially joined to form a single whole and for joint accomplishment of some functions.

For a system the following features are characteristic: 1) presence of system qualities which are not reduced to the sum of properties of elements forming it; 2) a certain structure of elements; 3) presence of the internal organization providing interaction of components; 4) subordination of all organization of system for some purpose.

The system analysis of safety is used for protection as methodological means. It is based on three principles: precise formation of ultimate goals; revealing of alternative ways of purposes achievement; analysis of expenses and achievable effects on each alternative.

The tasks of the system analysis of safety of any environmental object are:

1. Studying and analysis of all elements of an object from positions of safety.
2. Revealing and estimation of the dangers acting on an object.
3. Choice of possible (alternative) protective actions.
4. Comparison of alternatives with each other and a choice of the optimum variant of protective actions.
5. Estimation of realization of a protective action and its consequences.

The basis for study and analysis of object elements from positions of safety and also for revealing of dangers is provided with the knowledge of the

nomenclature of dangers, principles, methods and means of protection, as well as with safety knowledge.

To solve other problems of the system analysis of safety it is necessary to introduce the values describing dangers. Thus, complexity is in the necessity of comparison of dangers being various by the nature of origin and consequences caused.

Now the common measure of dangers is risk.

2.2. Determination of dangers risk

Risk (R) is an integrated value of danger, which in quantitative expression is determined as a product of value of a dangerous event (A) and a measure of its approach (q):

$$R=A \cdot q. \quad (2.1)$$

The value of event A is described according to the specific parameters, and the range of parameters can be rather wide – from economic up to ethical values. Economic parameters are usually used as a value of an event, for example, damage caused by consequences of danger realization. Though it is not always possible to describe the value of danger with economic criteria, and disputes on how to estimate a fatal outcome are conducted till now.

A measure of a possibility of dangerous event occurrence is probability of its occurrence.

Quantitatively parameters of risk are determined on the basis of previous events with application of the apparatus of the probability theory and mathematical statistics. Revealing of quantitative parameters is frequently complicated, that is connected with insufficiency of statistical data.

Alongside with quantitative ones they also use qualitative characteristics of risk of dangers.

To simplify the procedure of the system analysis it is usually divided into two stages:

- 1) preliminary analysis of risk;
- 2) quantitative analysis of risk.

2.3. Preliminary analysis of risk

The purposes of the preliminary analysis of risk are revelation of all dangers acting on the object, determination of their qualitative characteristics and development of basic measures of protection against dangers.

Qualitative characteristics of danger are a category of danger depending on the value of consequences and qualitative assessment of dangers realization frequency. Realization of danger will further be named a failure by analogy with technical systems.

The rank of danger is used as a risk.

Being based on the Interstate standard GOST 27.310-95 "The analysis of kinds, consequences and criticality of failures. General positions", adopted on April 26th, 1995, the following technique of determining qualitative characteristics of danger (for a category see table 2.1, for probability of failures see table 2.2) is offered.

Table 2.1

The scale for determining a category of danger depending on caused consequences

Category	Description of danger realization consequences
IV	Danger whose realization can fast and with high probability cause appreciable damage for a considered object and (or) an environment, as well as mass mortality or injuries of people
III	Danger whose realization can fast and with high probability cause appreciable damage for a considered object and (or) an environment either possible death or injury even of only one person
II	Danger whose realization can cause a delay in the object task accomplishment. It results in decreasing the work capacity of people. At long influence it leads to diseases
I	Danger at realization of which the values of its parameters do not exceed the bounds allowable

Table 2.2

Qualitative assessments of dangers (failures) realization frequency

Kinds of failures depending on frequency of its occurrence	The qualitative description
Frequent failure	A failure is observed constantly
Probable failure	Frequent occurrence of a failure is probable
Possible failure	A failure is observed several times during the object operation
Infrequent failure	A failure is quite possible even once
Practically improbable failure	A failure is improbable, but it is possible even once

The rank is determined as a product of a category of danger and probability according to table 2.3.

The ranks of dangers are:

AA – The actions on decreasing a rank by modification in the project are obligatory.

A – The quantitative analysis of safety and accomplishment of all complex of protective actions are obligatory.

B – The accomplishment of the quantitative analysis is desirable. The application of protective actions is necessary;

C – The accomplishment of the qualitative analysis is recommended. The use of life-support systems and accomplishment of protective actions are taken, if necessary.

D – The application of protective actions is not required.

Table 2.3

Matrix of determining of a rank of danger

Expected frequency of danger occurrence	The category of danger			
	IV	III	II	I
Frequent failure	AA	AA	C	C
Probable failure	AA	A	C	C
Possible failure	A	A	C	D
Infrequent failure	A	B	C	D
Practically improbable failure	B	B	D	D

The preliminary analysis of the object safety is executed according to the following algorithm:

1. Decomposition of an object is accomplished.
2. Interrelation of object elements is established.
3. Dangers and parts of an object being sources of these dangers are determined.
4. Category, probability and rank of dangers are determined. A special form of the preliminary analysis (table 2.4) is filled.

Table 2.4

Determination of qualitative characteristics of dangers

No.	Element of object	Danger	Characteristic of danger		
			Category	Probability	Rank

5. Restrictions on the analysis of dangers are introduced.
6. Conclusions and preliminary recommendations on safety are made.

2.4. The quantitative analysis of risk

After the decision on accomplishment of the quantitative analysis of risk is made, a set of alternative protective actions is formulated. Accomplishment of the quantitative analysis consists in a choice of optimum protective measures on the basis of quantitative criteria of safety.

Economic values are more often used as quantitative assessments of danger.

As a quantitative assessment of risk we will consider expected losses C , connected with realization of a dangerous event during the given interval of time. Expected losses are determined as a product of probability of occurrence of dangerous event P and the value of the average losses E determined from the last experience:

$$C = P \cdot E. \quad (2.2)$$

As a criterion of safety we will use factor k determined as a ratio of expenses for safety M to decrease expected losses ΔC (or to decrease risk of danger) due to realization of a protective action:

$$k = \frac{M}{\Delta C}. \quad (2.3)$$

The value of expenses is determined with expenses for introduction of devices, methods, and procedures so called protective actions, during the given interval of time.

As it may be seen from the formula of C determining, decrease of expected losses can be achieved due to reduction of probability or the average losses. As value E is determined on the basis of the last events, we will consider it to be constant. Hence, decrease of expected losses is directly proportional to reduction of probability of dangerous event occurrence.

Thus, after determining of losses and expenses for safety the major task of the quantitative analysis is determination of probability of dangerous event occurrence before and after introduction of a protective measure.

At determination of probabilities a technique of failure tree construction is used.

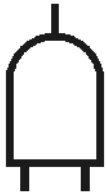
2.5. Construction of failure trees

The tree of failure is the structural-logic circuit with dangerous event so called head event on the top and with the basic or initial events at the basis.

The basic events are at the basis of a tree of failure, thus it is supposed, that the probability of their occurrence is known.

At construction of a failure tree two kinds of symbols are applied:

A. Logic symbols:

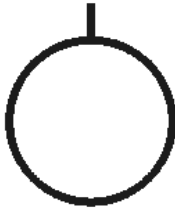


– "and" – outgoing event occurs, if all ingoing events take place simultaneously,



– "or" – outgoing event occurs, if any of ingoing events takes place ;

B. Event symbols:



– basic event provided with sufficient data, i.e. probability is known,



– event entered by a logic symbol.

A tree of failure is built with application of so called "inverse" logic. So it is needed to reply to a question what a cause of an inverse event is, asking how danger can be realized.

Let us consider an example of construction of a tree of refusals for a household electric iron. The structure of an iron is shown in fig. 2.1.

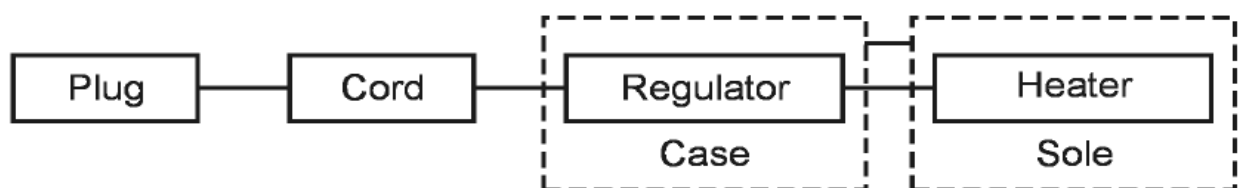


Fig. 2.1. Structure of a household electric iron

We will take the event "lesion with an electric current" as a dangerous one. The example of a tree of failure is shown in fig. 2.2.

After construction of a failure tree the probability of the head event occurrence is determined. Thus, we need to know probabilities of the basic events.

At building of the logic expressions connecting the head and basic events an apparatus of the probability theory is used.

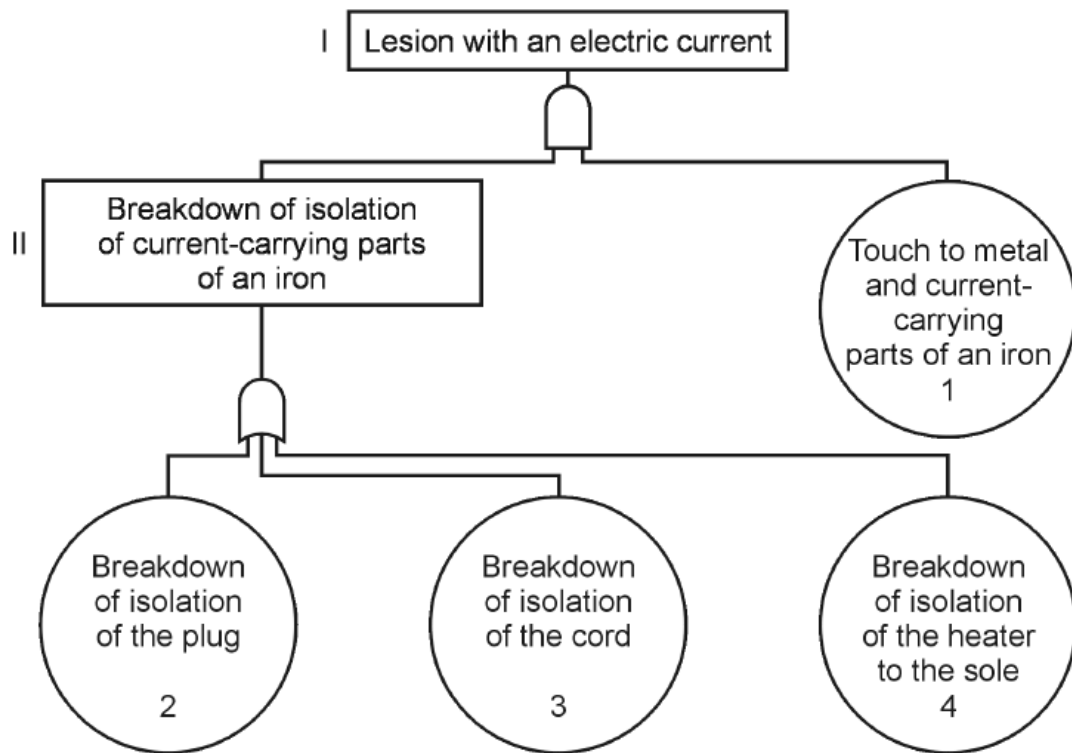


Fig. 2.2. A failure tree

Having the danger estimated quantitatively, alternative protective measures are developed.

For the analysis of efficiency of some protective measures the additional tree of failure is constructed, taking into account its influence on the system. For example, as an alternative protective measure a periodic external survey of a plug and a cord and their duly replacement are offered. Then the tree of failure will look like the following (fig. 2.3).

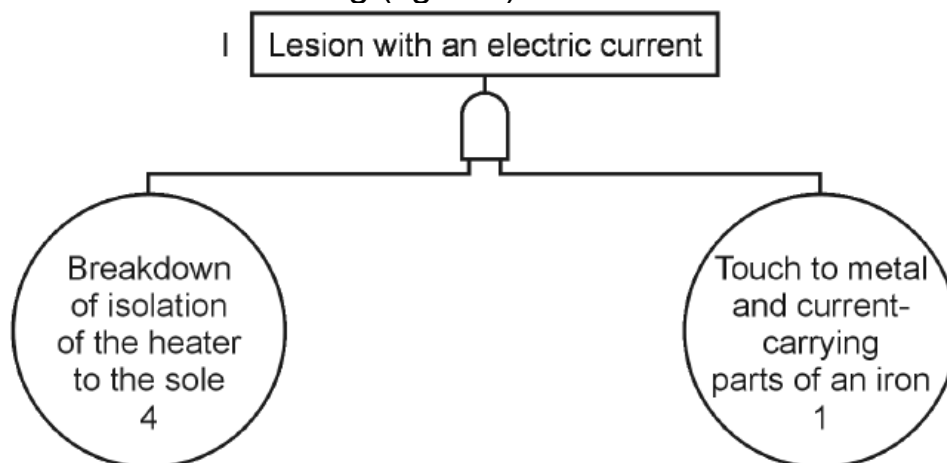


Fig. 2.3. A failure tree after application of a protective measure

After a new value of probability is determined, it is compared to the initial value, and then the conclusion of efficiency of the protective measure is made.

3. PERSON AS AN ELEMENT OF THE SYSTEM "PERSON – MACHINERY – ENVIRONMENT"

3.1. Person from the position of the system approach

A person in the system "person – machinery – environment" is an integral system which is:

- disbalanced as there are constantly fluctuations of its condition;
- stationary as the organism is in one condition for quite a long time (for example, illness – health, life – death) despite fluctuations;
- self-regulating as for support of viability the organism should adapt, be arranged under conditions, keeping the internal environment constant.

Besides, a person is open, i.e. they exchange energy, information and substance with the environment they exist in.

To investigate and provide health of a person, it is necessary to understand a phenomenon of a person and principles of their self-organizing. But being focused on research of mainly physical body, sciences about a person could not give this understanding until recent times. In an antiquity there were deep conceptions about a person as an integral system, about their structure and communication with the world. At recent time only the science began to translate this knowledge into the modern language, having taken as a principle above all the achievements of quantum physics, neurophysiology, psychology, etc. Shredinger, Prigozhin and other scientists showed that a person is a self-organizing system, and so, simple study of their inner life without taking into account interrelations with environment will not give any results.

It is possible to come nearer to understanding of integrity of a person with the help of the system approach. The system is a set of elements and connections between them, which functions as a whole one and has the uniform purpose of functioning. A person is a system, which is part of a more significant system. They are included in it as one of subsystems. In turn inside themselves, in the biological structure a person has so called mini-systems of similarity in which the whole organism is reflected. These are an iris of an eye, an auricle, a tongue, a mucous membrane of a nose, a skin, especially of hairy parts of a head, palms and feet. By changes in these structures it is possible to diagnose a state of health, and influencing them gives a possibility to correct deviations. Elementary mini-system of similarity of an organism is each of his cells, so it became a basis for cloning.

Each of three levels of the system "person" is considered as a subsystem organized by the same principle, as the whole system. In turn, in these subsystems of the first order subsystems of the second order, etc. are allocated. Subsystems of all orders function in relatively independent modes, but at meeting of principles of interrelation and submission of a lower level to an upper one. The principle of interrelation is both in mutual influences of various subsystems and common blocks available in them, i.e. in intersection.

Therefore one subsystem inevitably involves another in work and a person reacts to influences as a whole one. Research of a person as a whole one is in a principle of such philosophical direction as holism, which totals more than 5000 years (a latin word “holos” means “integral”).

As it is known, the final result, the purpose of functioning of system is a system-formative factor. The structure of the system is defined by the purpose, and change of the purpose demands change of the structure. Failures in the structure naturally reduce probability of the purpose achievement . So, the following basic purposes of human life are separated:

- 1) at a somatic level there are two of them:
 - survival, i.e. formation and preservation of individual biological structure,
 - reproduction that provides interests of a kind, preservation of a population.
- 2) at a mental level:
 - people aspire to realize themselves as individuals, i.e. to live a high-grade life in a society.

Naturally, the preference can be given to different purposes depending on a level of development of individuals and circumstances of their lives.

According to the structure of the purposes of human life, an individual mental and physical health of a person projected on strategy of survival is a separate aspect of safety of vital activity as a science, including diagnostics, forecast, formation, management, and adaptation.

- As a biosystem an organism has the following peculiarities:
- self-organizing is an ability to preserve individual existence.
 - self-development is an ability to develop irrespective of external conditions.
 - self-reproduction.

Ability of realizing all the features mentioned above simultaneously determines a phenomenon of biological life.

A person as a system constantly exchanges information, energy and substance with an environment. It is possible to allocate several forms of this exchange: feeding, breathing, motion, psycho- and energy-informational exchange. Optimization of an exchange promotes orderliness of the system, and it is one of the basic approaches to healthy life, optimum vital activity of a person.

A person as a system lives in space and develops in time. Therefore to preserve health there is a series of requirements for ecology of large and small vital space of a person, which should be known by every expert engaged in problems of health. For preservation of health it is also necessary to fit in the time organization of life, i.e. to take into account biorhythms. Failure of biorhythmic activity correlates with decrease of a health level.

Thus, in the modern science a person is represented as a bioenergy system, which is open and has certain spatial-temporal aspects of functioning. System representation is a scientific analogue of the holistic

(system) approach to a person. Within the limits of the given approach we will consider a person as a system and their vital activity as the system phenomenon.

3.2. Health of a person as a medical biological and social category

Let us consider health as a system phenomenon. As a category health plays a huge role in development and existence of an individual person and society as a whole. Health is eternal natural necessity, because without it not only progress of the society and technical progress would be impossible, but also existence of the society as a phenomena. From various aspects of human life health plays a lot of roles in human life.

The medical and biologic role of health is that a person is a natural creature having peculiarities of the nature, which has created them. These properties exist in a person as certain abilities, talents, opportunities. As a natural creature a person has organs and feelings (sight, hearing, taste, scent) and as the natural and social creature they also have mental abilities (thinking, supervision, desire, activity, love). To appropriate everything that is in the nature and to transform it to a kind suitable for existence and use, a person uses all their abilities and opportunities, put some efforts, i.e., in other words, participate in labor process. Thus, in labor process, accomplishing work necessary for them, people use a brain, muscles, sense organs, and the nervous system. The higher level of health is, the more efficient a person is, the more qualitative use of their own resources will be achieved to accomplish work necessary for them. Therefore, health has a biological (physiological and psychological) basis.

A social role of health occurs because of work having a social character. To make products people are to enter certain relations and communications for more effective joint influence on the nature. These communications are not only mechanical, but they are organic and internally interconnected with the essence of people and their activity. Therefore health, which a working person has, essentially changes organization of labor, rational use of labor, distribution of facilities, manufacturing methods and products of labor.

It is not difficult to notice that labor, as any activity of a person, is not only a physiological process of spending human energy, but also activization of all mental functions of a person. i.e. from the psychological-physiological point of view labor is a form of vital activity, which is shown in functional changes of organs and systems of a person's organism, accompanied with various forms of mental display of the reality.

By definition of the World Organization of Health services, health is a full physical, mental and social well-being of the individual. Any activity of a person is accompanied with a significant stress of functional abilities of an organism. Thus, loading can be both physical and mental, nervous. i.e. irritators affecting a person during labor activity are capable not only to change physiological processes, but also essentially influence mental activity.

Finally, changes occurring in a person's organism at all levels of the organization are reflected, first of all, in quality of their vital activity. Thus, there is a vicious circle of cause-and-effect relations being around of basic concept – health of a person.

Health is a very complex system phenomenon representing a result of interaction of individual and environment (conditions of his existence), leading motives of their vital activity and attitude as a whole. Preservation and strengthening of health represents, as a matter of fact, an integral problem of health management. Management process consists of the following formal stages:

- gathering and analysis of the information on an object condition, and also its forecast;
- formation of the program of management actions and its realization;
- analysis of adequacy and efficiency of the management program, i.e. a feedback.

As we see, the second and the third stages in essence represent tasks of safety of vital activity as a science about a person.

3.3. Health and its mechanisms from the position of the system approach

Mechanisms of health. According to modern concepts, mechanisms of health are automatic mechanisms of self-organizing of a person, which provide formation, preservation and strengthening of their health. Control contours submitted with direct connections and feedback lay in their basis. Due to self-organizing living creatures support their orderliness, prevent from destruction and so contradict the second law of thermodynamics. These mechanisms work constantly both in a state of health and illness.

Homeostasis. Mechanisms of health provide a support of regulatory, energy and structural homeostasis. Thus, homeostasis is understood as a condition of dynamic balance inside an organism. However, any living system, as we know, is always in a disbalance condition relating to the environment. It is a universal property of the living. Mechanisms of self-organizing provide dynamic stability of a system, i.e. keeping it in motion during an exchange with the environment.

The most researched mechanisms of health are regeneration, physical adaptation and compensation. Compensation is a replacement of the insufficient, lost or weakened function due to additional same or similar parallel mechanisms. The organization of compensative reaction occurs at the level of the structural organization, which is higher than the level where there was a failure. Regeneration, adaptation and compensation provide individual health basically due to influence on the form-building process. They restore the body form, adapt it for loadings in physiological conditions (adaptation) and in the progress of illness (compensation).

Viability of a living system is connected basically with an energy potential resisting to destructive tendencies in the system. Therefore, first of all, the processes promoting formation, preservation and strengthening of this potential concern mechanisms of health. Mechanisms of health as mechanisms of self-organizing operate constantly in an organism both in conditions of health and illness, providing recovery. It is possible to support, make active, direct, train, create conditions for display of activity of these mechanisms, and it makes essence of tasks of sciences about a person, which also concerns safety of vital activity.

3.4. Functional condition of a working person from the point of view of the system approach

At operation of the system "person – machinery – environment" it is necessary to solve a lot of the major practical problems, such as the optimum organization of manufacturing process, normalization of labor and determination of allowable zones of influence of loadings, prevention of occupational diseases, optimization of the process of industrial training and selection of the staff. Solving these problems is possible with the help of the data on specificity and peculiarities of a human body. One of the most complex characteristics of an organism of people is their functional condition.

The concept of "a functional condition of a person» is one of the most uncertain. There is a huge amount of definitions explaining this concept. It concerns a plenty of problems in this area and methods of research. Therefore, from positions of the system approach the functional condition can be defined in several ways, and each of them has the right to life:

1. Qualitatively peculiar answer of functional systems of different levels to external and internal influences arising during activity.
2. An opportunity to accomplish a particular kind of activity, taking into account influence on a person's health
3. Dynamic result of interaction of various subsystems of an organism
4. An integrated complex of those functions and characteristics which directly or indirectly cause accomplishment of activity.
5. Complex system reaction of an organism to activity, a respond of an organism to external and internal factors of activity.

The last definition may be considered as the most complex and adequate one.

3.5. Factors influencing formation of functional conditions

There are plenty of factors influencing formation of functional condition of a person. The generalized classification of factors is shown in fig. 3.1. Systematizing and a little simplifying the resulted classification, it is possible

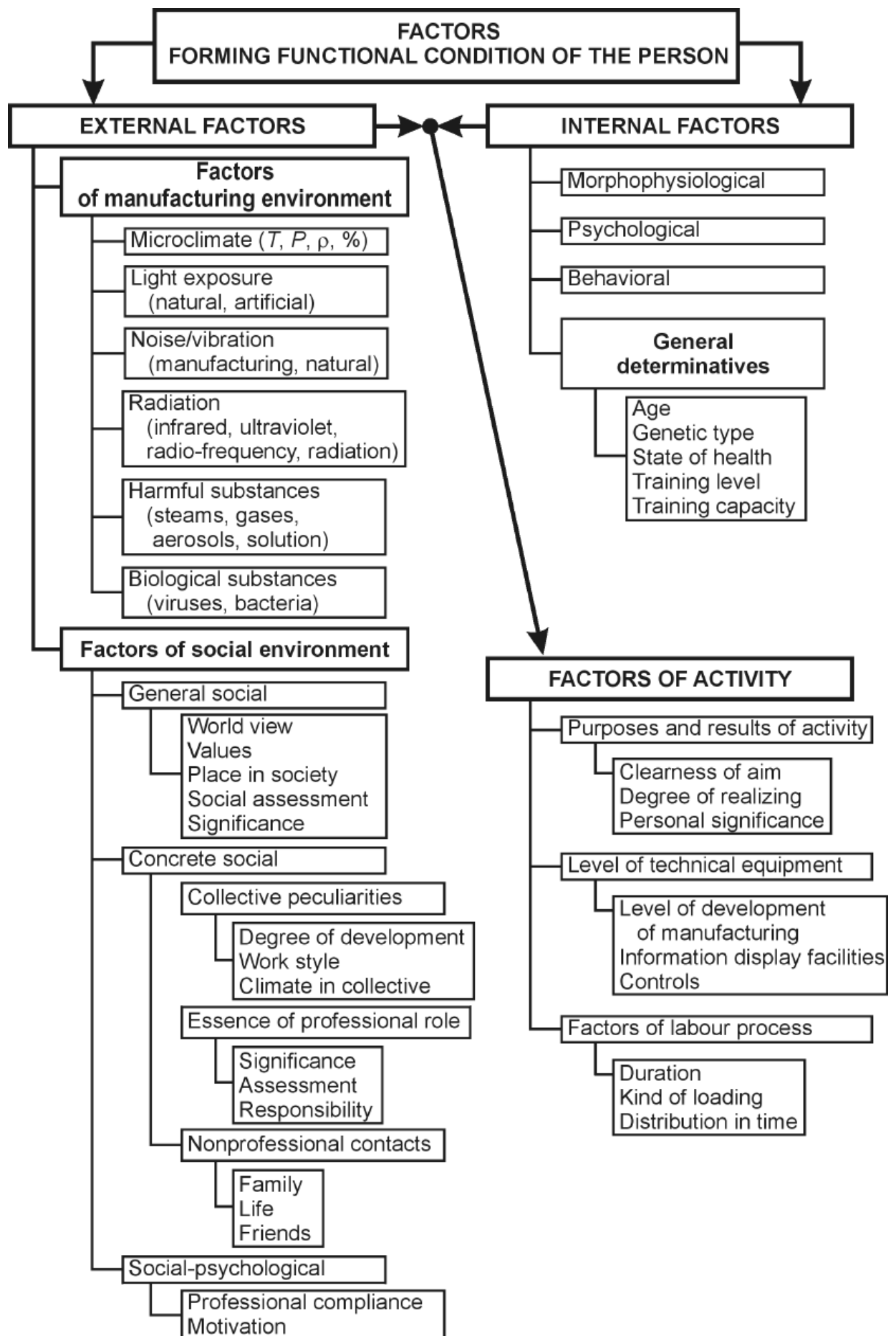


Fig. 3.1. Factors forming functional condition of a person

to make a conclusion on primary influence of different categories of factors on certain components of a functional condition:

- factors of the manufacturing environment directly determine a degree of psycho physiological comfort;
- factors of the social environment in aggregate with the purposes of labor activity characterize motivational aims and emotional background of activity;
- characteristics of labor process and technical equipment of manufacturing determine an activity intensity level and dynamics of work capacity conditions;
- specific peculiarities of a person mediate influence of these factors, transforming external influences into the reactions corresponding to subjective abilities.

3.6. Work capacity of a person

The following system display of vital activity of a person is their work capacity, which has a property to change during life, a year, a month, a week, day and even an hour.

Dynamics of work capacity. It is established that changes of functional condition of a person during activity pass several phases which are characterized by natural changes of physiological and behavioral functions. 8 basic phases are distinguished, the last three of which represent exhaustion. The peculiarities of operator activity leading to exhaustion are physical loading; static or dynamic character of loading; intensity of loading; constant or rhythmic character of loading; noise, weak illumination and temperature of air, adverse for work; conflicts, anxiety or absence of interest for work, i.e. emotional environment; a disease, pain and insufficient feed, a physiological component of a condition of a person.

Phases of change of the operator work capacity are:

1. A phase of mobilization, or a pre-starting phase. The organism is mobilized even prior to the beginning of work when there occur a conditioned-reflex way increase of central nervous system tone and amplification of functional activity of some organs and systems, facilitating functioning of those systems which will directly participate in work. Character of specific shifts is determined with earlier produced skills in work and a degree of a training capacity of an organism. Direct expression of a mobilization phase is in some increase of a heartbeat force, rise of the maximal arterial pressure, amplification and deepening of breath. Subjectively, this phase is expressed in some derivation from external irritators, internal concentration, considering of peculiarities of forthcoming work.

2. A phase of primary reaction. It is characterized by a small decrease of almost all parameters of functional condition of the person. The physiological mechanism concerns the external braking arising as a result of change of

character of irritators acting in the central nervous system. It lasts for a few minutes, and its duration depends on training capacity of the operator.

3. A phase of hypercompensation. It reflects a process of mobilization of an organism and increase of the central nervous system tone. There is a person's adaptation to the most economical, optimum mode of work accomplishment. The organism reacts to loading with a greater force than it is necessary. External display of this phase is initial increase of all parameters of functional condition of the systems providing work.

4. A phase of compensation. There is establishment of an optimum operating mode of organs and systems of an organism and the certain stabilization of parameters is developed.

5. A phase of subcompensation. At a certain duration and intensity of work the high level of physiological reactions starts to reduce, and parameters of functional condition become worse. The necessary level of work is supported due to easing less important functions. Character of compensatory reactions qualitatively varies, compensation is accomplished due to processes less favourable energetically and functionally.

6. A phase of decompensation. There is a steady deterioration of a functional condition of an organism, the most important functions for the given kind of work change. This phase is characterized both with expressed vegetative failures (tachycardia, increase of breath) and loss movement coordination accuracy, occurrence of a plenty of mistakes in work, etc.

7. A phase of overstrain or failure. Significant frustration of regulating mechanisms, strongly pronounced inadequacy of an organism reactions to signals of an environment, sharp work capacity falling down to impossibility of work continuation are observed. Failure of activity of the internal organs accomplishing vegetative functions can result in a collapse and faints.

8. A phase of a final gap. It arises before the end of work. The essence of this stage consists in urgent mobilization through the second alarm system of all additional reserve forces of an organism and sharp increase of work capacity. It often terminates in full switching-off of the person from internal life-support systems.

3.7. Biorhythms

Many factors, which determine physical and intellectual work capacity, periodically change according to biorhythms. The biological rhythm is a self-sustaining independent process of periodic change in conditions of an organism and oscillations of intensity of physiological processes and reactions. It is better to say, biorhythms are periodic changes of work capacity of a person.

Biorhythm is a system phenomenon in life of biological objects. Biological rhythms play a huge role in self-regulating of living systems and regulation of environmental communications. Rhythmic oscillations of certain conditions in living systems are registered with frequency from one time per millisecond up

to one time per several years. Biorhythms of a person's organism are given in table 3.1.

Table 3.1

Biorhythms of a person's organism				
Frequencies				
High	Medium		Low	
Length of a period				
Less than 0.5 hours	From 0.5 up to 20 hours	From 20 up to 28 hours	From 28 up to to 2.5 days	More than 2.5 days
Biorhythms				
Electroencephalogram, pulse rate, breathing rate	Ultradian rhythm	Circadian rhythm	Infradian rhythm	period of about 7 days period of about 20 days period of about 30 days period of about 1 year

A biological rhythm is a consequence of existence of a set of external factors. The Sun and its activity, geomagnetic activity of the Earth, space radiation concern most biologically significant pacemakers ("drivers of a rhythm"). The most influential factor is a social way of life.

At interaction of an organism with an environment there is a continuous imposing of "external" rhythms on "internal" ones, and the result of such summation finally determines a physiological condition of various organs and tissues. An oscillatory biological system has advantages over a "rigid" system in terms of stability, energy and response speed.

So, it is established that general productivity of operators work and amount of mistakes per hour look like the curves shown in fig. 3.2 and 3.3. As labor productivity is related to cyclic changes in an organism, i.e. circadian biorhythms there are curves of work capacity constructed for "larks" and for "owls" which differ not only by the form, but also are shifted by the phase (fig. 3.4).

Work capacity of the operator within a working week also naturally changes under action of the factors given above (fig. 3.5). The number of accidents during the working day also has periodicity.

The phenomenon of biorhythmical changes is observed at all kinds of loading – intellectual, emotional and physical.

With degrading development of ecology thesis about desynchronizing influence of disbalance between biological rhythms of a person with rhythms of their industrial and social activity receives an increasing distribution. i.e. the reasons for desynchronizing under certain conditions are factors making a person's way of life.

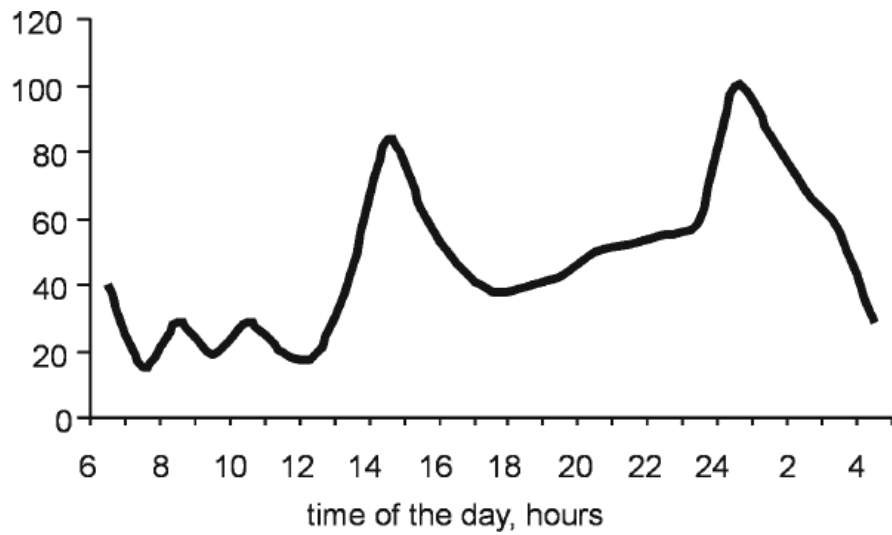


Fig. 3.2. Amount of mistakes of the operator per hour, changing within a day

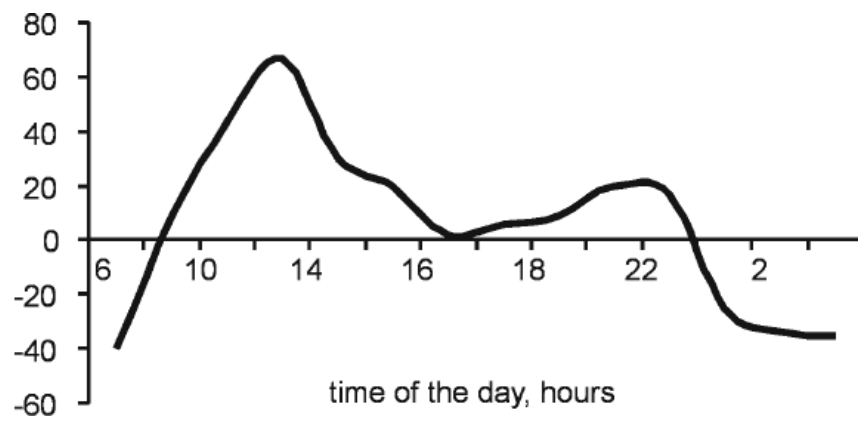


Fig. 3.3. Productivity of operators within a day

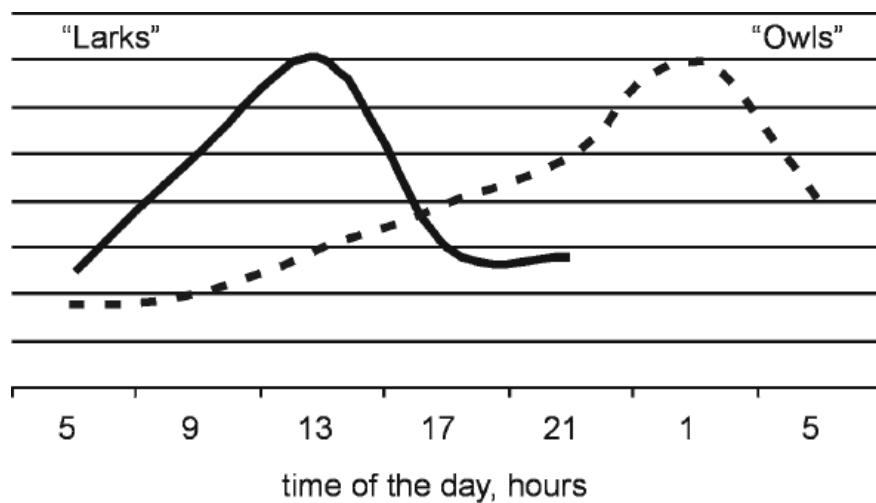


Fig. 3.4. Changing of work capacity of the operators, concerning biorhythms

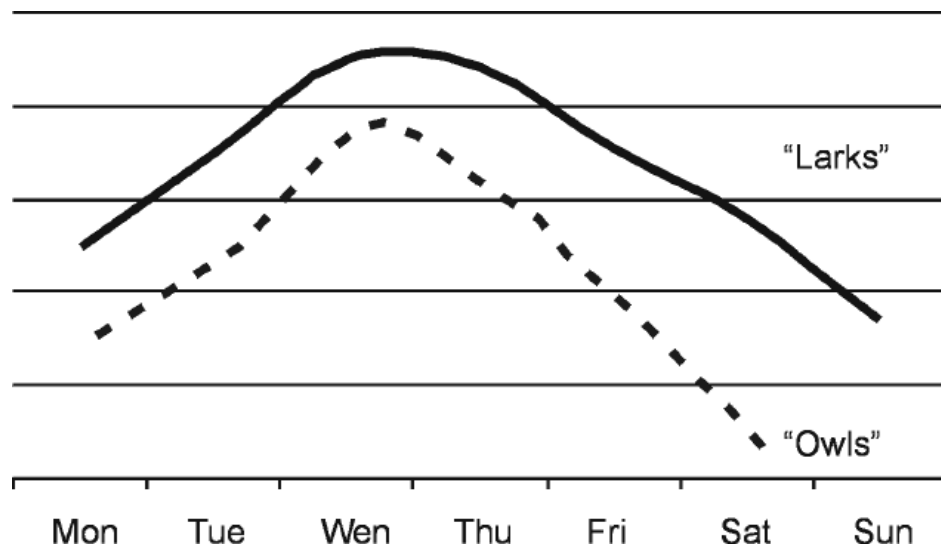


Fig. 3.5. Changing of work capacity within a week for "owls" and "larks"

3.8. Homeostasis as a system mechanism of person's organism protection

During vital activity a person is influenced by enormous quantity of factors changing his/her condition. It is impossible to list all factors influencing a person, however it is obvious that, despite their abundance, a person continues to live, work and develop. Hence, it is possible to assume that there is something, a process or a system, a mechanism, which assist protection of a person from all influencing factors with the purpose of a survival of a human kind. Indeed, such mechanism of protection exists. It is homeostasis.

A variety of external regulating mechanisms (genetic, evolutionary, etc) influences an organism of a person as a complete biosystem. There is also a number of internal regulating mechanisms: regulation of temperature, salt balance, content of haematocytes, intracranial and arterial pressure, i.e. there is a spatial and time hierarchy of the interrelated control mechanisms.

Importance of homeostasis is that its presence allows an organism to adapt for conditions of existence, i.e. to changes of an environment. That underlies a survival of human as a kind. So, the role of homeostasis is that a condition of a person's organism as a result of its activity in the system "person – machinery – environment" is determined by the ability of control mechanisms to provide a balance between an organism and the environment, its adaptation to conditions of the environment. For example, one of the basic mechanisms of homeostatic regulation is body temperature maintenance.

3.9. Thermal balance. Regulating of a body temperature

Mechanisms of thermoregulatory thermogenesis are mechanisms of generating heat in a person's organism. When body temperature constancy maintenance needs additional heat, it can be produced in the following ways:

- 1) due to any activity of the muscular apparatus;
- 2) due to involuntary muscular activity (shiver);
- 3) due to acceleration of exchange processes not connected with traction. This form of heat generation is called a unshivering thermogenesis. For an adult a shiver is the most important involuntary mechanism of thermogenesis.

Temperature gradients in a person's organism. Heat being generated by the organism in a normal condition (i.e. in condition of balance) is given to environment from a body surface. According to physical laws of distribution of thermal streams the temperature of the body parts close of its surface should be lower than the temperature of its central parts. In extremities there are longitudinal (axial) radial (perpendicular to a surface) temperature gradients. Spatial distribution of a body temperature is described by complex three-dimensional function because of abnormality of geometrical forms of a body. The fluctuations of a body temperature caused by changes of external temperature are much more expressed near to a surface of a body and in end parts of extremities. The isotherms resulted on fig. 3.6 characterize temperature gradients in a body of the person in conditions of a low and high temperature of environment.

Periodic fluctuations of internal temperature. The body temperature of the person changes within a day. It is minimal at dawn and maximal (with two peaks) in the afternoon. The amplitude of daily fluctuations on average is approximately 1°C.

Oscillation of a body temperature during 24 hours is one of many daily rhythms. Even in that case when all focusing external signals are excluded (light, changes of temperature, usual food reception hours), a body temperature continues to change rhythmically, but the period of fluctuations in this case stops to equal 24 hours exactly. "Freely fluxing" period is from 24 up to 25 hours and is usually synchronized with external signals, in particular, with the Earth rotation.

Change of a body temperature of a person in conditions of physical loading. In conditions of physical loading the internal temperature rises, and the average temperature of a skin falls due to secretion and evaporation of sweat caused by work (fig. 3.7). In figure the columns are divided as follows: the bottom part is heat emission by radiation, the medium part is heat emission by convection, the top part is heat emission by evaporation (without taking into account heat emission due to heat conducting).

Working with the submaximal loading the degree of internal temperature increase almost does not depend on environmental temperature within the limits of a wide range (from 15°C up to 35°C) while there is secretion of sweat. Dehydration of the body results in internal temperature rise, and hence, limits work capacity. The stable level of internal temperature achieved at work with the submaximal loading is proportional to relative productivity.

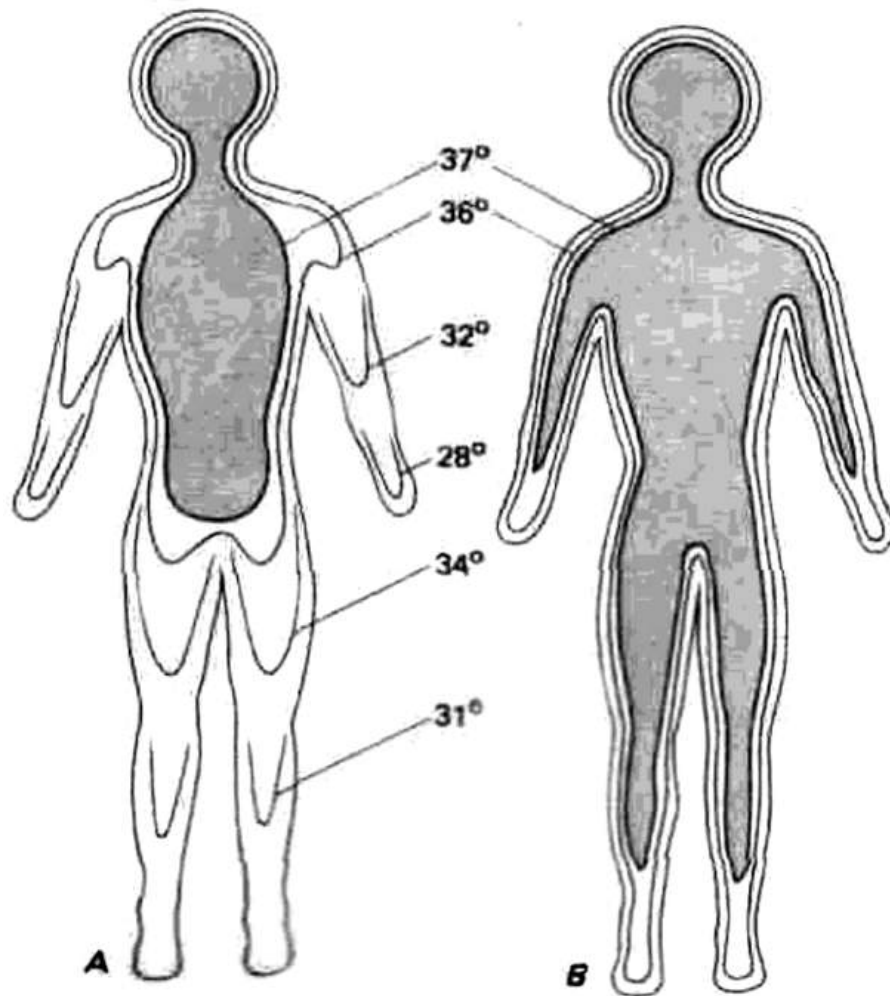


Fig. 3.6. Temperature of different areas of a person's body in conditions of cold (A) and warmth (B)

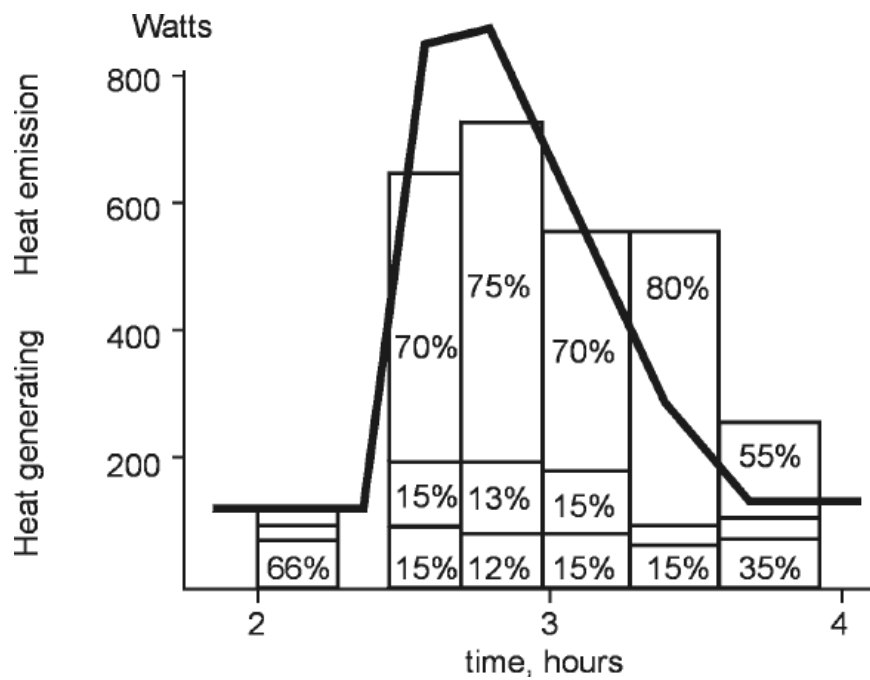


Fig. 3.7. Body temperature, heat generation (line) and heat emission (columns) in conditions of rest and physical loading

Heat emission. In the stationary conditions of rest characterized with a constancy of an average body temperature, intensity of metabolism (M) should be equal to speed of heat transmission from internal area of a body to a superficial layer – so called an internal stream of heat (H_{in}) – and also to speed of heat transmission from a body surface to an environment – so called an external stream of heat (H_{ext})

$$M = H_{in} = H_{ext}. \quad (3.1)$$

1. An internal stream of heat. The basic mechanisms serving for emission of excessive heat by an organism: radiation, convection and transmission. Less than half of all heat produced inside a body spreads on a surface due to its transmission through tissues; the biggest part of generated heat is transferred with convection to a bloodstream. Due to the high thermal capacity blood suits very well for transmission of heat and so it suits for maintenance of thermal balance in an organism. The internal stream of heat H_{in} , as it shown in the equation, is proportional to a difference between internal temperature T_{in} and average skin temperature T_{skin} . It is also determined by heat conductivity C , whose value depends on speed of a bloodstream in the skin and extremities:

$$H_{in} = C \cdot (T_{in} - T_{skin}) \cdot A, \quad (3.2)$$

where A is the surface area of a body. Heat conductivity of the adult person can vary with speed of a bloodstream from four up to seven times, depending on thickness of a superficial layer of a body and on a hypodermic fat layer. The value, inverse to C ($1/C$), is named a thermal resistance or thermal isolation.

2. An external stream of heat. To quantitatively estimate an external thermal stream and also influence being shown by external factors it is necessary to consider its components separately. They are the heat emission components: heat conducting H_{trans} , convection H_{conv} , radiation H_{rad} and evaporation H_{ev} . The overall stream of heat is determined as a sum of these components:

$$H_{emission} = H_{trans} + H_{conv} + H_{rad} + H_{ev}. \quad (3.3)$$

Heat transmission by conducting occurs, when the body adjoins (in position standing, sitting or laying) a dense substratum. The value of a stream of conducting heat is determined by temperature and heat conductivity of adjoining substratum.

From those parts of a body surface adjoining air heat transmission is accomplished by radiation, convection and evaporation.

Heat transmission by convection. If the skin is warmer than air, the layer of air, adjoining it, is heated up, rises and is replaced by colder and dense air. During this natural convection the heat is taken away by a laminar stream of air at the skin surface. The difference between body temperatures and the environment close to it serves as a driving force of this stream. The more movements arise in external air, the thinner the boundary layer becomes, the stream in which is laminar; the maximal thickness of such a layer achieves

four to eight mm. Close to the skin the stream of air becomes turbulent. Forced convection considerably strengthens heat emission intensity.

Determining factors of heat transmission by convection are the difference between average temperature of skin T_{skin} and temperature of air T_{air} , the effective surface area A (which is less than the geometrical surface area of a body as some surfaces adjoin each other) and the factor of convective heat transmission of h_{conv} whose value is proportional to a square root from speed of blowing air:

$$H_{\text{conv}} = h_{\text{conv}} \cdot (T_{\text{skin}} - T_{\text{air}}) \cdot A. \quad (3.4)$$

Heat transmission by radiation. Heat emission as long-wave infrared radiation emitted by the skin (the conducting environment does not take part in it) is precisely described by Stefan-Boltsman equation, i.e. radiation is a function of the fourth degree from absolute temperature. For a small range of body temperatures of the person heat transmission due to radiation H_{rad} can be described with sufficient accuracy by means of the linear equation

$$H_{\text{rad}} = h_{\text{rad}} \cdot (T_{\text{skin}} - T_{\text{rad}}) \cdot A, \quad (3.5)$$

where T_{skin} is an average temperature of the skin, T_{rad} is an average temperature of radiation (temperature of surrounding surfaces, for example, walls of a room), A is the effective surface area of a body and h_{rad} is a factor of heat transmission due to radiation. It is possible to illustrate a value of surrounding surfaces temperature with the help of the palm brought close to the person – right away there is a sensation of heat at the face area as a result of easing the heat emission caused by radiation.

The factor h_{rad} takes into account a radiating ability of the skin, which for long-wave infrared radiation is equal approximately to 1 irrespective of pigmentation, i.e. the skin radiates almost as much energy, as “a full radiator”, or absolutely black body. Emissive ability of surrounding walls should be taken into account only in the case they are located very close to a body. Radiating heat is absorbed by a body in the rooms containing heat radiators or covered by the sunlight when the average temperature of radiation T_{rad} exceeds T_{skin} . In case of short-wave infrared radiation (emitting from such radiators as electroradiators or the Sun) both emitting and absorbing abilities of the skin become much less than 1 (from 0.5 to 0.8) and appear dependent on skin pigmentation.

Heat transmission by evaporation. About 20% of heat emission of a body of a person in conditions of neutral temperature is accomplished due to evaporation of water from the skin surface or from a mucous membrane covering respiratory ways. Heat transmission from the skin by evaporation is described by the following equation:

$$H_{\text{ev}} = h_{\text{ev}} \cdot (P_{\text{skin}} - P_{\text{air}}) \cdot A, \quad (3.6)$$

where P_{skin} and P_{air} are pressures of water steam on the skin (average value) and in air accordingly, and h_{ev} is a factor of heat transmission by evaporation. The value h_{ev} varies depending on outlines of the skin surface, atmospheric pressure and speed of blowing air.

The most important conclusion from the above mentioned equation is that heat emission by evaporation occurs even when relative humidity of air achieves 100%. The unique necessary requirement is that P_{skin} must be higher than P_{air} . This condition is kept until the skin temperature is higher than the environment temperature and the skin is completely humidified due to sufficient secretion of sweat.

Loss of water due to its diffusion through the skin and a mucous membrane is named insensible or out-glandular loss as against glandular loss of water as a result of a sweat-gland function. Only the last mechanism is under control of the thermoregulation system and makes essential influence on the total amount of transferrable heat. When the environment temperature exceeds a body temperature, heat emission can be accomplished only with evaporation. With evaporation of 1 liter of water the organism of the person can give one third of all heat produced in conditions of rest for all the day.

Influence of clothes. Clothes are a form of thermal resistance or isolation whose value needs to be added to values of thermal resistance of tissues of an organism and a surrounding boundary layer. Efficiency of clothes is conditioned by the smallest volumes of air present in structure of material or in pile where there cannot be any appreciable streams of air. In this case, heat is transferred only by conducting, and air is a bad heat conductor.

3.10. Person and information. Ability to process external information and its role in maintenance of safety of vital activity

3.10.1. Psychophysiological Weber-Fechner law

Ability of a person to process information is a complete phenomenon caused by psychophysiological peculiarities of an organism of a person.

From all amount of factors of the environment influencing our organism, some (but not all) are caught by an organism, namely with its sensors. Such factors are named sensory stimuli.

The sensory stimulus frequently results in occurrence of subjective sensation. For example, electromagnetic oscillations with a wave length of 400 nanometers cause sensation of "blue color". When comparing different chemical and physical stimulus, it is not always simple to determine, which of them is adequate for the given sensor, if we formally take into account only energy of influence. For example, cold receptors in mucous of a mouth and a nose react not only to cooling, but are also rather sensitive to certain chemical stimulus, in particular, menthol. Smoking menthol cigarettes causes sensation of cold smoke.

There are 5 basic "senses" of a person – sight, hearing, taste, sense of smell and touch, and several new ones – feelings of temperature and balance. Sensations cannot be compared with senses by direct measurements. However, it is possible to compare them qualitatively, using a

concept of a sense threshold which became the central concept of psychophysics. Fechner introduced this concept in 1850.

There are distinguished absolute and differential thresholds. Absolute threshold is defined as the minimum of intensity stimulus capable of causing a certain sense. For example, threshold values for hearing depend on a sound frequency, and for sight they depend on adaptation time.

Differential threshold is a hardly assessable distinction between two stimuli which must be perceived by a person.

Weber shown in 1834 that for distinction of weight of two subjects their difference should be bigger if both of them are heavy and smaller if both are light. Minimally distinct change of stimulation intensity ($\Delta\phi$) makes a constant portion (c) of its initial intensity (ϕ). It is a Weber law:

$$\Delta\phi/\phi=c. \quad (3.7)$$

It means that $\Delta\phi/\phi$ is a constant for all intensity of stimulus. The given rule is true in a wide range for all senses, however when approaching an absolute threshold the Weber factor $\Delta\phi/\phi$ usually grows.

Weber factor is a convenient measure of relative sensitivity of sensory systems. It is impossible to compare sensitivity of an eye to a force of light with sensitivity of an ear to a level of sound pressure, but it is possible to compare dimensionless Weber factors for these modalities with each other.

Fechner suggested using differential thresholds for construction of a scale of sense intensity. As each step corresponds to the minimum possible amplification of sense, this gain is undertaken as a basic unit of sense intensity. The schedule of dependence of sense intensity on intensity of stimulus is shown in fig. 3.8.

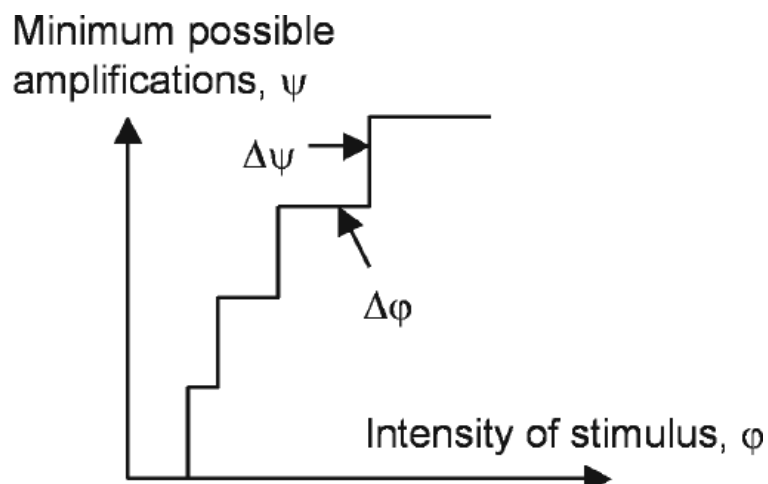


Fig.3.8. Dependence of sense intensity on intensity of stimulus

This ratio between ψ and ϕ is described with the equation known as psychophysical Fechner law. The law asserts that at linear increase of sense intensity ψ intensity of stimulus ϕ grows logarithmically. Fechner law is expressed by the equation:

$$\psi=k\cdot\log(\phi/\phi_0), \quad (3.8)$$

where ψ is a sense intensity, k is a constant, ϕ is an intensity of stimulus and ϕ_0 is its absolute threshold.

From modern positions a merit of Fechner is that he was the first to introduce a suitable scale for "sense intensity". Thus ψ in Fechner law means a more likely resolution than sense intensity.

Taking into account that both of these laws actually assert the same, the law is named Weber-Fechner law which asserts that if force of irritation increases in a geometrical progression then the sense increases only in arithmetic one, i.e. the sense changes proportionally to the natural logarithm of irritation.

3.10.2. Pain and its role in life-support

One more system concept is "a pain" that is a complex phenomenon including sensations caused by painful stimulus or tissue damage, and also reactions to these sensations. Thus, the system concept "pain" includes:

1. Pathogenic stimulus, which informs on forthcoming tissue damage.
2. Personal sensation of the harmful factor.
3. Complex of answers directed on protection of an organism from a harmful factor.

As a feeling the pain plays a role of a signal about possible tissue damage. As the emotional answer the pain starts formation of the general reaction of an organism to painful stimulation (attack, run away). The pain as a multicomponent reaction has the following components:

- 1) Sensory component, i.e. the pain is a sensation.
- 2) Affective component, when affects or emotions caused by a pain are almost exclusively unpleasant.
- 3) Vegetative component. For example, at bilious colic there is nausea, vomiting, sweat secretion and blood pressure fall.
- 4) Motive component is a reflex of avoiding or protection in many situations. It is shown as a muscular effort.

Experimentally and also with subjective supervision it is established that adaptation to a pain is not present. Besides, there is a downturn of a threshold of sensitivity so, despite a constancy of stimulus the pain becomes stronger.

Theory of pain. Modern hypotheses are based upon the assertion that the person has special receptors with a very high threshold which is raised only by the stimulus injuring or threatening to damage surrounding tissue, so called nociceptors. It is established that painful sensitivity is allocated on a skin irregularly. Painful stimuli are perceived only in discrete painful points. Their number is greater than amount of points of pressure. The ratio is about 9:1. The majority of nociceptors in the skin of the person which are known today, react to mechanical (prick, nip), thermal (heating, cooling) and chemical stimuli.

Excitation of nociceptors always begins with occurrence of "the first danger", i.e. the agent menacing to interrupt normal functioning of tissue. This agent results in liberation of one or several chemical substances (for example, serotonin and bradykinin at an inflammation of a joint), which then serve as direct stimuli raising nociceptors.

Internal systems of suppression of pain. The human body has the "built-in" opportunity of pain reduction. The basic mechanism is realized with substances – so called opiates – developed by an organism (endorphins, enkephalines and dinorphine). Opiates are substances which suppress painful sensation. Their action is highly specific, i.e. narrow-directional one, due to presence of opiate receptors. The substances being opiates are liberated at the certain kinds of stimulation of nervous system. Operating on opiate receptors, they cause analgesia, i.e. anesthesia.

Methods of pain relief. If it is impossible to remove the cause of a pain, it is needed to relieve. The major ways of pain relieve are the following ones.

Pharmacological pain relief. Nonnarcotic analgetics weaken a pain not cutting off and not limiting consciousness (as at narcosis). For example, derivative of a salicylic acid, acetylsalicylic acid. Narcotic analgetics are capable of removing the strongest pain, but with the strong collateral calming action causing a narcotic condition. It is morphine, a component of opium, which communicates directly with opiate receptors. Psychotropic means are tranquilizers and antidepressants. Tranquilizers remove a pain and eliminate or weaken feeling of alarm and nervous stress. Local anesthesia means either blockade of a nerve or tissue anesthesia.

Physical pain relief. It is in applying of hot and cold, massage and gymnastics, electric stimulation and neurosurgery. At electric stimulation the stream of nervous impulses from receptors of a pain does not change, but is braked either in a spinal cord or in a brainstem or thalamus. Acupuncture is also a method of analgesia using afferent braking. Neurosurgery methods belong to the most extreme methods of anesthesia. Spinal cord transection, interrupting transmission of impulses from nociceptors, belong to them.

3.11. Basic mental displays of a person during working activity

3.11.1. Unity of mental and physiological factors of vital activity

Because of complication of systems "person – machinery – environment" requirements for mental sphere of the person considerably grow. As expedient activity of the person work demands internal (mental) activity and is adjusted by the realized purpose, except for external (physical) activity. Thus, the mental sphere of the person is considered as display and form of existence of inner life of the complete person, which develop historically and is formed during person's social growth, in dialogue, in various macro- and microsocial relations and interactions. So, mentality is also a system phenomenon.

The mentality is a property of specifically organized matter – a brain. Activity of a brain, and in particular its big hemispheres, is a basis on which mentality is raised.

Research of mentality is based on studying of physiological processes, which occur in the big hemispheres of a brain. Nevertheless problems of psychology should not be reduced only to studying physiology of the higher nervous activity. The mentality is a product of a brain activity, however it is a special kind of its activity which consists in display of real world around. Thus, the contents of mentality are images of real subjects, phenomena, events determined by individual experience, interests, feelings, and worldview of the person. So, the mentality is subjective display of the objective world whose correctness is proved with practice. On the other hand, the mentality is such a display of objective reality, which depends on life experience of a person, knowledge, which they has got, functional condition for this or that moment. So, the same phenomena of the objective world are differently displayed in mentality of different people or in mentality of the same person, but during different periods of time, under different circumstances and conditions.

Thus, the understanding of mentality of a person is based on unity of physiological and mental ones. This unity is the most expressive being shown in working activity of people. Labor process is just the functioning of labor, which, in turn, is a set of physical and spiritual abilities of a living organism. Labor activity provides not only physiological and biochemical processes, but also a psychological side, which is characterized by purposefulness, activity, social conditionality.

The highest level of mentality development is consciousness, characteristic only for a person. It is a result of socio-historical conditions of formation of a person, and first of all, during work, at a constant dialogue with other people. The structure of consciousness includes cognitive processes with which the person enriches the knowledge. The consciousness provides purposefulness in activity, formation of needs and motives, decision-making. The world of feelings which display complex relations of a person with existing realities and other people, enters a person's consciousness. A distinctive feature of consciousness is self-consciousness of a person, which is a separation and opposition to all surrounding, a person's knowledge and a self-appraisal of the acts.

3.11.2. Displays of mental activity of a person

Displays of mental activity of a person are very various, however they can be considered only as a whole. Two groups of mental displays are separated:

1. Mental processes are dynamic mental phenomena which proceed as a reaction to external stimuli. They are sensation, perception, representation, memory, thinking, attention, emotions, etc.

2. Mental properties of a person are complex peculiarities which determine behavior of each separate person. They are a vital position of a person (needs, interests, belief, ideals), temperament, character, will, abilities, knowledge, skills.

Mental phenomena play an extremely important role in vital activity of people. The account of psychological factors is necessary for a substantiation of mental loadings on the worker in connection with complication of manufacturing, increase in amount of information streams, increase in responsibility. Therefore, each group is considered separately.

3.11.3. Major mental processes of a person as a system

Sensation and perception. During vital activity the organism of the person feels influence of internal incentive forces (needs, interests, motives) and external ones (environment), which make active its analyzer functions (visual, acoustical, thermal, vibrating sensitivity, etc.). As a result, there are various sensations. Through sensation a person receives ideas about separate properties of surrounding subjects – color, weight, smell, sound, etc. Display of all set of properties, subjects and phenomena in a person's brain are called perception.

Perception has an active selective character that is shown in an orientation for a subject of work and accomplishment of actions and movements in close interrelation with other mental phenomena (attention, thinking, memory, etc.).

Working action of a person with an obviously realized purpose which includes one or several movements directed to achievement of this purpose, forms a psychomotor process which includes mechanical, physiological and psychological sides. On workplaces they distinguish a) a sensory field as a set of elements of a workplace which influence analyzers of the person, bring the information necessary for work, and b) a motor field as a set of elements of a workplace where a motive action of the worker can be directed.

The purposeful perception during work is named supervision. From the point of view of manufacturing process organization, a problem of determination of loading on the visual analyzer is getting a great significance. Researches show that the amount of arriving signals changes from 60 up to 400, and sometimes up to 3000 per hour. During work workers perceive from 85 up to 90% of the information with the visual analyzer, nevertheless, it is necessary to note that the amount of mistakes increases not only in connection with increase in the information amount, but also at its limitation, which causes "sensory shortage" and results in development of a condition of monotony.

On the basis of sensation and perception a more complex form of sensitive display arises which is called named representation. Representation is a process of displaying subjects and phenomena in a person's brain, which influence sense organs at present. In other words, external irritations result in

occurrence of appropriate images in consciousness. They make the basic fund of sensitive knowledge of a person, base for formation of particular concepts.

Thinking and memory as the highest forms of mental activity of a person. All conscious human life is accompanied with display and perception of the objective world. The highest form of display and perception is the thinking. The thinking is a process of perception directed to disclosing general and essential peculiarities, attributes, subjects of phenomena and communications between them. The result of thinking is an idea, and its language formulation fixes this result. A conditioned reflex lays in a basis of idea formation. The thinking is accomplished with the help of such operations as analysis, synthesis, comparison, abstraction, dialogue, concrete definition, systematization.

The main psychological law of thinking is analysis and synthesis. Due to it, an object includes all new communications and features fixed in corresponding ideas (concepts, images, etc.) during creative thinking. The process of the analysis through synthesis inevitably receives a language expression as a new formulation of a problem.

The most important feature of thinking to support safety of vital activity of a person is that thinking allows analyzing the past and the present and making forecast for the future.

Attention. Attention is a concentration of mental activity on one or several objects. A feature of this mental process is that certain perceptions, images, ideas and feelings a person understands especially brightly, precisely while others fade into the background, or absolute meaningfully are not perceived. A physiological basis of attention is reflex activity.

Three kinds of attention are distinguished:

1. Unintentional or passive attention when the consciousness concentrates on this or that object due to its features, novelty, being unusual.
2. Voluntary or active, will attention when the concentration of mental activity on this or that object is adjusted meaningfully.
3. Involuntary, or secondary involuntary attention is attention which is involuntarily inverted to result of activity, in particular, labor.

There is a classification of work depending on amount of objects and duration of supervision. So, if amount of objects is less than 5, and time of the concentrated supervision is up to 25% then such work is considered easy, unstressed one; at 5 to 10 objects and 50% of time of supervision it is less stressed work; at 11 to 25 objects and 75% of time of supervision it is stressed one. If amount of objects of supervision exceeds 25 and time of the concentrated supervision is over 75% of working time such work is considered heavily stressed one.

Risk and caution. In psychological understanding risk is an action "at random" made for the following reasons: bravado, imprudence, boldness, despair, fear, etc. A person often estimates a degree of risk of any action involuntarily. It represents the relation of the person's idea about danger to

their idea about factors protecting them from this danger. It is obvious that such estimation of a degree of risk is especially subjective, and appreciably, inadequate. The subject's psychological estimation of risk essentially depends on experience: the more skill is got by the person, the more adequate estimation is given to a situation.

Caution is an opposite feature. Caution is an acquired mental feature being a result of a conscious and disciplined attitude of the person to life and work. There is an excessive caution which as well as the unjustified risk results in vulnerability of a person at the age of rash technical progress.

It is possible to distinguish the following reasons for carelessness of a person: non-observance of safety rules; indiscipline; ignorance of essence of manufacturing processes; consequence of anatomic-physiological and psychological lacks; result of adaptation to danger.

Sensomotoric reactions.

Sensomotoric reaction is an inverse reaction of people to influence of the external factors touching sensors of their organisms. Sensomotoric reaction has 2 stages:

- A latent stage includes the time from the moment of occurrence of a signal to the beginning of movement;
- A motoric stage is the time of accomplishment of movement.

Sensomotoric reaction is characterized with correctness, timeliness, and accuracy. Reaction of a person can be timely, but not correct and vice versa. Time of sensomotoric reaction determines reliability of a person. With the years the time of reaction is reduced, however it is compensated by experience.

3.11.4. Mental features of the person

Abilities.

Abilities are essential psychophysiological features of a person which are shown in purposeful activity and causing success of acquisition of knowledge, skills, habits and improvement of them. Abilities are found out in activity by comparison of the achieved successes and the spent efforts. Therefore abilities can be defined as synthesis of features of the person, which meet the requirements for activity and provides high achievements in it. Abilities are divided into general abilities (inherent in many people) and special ones which allow achieving results in any area (science, sports, art, etc.). The first kind of systems is represented by the system of volitional features of a person, providing relative ease and productivity in knowledge acquisition and realization of different kinds of activity.

Development of abilities of a person consist of some stages which are possible, but not obligatory:

1. Inclinations are natural opportunities of development of the person. If there are many inclinations they are named endowments.
2. Abilities are rather realized inclinations.

3. Talent is a complex of especial abilities of the person in any area.
4. Genius is the best level of development of abilities.

Will. Will of the person is an important factor of psychological regulation during work. It provides him with conscious regulation of actions demanding of overcoming of internal and external obstacles. Volitional regulation during work is an unconscious direction of intellectual and physical efforts to achievement of the set task. Due to mobilization of volitional efforts the overall efficiency of work grows more than twice.

The volitional effort demands the certain stress and is characterized with amount of energy spent for accomplishment of action or abstention from it. Intensity of volitional effort depends on worldview and responsibility of the person, and volitional actions in many aspects depend on needs and motives inducing the person to activity. During work special significance is got with volitional features of the person, such as purposefulness, initiative, independence, resoluteness, persistence, self-control, organization, boldness, efficiency, discipline.

Emotions and feelings. Emotions and feelings are one of displays of mental activity of a person. They characterize the original attitude of the person to the surrounding reality and to himself/herself that is shown as experiences. Emotions are characterized by:

- affective reactions (voice sounds, mimicry, gestures, original breath, activity of heart and vessels, etc.);
- subjective feeling of an emotional condition.

Emotions can be divided into two kinds. The first kind of emotions arises during creative activity of the brain; the second kind arises as an alarm (precautionary, preparatory) reaction.

Subjectivity is an essential feature of emotion. In the structure of emotional processes they distinguish affects, self-emotions, feeling, mood, stress. Affect is the most powerful emotional short reaction. Self-emotions are a more long condition. Feeling is a proof of mental condition which has a well defined subject character. They develop and are formed on the basis of emotions. Mood is a longer emotional condition which appreciably determines all behavior of the person. Stress is a condition caused by unexpected and stress conditions.

By orientation the emotional condition can be positive or negative. Positive emotions and feelings create favorable conditions for activity and make it active. They are factors of the worker's health. Negative emotions and stresses, on the contrary, disorganize, badly influence results of activity, cause different diseases (neuroses, heart attacks, hypertension, stomach ulcers, etc.).

Bashfulness. Bashfulness is some kind of a phobia, fear of people from which there is an emotional menace. Lack of such a property of the person is not the condition of bashfulness itself, but its accompanying conditions (mistrust to people, excessive caution in acts, uncommunicativeness,

loneliness, quite often bad reputation). All this can result in a paralysis of the consciousness, most frequently expressing itself in depressions.

Temperament. Temperament is a characteristic of the individual on the part of dynamic features of its mental activity, i.e. rate, speed, rhythm, intensity of mental processes making these activity and conditions.

I.P.Pavlov's doctrine about typological features of nervous system of animals and the person is a basis for development of the scientific theory of temperament. Pavlov proved a thesis of a leading role and dynamic features of the central nervous system – unique of all systems of the organism, possessing an ability of universal regulating and control influences. Pavlov separated three basic features of the nervous system: power, balance and mobility of exciting and brake processes. From the set of possible conditions of these features Pavlov separated four basic, typical combinations as four types of the higher nervous activity. Their displays in behavior Pavlov put in relation with antique Hippocrates' classification of temperament (table 3.2).

Table 3.2

Types of the higher nervous activity

Temperament	Power of nervous system	Balance of nervous system	Mobility of nervous system
Sanguine person	Strong	Balanced	Mobile
Phlegmatic person	Strong	Balanced	Inert
Choleric person	Strong	Unbalanced	Mobile
Melancholic person	Weak	Unbalanced	Inert

3.11.5. Behavior of a person in extreme situations

Behavior of a person in a stress situation is one of the most serious problems interesting a science about the person. The person facing danger has only several ways out from such a situation: quickly prepare themselves; to parry the created threat; to run from danger; to sit and wait what will be. Readiness of the person for an emergency depends on presence of the information on incident, on experience and on presence of hope for rescue.

According to the theory, behavior of the person is influenced by the increase of stressors – such factors of an environment, which result in stress. Stress sometimes results in better accomplishment of necessary actions, especially when tasks necessary for solving are simple, and their accomplishment is well worked through. But in many cases the stress has an opposite effect on abilities of the person to remember or accomplish some actions. One of consequences of stress are a reduction of ability of the person to remember the information, for example, instructions especial being badly made, reduction of ability to accomplish necessary actions, expectation of death as inevitability.

Two most typical reactions to stress are separated: panic and apathy.

Characteristic features of panic:

- 1) Panic runaway is always directed aside from danger.
- 2) At panic the direction of runaway is not casual.
- 3) By its character panic runaway is asocial.
- 4) The person in panic always believes that conditions are extremely dangerous.
- 5) The person in panic is capable of thinking rationally.
- 6) The person in panic thinks poorly but his ideas are not unreasonable.

Fulfillment of some conditions allows reducing chances of occurrence of panic:

- 1) Knowledge. Before running into a panic the person should come to a belief that condition is extremely dangerous. The warning should be both convincing and plausible. The effective warning should contain the information that ways of avoidance of danger exist and that people have sufficient time to accomplish necessary actions.

- 2) Responsibility. In an emergency the people who are responsible for well-being of others or carrying out some important work are probably less inclined to improper actions in given conditions, including panic runaway.

- 3) Availability of ways of evacuation. Panic can take place when the person thinks that there is a way of evacuation, but is afraid that it is not accessible for them or there is a probability of not getting there.

Other reaction is a condition of apathy which is less dramatic, but, probably, happens more frequently and is more dangerous than panic runaway. Many people call this phenomenon as "catalepsy" and "a panic on the contrary". Apathy is shown more often than panic runaway. Causes of such condition are not quite clear, however, interviews of people who survived in various accidents, showed that more often such condition was observed in people with a weak will power, perceiving events in life as fate. And, on the contrary, people with a character of a command type, being used to making decisions and bearing responsibility, experience such a condition as apathy less frequently.

In general, stress is considered as a kind of reaction of mentality and an organism to any increased loading on a person. This internal condition is caused by any external circumstance, which the person perceives as menace. However, it is not so necessary for stress causing an external event to have a negative character. The big winnings in a lottery or promotion at work can be presented as quite positive events, but, nevertheless, any of the mentioned above circumstances can cause stress if a person interprets them as events to deal with.

Stressor is any external factor causing stress. Stressor can have both purely physical character (poison, strong noise, sharp cold snap, aviation accident) and purely psychological. Thus, stressors are such external factors which a person interprets as menace or as a significant obstacle in a way of

achieving a goal. In that case, a person can feel one or several stressful conditions. These conditions can be shown at a physiological, psychological level, and also can affect behavior of a person.

One of the most widespread conditions of a person at the moment of fatal menace is a condition called loss of individuality. Loss of individuality occurs when the whole stream of strong feelings and sensations simultaneously falls upon the person. These feelings and sensations strongly differ from each other and sometimes can be mutually contradictory.

It is considered that loss of individuality can be a process of adaptation with which understanding of danger of a situation strengthens a feeling of alarm and ability to think, but at the same time there is a dual personality. The second of these becomes an exterior observer, thus suppressing strong emotions which could paralyze an ability of the person to think and operate.

Negative reactions to stress are manifold: depression, sharp anxiety, irritability, sleeplessness, nightmares connected with the period of accident, loss of sexual excitability, tearfulness, sensations of guilt and own uselessness.

The most widespread reactions are breaking of heart work, blood system, gastroenteric and respiratory systems. The most prevailing stressful reaction is often nausea.

So, reactions to the stress caused by accident at various people can vary in wide limits.

4. NATURAL DANGERS AND THEIR INFLUENCE ON A PERSON

As an element of system "person – machinery – environment" a person can operate machinery, but is not capable of operating the nature, its powers. They often represent unexpected and hardly predictable menace for life and health of a person. Practically always the elements become independent of a person, develop into an accident – an unexpected and unpredictable situation which the suffering population cannot deal with on its own.

By localization natural dangers or disasters are subdivided into meteorological (storms, hurricanes), topological (flooding, landslips, snow collapses), telluric (earthquakes, volcanic activity) and tectonic (movement of the ground layers).

By character of distribution, natural disasters are instantly extending (earthquakes) and gradually extending (hurricane, storm, fire) ones.

As a rule, struggle against natural disasters consists of three stages:

1. Accomplishment of preventive actions whose purpose is non-admission of natural disaster and reduction of its consequences.
2. Actions on localization of a disaster, whose purpose is to reduce space and time of disaster spread to a minimum.
3. Liquidation of consequences.

At non-observance of rules of behavior in extreme situations and disorganization such natural disasters have the most serious consequences.

So, according to the International Red Cross, for 100 years more than 11 million people were lost as a result of natural disasters, where 9 million were lost as a result of flood, 1 million was lost owing to hurricanes and 1 million was lost as a result of earthquakes. Let us consider some of the most frequent natural phenomena.

4.1. Influence of the Sun energy on a person

The most complex and obscure external influence on a person is influence of the Sun. Influence of solar ultra-violet radiation is most investigated.

Ultra-violet radiation influence on an organism of a person is dual. Positive influence is a rise of life, development of substances useful for an organism (for example vitamin D), acceleration of metabolism, namely, recycling of protein disintegration products.

Negative influences are external and internal.

External negative influences are:

- Erythema of skin;
- Rise of skin temperature.

Internal negative influences are:

- Formation of inflammatory process in the skin which is shown in swelling of epithelium and puffiness;
- Change of colloid condition of cellular proteins;
- Denaturation (destruction) of protein;
- Quantitative changes in secretion of a stomach and salivary glands;
- Separation of histaminoid substances in blood, which causes and deactivates smooth muscles of vessels, intestines, etc.

Long influence of ultra-violet radiation causes darkening of the skin due to deposit of melanin in it. Melanin is developed in cells from the substances coming with blood. Melanin protects the person from overheating: it absorbs an infra-red part of solar radiation, causes, as a consequence, the skin temperature rise that results in increased sweat secretion. Evaporation of sweat cools an organism of a person. Tissues with melanin absorb solar radiation in dozens of times more than tissues without melanin (table 4.1). Hence, pigmentation of the skin increases amount of absorbed radiation.

The skin absorbs different rays in a various degree (table 4.2).

Dark skin absorbs more and diffuses one and half times less than light one. The ultra-violet range is divided into three areas; each of them has the allowable density of energy being of the normalized value (table 4.3).

As it seen, more "rigid" ultra-violet radiation (areas B and C) shows the strongest biological action mentioned above.

Table 4.1

Absorption of radiation of various wave lengths by the skin

Energy absorbed by skin, %	Infra-red rays	Red rays	Yellow rays	Green rays	Blue rays	Violet rays	Ultra-violet rays
Unpigmented skin	38	62	76	79	82	85	87
Pigmented skin	58	80	88	91	92	94	92
Increase of absorption	20	18	12	12	10	9	5

Table 4.2

Portion of absorption of radiation of various wave lengths

Rays	Portion of absorption, %	Rays	Portion of absorption, %
Yellow	30	Dark blue	24
Green	30	Violet	21
Blue	28		

Table 4.3

Allowable densities of energy for radiation of ultra-violet range

	Ultra-violet range, nm	Allowable density of energy, Watts per square meter
A	390...315	10
B	315...280	0,05
C	280...1	0,001

4.2. Magnetic storms

Magnetic storms are amplification of solar activity, which is accompanied with significant amplification of circulation of air masses, and collision of hot and cold air currents. The difference of temperatures results in difference of pressure, and cyclones and anticyclones, which, in turn, generate storms, hurricanes, and downpours.

Amplification of solar activity is of an 11-years cycle. Consequences of such cyclicity are:

- Periodicity of death rate, for example, with increase in activity of the Sun the number of cardiovascular diseases increases;
- Periodicity of rise in temperature on the Earth, droughts and rains;
- Periodicity of electromagnetic disturbance of the Earth;
- Periodicity of circulation of air masses and other phenomena.

Magnetic storms represent the processes caused by explosions on the Sun as a result of which the Earth is attacked by "a corpuscular downpour".

Such an attack is so strong that the atmosphere cannot diffuse all radiation; therefore its significant part reaches the Earth.

4.3. Strong winds

A strong wind (or storm) is the wind blowing with a speed of more than 15 km/s or 8 points on the international wind scale. If wind speed exceeds 30 km/s, such a wind is named a hurricane.

The cause of storms is a difference of temperatures in different layers of air causing its movement, i.e. a wind. Storms are formed due to occurrence of pressure differences and friction on a rough surface of the Earth. For this reason the storm on the ground is much weaker by its power than the storm in a sea and an ocean.

The ring of the winds blowing counter-clockwise forms a cyclone. Cyclones are formed where there are cold and warm currents of air, for example, in Ireland, the Mediterranean Sea.

They also distinguish squalls – suddenly beginning and finishing winds with a different change of the direction, and tornados – whirlwinds with a vertical axis, whose speed can be higher than 100 km/s.

5. MAN-CAUSED DANGERS AND THEIR INFLUENCE ON A PERSON

There are general laws of occurrence of the man-caused dangers, related to the service life of any machine. This period is a life cycle. At every stage of it there is a set of factors influencing a person (fig. 5.1).

Basically all dangers proceed from the basic design and manufacturing faults of machinery. They are as follows:

- non-observance of requirements for the design in terms of safety and hygiene of labor, for workplaces of operators, for noise and vibration level at a workplace, for external lighting devices;
- inadequacy of color covering machines and their components to functional purpose;
- absence of protection of the person from moving parts of the equipment;
- absence of preventive inscriptions; low-quality design of package; low-quality warehousing.

According to the official standard all dangers are divided into:

- Physical – moving machines and mechanisms, increased dust content in the air of a working zone, abnormal temperature, increased level of noise, vibration, sound oscillations, etc.;

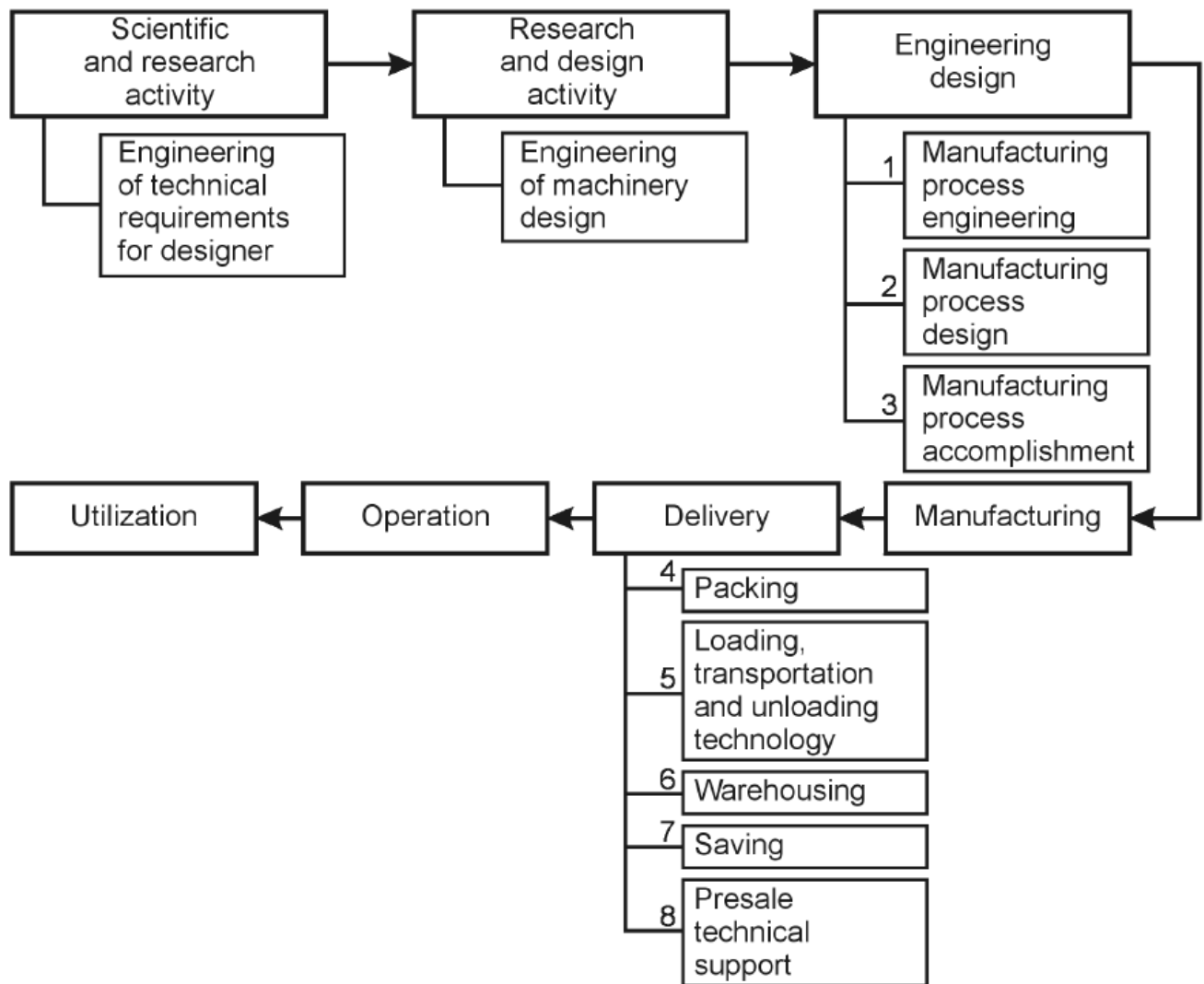


Fig. 5.1. Life cycle of a machine

- Chemical – products of burning and metabolism, household gases, emissions from synthetic materials, harmful substances used or produced during manufacturing, etc.;
- Biological – pathogenic microorganisms, products of their vital activity and macroorganisms (plants, animal);
- Psychophysiological – physical overloads, static loadings, dynamic loadings, hypodynamia, nervous-emotional loadings, intellectual overstrain, overfatigue, overstrain of analyzers (skin, visual, acoustical, etc.), monotony of work, emotional overstrain.

5.1. Physical factors of danger

Factors whose interaction with a person and environment is based on transformation of enclosed (transferable) energy are physical factors of danger. They are subdivided to mechanical, thermal, electric and electromagnetic factors.

Mechanical factors are characterized by potential or kinetic energy and mechanical influence on a person and environment; thermal factors are characterized by thermal energy; electric factors - by electric energy; electromagnetic factors - by energy of electromagnetic oscillations.

5.1.1.Dangers connected with use of the processes being accomplished at increased temperature and pressure

Huge influence on a condition of a person is provided with a microclimate. Temperature, humidity, pressure and speed of movement of air masses belong to parameters of a microclimate.

Depending on clothes, level of physical activity and individual predisposition subjective reactions of the person to these factors can vary from sensation of comfort up to condition of discomfort. Psychologically determined zone of comfort is an area of physiologically determined neutral temperature. There are precise distinctions between conditions of comfort, depending on a person being in the open air or being dipped into water, and also on clothes (table 5.1).

Table 5.1

Neutral temperatures felt as comfortable for an adult person at various conditions

Environment	Other conditions	Clothes	Limits of temperature, °C
Air	Calm, 40-50 % of humidity, physical rest, neutral radiation conditions	Normal for street	20...22
		Without clothes, a bathing suit	28...30
Water	Rest in a bath	Without clothes, a bathing suit	35.5...36
	Swimming with speed of movement in water of 0.4m/s	Without clothes, a bathing suit	28

Influence of temperature is considered in the first part of the abstract. Here we shall remind that the thermal balance of an organism of a person is a function of the following factors:

$$Q = f(t_{\text{env}}; \omega; \varphi; P; T_{\text{sur.subj.}}; I),$$

where t_{env} is an environment temperature; ω is a mobility of air; φ is a humidity; P is a pressure; $T_{\text{sur.subj.}}$ is a temperature of surrounding subjects; I is a physical loading. At normal conditions parameters of a microclimate are within the following limits: $t_{\text{env}}=20...24^{\circ}\text{C}$, $\omega=0,1...0,3$ m/s, $\varphi=30...70\%$, $P=750...760$ millimeters of mercury.

Let us analyze possible changes in an organism of a person at interaction with an environment.

Increase in the environment temperature creates superfluous evaporation that results in loss of salts and dehydration.

At decrease in the environment temperature surplus of energy is spent for heating that results in reduction of work capacity.

Increase in humidity of air results in reduction of evaporation that causes fast overheating an organism.

At reduction of humidity of air there is moisture evaporation from mucous membranes, and, hence, formation of cracks in them that raises risk of microbic infection. Reduction of moisture in an organism of a person by 2...3% results in dehydration, by 6% in disorder of mental performance and reduction of visual acuity, by 15...20% in a fatal outcome.

5.1.2. Temperature and its influence on the person

General hypothermia. At temperature lower than $+4^{\circ}\text{C}$ peripheral blood vessels are sharply narrowed; thereof such parts of a body as a nose, ears and fingers and toes are not supplied adequately with nutrients. Tissue dying off (necrosis) in these conditions does not cause painful sensations as at such low temperatures conducting of nervous impulses is broken (cold anesthesia). As a result of hypothermia the normal blood supply is kept only in the central organs, such as heart and central nervous system, and blood supply of extremities and peripheral organs is reduced more and more considerably. Finally, the brain and heart are also cooled; at temperature drop lower than 30°C in internal parts of a body a person loses consciousness, and at temperature of lower than 28°C there is a ventricular fibrillation.

Nothing should be done to a person in a hypothermia condition, which can cause expansion of vessels or effect of a muscular pump and, thereof, too fast restoration of a peripheral blood supply. In this case, blood in body peripheries is not only too cold, but also is strongly changed as a result of a bloodstream delay (for example, if lactate concentration rises in it), therefore its fast returning in the central bloodstream will cause disorder of activity of heart and brain. Massage and active movements are contraindicated; a person in a hypothermia condition should not run to be warmed, even walking in such cases can lead to death. The simplest and safest form of medical aid is wrapping up a body with foil reflecting heat and with blankets to provide slow soft warming with heat self-generating by an organism.

Hyperthermia. Strong heat can become a cause of a circulatory collapse and thermal or sunstroke. Expansion of skin vessels may lead to a thermal faint (especially in a condition of rest) if rectal temperature rises only up to $38.0...38.3^{\circ}\text{C}$. Physical activity counteracts the tendency to a faint despite amplified heat generating, due to narrowing of skin vessels and blood pressure increase. Thus, at operating time in hot weather there is big danger of thermal disturbance of the central nervous regulation at the brain

temperature of above 40°C. In case of a thermal faint it is necessary to lift the person's feet, to lower a body temperature with external cooling and to prevent further heating. However, sharp cooling of skin is ineffective as the bloodstream in the skin becomes so weak that cooling does not affect properly internal parts of an organism.

5.1.3. Atmospheric pressure

Negative influence on a person is caused both by raised and lowered atmospheric pressure.

A person faces the lowered atmospheric pressure at ascending to height. At the big heights loading for people is created with three major factors: lowered partial pressure of oxygen, increased solar radiation, and cold. The most important of them is gradual fall in partial pressure of oxygen with height.

In the process of height ascending the atmospheric pressure is reduced, whereas concentration of oxygen remains constant up to big heights. Partial pressure of oxygen falls proportionally to atmospheric pressure decrease; so, for example, at the altitude of 5500 m above sea level it is reduced up to half. Reaction of an organism to oxygen insufficiency (hypoxia) depends not only on its intensity, but also on duration of loading. Depending on duration of influence there are acute hypoxia (for example, at sharp loss of pressure inside the plane or at malfunctions in the respiratory equipment), quickly progressive hypoxia (for example, at rise in a funicular) and chronic hypoxia (for example, at long stay at the big heights). Height tolerance also depends on a character of rise; the big heights are easier taken, if a person reaches them actively (on foot), instead of a passive way (by car or plane).

Characteristic attributes of hypoxia at the big height are reduction in the volitional beginning, sleepiness, loss of appetite, breathlessness, tachycardia, vertigo, vomiting, headache, and apathy (though there can be marked euphoria condition). Depending on predisposition of the person and on particular conditions these symptoms can be shown one at time or in various combinations. Their significance as signals of danger frequently is not realized or it is underestimated. In particular, slowly developing hypoxia is especially dangerous to the person in a condition of rest as it can lead to loss of consciousness before occurrence of any symptoms serving as a signal of danger.

All effects of hypoxia can be subdivided into four zones of height differentiated by thresholds of effects.

A neutral zone. Up to height of 2000 m physiological functions, such, for example, as the maximal speed of dynamic work, suffer a little or at all are not influenced.

A zone of full compensation. At heights between 2000 and 4000 m a reaction to the lowered oxygen supply is observed even in rest: frequency of heartbeat, heart ejection and respiratory minute volume grow a little. The

increase in these parameters in an operating time at such heights occurs to a greater degree than at a sea level so both physical and intellectual work capacities are considerably reduced.

A zone of incomplete compensation (zone of danger). At heights from 4000 up to 7000 m various frustrations develop in a not acclimatized person. After achievement of a threshold of disturbances (a limit of safety) at height of 4000 m physical work capacity strongly falls, as well as an ability of reacting and decision-making weakens. There are muscular twitching, arterial pressure decrease, and gradual loss of consciousness. These changes are reversible.

A critical zone. Starting with 7000 m and higher the partial pressure of oxygen in alveolar air falls below a critical threshold of 30 to 35 millimeter mercury (4,0...4,7 kilopascal). There come potentially lethal disorders of the central nervous system accompanying by unconsciousness and spasms; these disturbances are reversible under condition of fast $P(O_2)$ increase in inhaled air. In a critical zone, duration of oxygen insufficiency has a conclusive importance. If hypoxia proceeds for a too long time, there are disturbances in regulating parts of the central nervous system, and there comes death.

Aerospace flights. At flights at the big altitude a person faces the problems of acute hypoxia described above. In addition to changes in a cabin, where pressure is supported approximately equal to one at height of 2300 m, there are its short-term changes during take-off and landing; these pressure differences influence basically the skull sinuses filled with air. With altitude increase it is also necessary to take actions against influence of increased radiation and lowered environment temperature.

At space flight it is necessary to use cabins or suits being under pressure; without them blood at 37°C will begin to boil at the heights equal or exceeding 19 kms (this phenomenon is called a boiling up). The cabin under pressure also provides adequate partial pressure of oxygen in inhaled air and protects from cold, and also, though not completely, from irradiation in outer space. As a whole, both person's ability to adaptation and machinery can provide a life in space within weeks and months at the expense of new difficulties of readaptation after returning to the Earth.

A person faces increased atmospheric pressure at underwater diving. As pressure of alveolar air corresponds to atmospheric one at the water surface, additional water pressure upon other parts of a body causes a pressure gradient. Therefore at great depths the chest will be more and more filled with blood at more and more deep breaths and as a result, there can arise potentially fatal overdistension of pulmonary vessels and heart.

Barotraumas (injury caused with pressure). At diving the increasing pressure of environment can lead to disturbances which will finally cause tissue damage. For example, at the beginning of diving the chest capacity and, hence, lung volume easily decrease without difficulty, achieving a minimum at the depth of 30 to 40 m. As it is impossible to squeeze lung for

more, at more considerable depths pressure inside the chest remains constant, despite continuously increasing pressure outside the chest (environment pressure) during the depth increase process. The arising difference of pressure causes significant blood inflow to organs of the chest cavity; the air volume inside the chest is further reduced according to overdistension of pulmonary vessels and heart, which results finally in their damage.

Pressure in the skull sinuses filled with air should to be leveled with pressure inside the chest through the nose and throat either spontaneously, or in a special way. If channels connecting the middle ear and paranasal sinuses with throat are impassable (for example, in case of puffiness of mucous membrane at cold), then it is difficult or even impossible to equalize these pressures. In such cases the pressure balance is achieved only at bulging to outside of eardrum (down to its rupture) and/or the further blood filling of mucous membranes with their painful edema and rupture.

Decompression. To avoid barotraumas, it is necessary to keep pressure balance in the body cavities filled with compressed air in the process of surrounding pressure reduction during a rise to the surface. For example, if the diver using equipment with compressed air rises to the surface from the depth of 50 m with the shut mouth, the lung is stretched, and then broken off, and air gets into vascular system (air embolism). Besides, inert gases (for example nitrogen) accumulated in tissues should leave them slowly, and then exhaust; if decompression occurs too quickly, they form bubbles in blood and tissues just as bubbles are formed when a bottle with soda water is opened. Rise and coming out onto the surface should be made systematically and slowly, step by step. The immediate coming out onto the surface can be accomplished, only if diving was made in time within the limits of which the critical tissue concentration of gases necessary for bubbles formation has not been achieved yet (zero time); this is the situation for almost all kinds of diving with a breath delay and at all diving to the depth not exceeding 10 m. A decompressive injury can also take place when long diving is followed by a fast rise above the ground (for example in the plane).

5.1.4. Electric current and safety of vital activity of a person

Usage of electric power in all spheres of human life causes the fact that danger of lesion by electric current is the most widespread realized danger.

The body of the person as any biological tissue is a non-uniform conductor of an electric current. The electric current is conducted due to presence of the charged ions in protoplasm.

As it seen, resistance of a body is non-uniform and is determined by the following components (table 5.5):

- A person's skin resistance including: a) resistance of an external layer – epidermis (10...100 mOhm·sm); b) resistance of an internal layer – derma, which is insignificant;

– Internal tissues resistance which is insignificant and comparable to resistance of derma.

Table 5.5

Resistance of a person's body tissues

Tissue	Resistance	Tissue	Resistance
Skin	300...2000 kOhm·sm	Muscular	150...300 Ohm·sm
Bone	100...2000 kOhm·sm	Fatty	3...6 kOhm·sm
Blood	100...200 Ohm·sm	Spinal liquid	50...60 Ohm·sm

In table 5.6 values of a person's body resistance are given at the voltage of up to 20 volts.

Table 5.6

Resistance of a person's body at the voltage of up to 15...20 volts

Value of resistance, Ohm	Coverlet
3000...100000	Dry, clean and intact skin
1000...5000	Scraped horny layer
500...700	Removed top layer (epidermis)
300...500	Completely removed skin

Besides, living tissues do not only possess ohmic resistance, but also include a capacitive component.

Influence of electric current on the organism of a person. Influence of electric current is triple: a) biological influence causes reduction of muscles; b) thermal influence results in heating of tissues; c) electrolytic influence changes a chemical composition of liquids in the body of a person.

A person's body resistance is inconstant and changes depending on a lot of factors, both external and internal. So, a person's body resistance decreases: at current frequency increase due to reduction of a capacitive reactance of the skin; increase of time of current passage through a person's body resistance due to amplification of the skin heating; increase of voltage applied to the body due to breakage of a horny layer of the skin; increase of temperature and humidity of air; use of alcohol due to changes of tissue cells functions; presence of hunger; presence of a person in a stress condition.

Calculated resistance of a body of a person is equal to 1 kOhm. At frequency of 10...20 kHz it is possible to neglect active resistance of the external layer, and the total resistance will be equal to 300...500 Ohm.

Lesion of the person with an electric current is influenced by the following parameters: condition of the skin (the more humidity in the skin, the more probability of lesion by the current; besides, presence of various wounds makes skin electro vulnerable due to own conductivity of blood, and lymph); current magnitude; current frequency (the direct current is 4-5 times safer

than an alternating current frequency of 50 Hz; passing through the body of a person, it causes weak tractions and less unpleasant sensations, but such law is applicable only for a voltage of 500 volts; for the voltage of more than 500 volts the direct current is more dangerous than the current with frequency of 50 Hz; at an electric current frequency increase, the body resistance decreases and, accordingly, current magnitude rises, however danger of lesion decreases and completely disappears at frequency of 400...500 kHz); duration of influence; way of a current through the body of a person (the most dangerous passage of a current is along the direction "hand – hand" and "left hand – foot") (table 5.7).

Table 5.7

Characteristic current magnitudes		
I_{AC} , mA	I_{DC} , mA	Kinds of a current
0.5...1.5	5...7	Threshold perceptible current
10...15	50...80	Threshold not-releasing current
100...500	300...500	Threshold fibrillate current
Above 500		Current resulting in a cardiac arrest

Fibrillation is a chaotic heartbeat. Fibrillation leads to insufficient blood supply of a cardiac muscle and, as a result, in a cardiac arrest.

Kinds of lesion by an electric current. The following lesions of a person by an electric current are possible:

1. Electric injuries are well-determined places of the organism tissues integrity disturbance caused by influence of the current:

- electric burn (60...65% of lesions): current one is a skin burn at the passage of the current; arc one is a burn due to influence of an electric arc, arising at short circuit;
- electric signs are clearly outlined stains of gray or pale yellow color on the skin surface, which occur after influence of the current;
- metallization of the skin – penetration of the smallest particles of metal into the skin under influence of an electric arc (up to 10% of victims);
- mechanical injuries which arise due to involuntary tractions of the person under action of the current.

2. Electric strike is excitation of living tissues with electric current accompanied by convulsive tractions:

- the 1-st degree electric strike occurs without loss of consciousness;
- the 2-nd degree electric strike is accompanied by loss of consciousness;
- the 3-rd degree electric strike is accompanied by the loss of consciousness, heart activity disorder, and termination of spontaneous breath;
- the 4-th degree electric strike is followed by an immediate death.

Protection of a person from lesion by electric current. The following measures are taken to protect a person from lesion by electric current:

Normalization of levels of voltage and current strength. It concerns both industrial and household electric equipment. The following maximum voltages applied to a person are established at frequency of 50 Hz and allowable time of the current passage (see table 5.8).

Table 5.8

Maximum allowable voltage applied to a person								
Voltage, volts	500	400	200	130	100	65	18	6
Time, seconds	< 0.1	0.2	0.5	0.7	1	< 5.0	3...30	> 30

The maximum allowable touch voltage $[U_T]$ and current strength $[I_h]$ are shown in table 5.9.

Table 5.9

Maximum allowable voltage applied to a person		
Kind and frequency of current	Allowable values	
	U, volts	I, mA
Alternating current of 50 Hz	2	0.3
Alternating current of 400 Hz	3	0.4
Direct current	8	1.0

1. Inaccessibility of current-carrying parts. It consists of insulation, accommodation of current-carrying parts at inaccessible height, enclosure, etc.

2. Electric wiring insulation. It is a division of wiring into separate non-interconnected places. It is made with the usage of special insulating transformers. Separate sites possess more insulation resistance and less capacity of wires relative to the ground.

3. Small voltages.

4. Potential balancing. It means that all metal parts of assembly should be connected with conductive elements (for an aircraft frame they use surface metallization).

5. Protective grounding. It is an intentional electric connection between the ground or its equivalent and not current-conducting metal parts, which can appear under voltage. A principle of action of protective grounding is in a decrease of touch and step voltage, caused by short circuit on the case, to safe values.

6. Nulling is an intentional electric connection between a null protective conductor and not current-conducting metal parts, which can appear under voltage. A principle of action of nulling is in transformation of short circuit on the case to a single-phase short circuit (i.e. short circuit between a phase and zero wire) with the purpose of creation of the big current strength capable of providing a protective operation.

7. Protecting cutout is a high-speed (of about 0.2 c) protection providing automatic cutout of an electrical power unit at lesion danger occurrence with a current in it.

8. Insulating electrical protective means. General electrical protective means are able to maintain working voltage for a long time: for electrical power units with voltage up to 1000 volts the dielectric rubber gloves, instrument with insulating handles, and voltage indicators of 1000 volts are used; for electrical power units of voltage of higher than 1000 volts the insulating bars, electric measuring pincers, and voltage indicators of higher than 1000 volts are used. Additional electrical protective means have insufficient electric strength and cannot independently protect a person from lesion by the current. Additional insulating electrical protective means are the following: for electrical power units up to 1000 volts the dielectric galoshes, insulating mats, and insulating supports are used; for electrical power units with voltage above 1000 volts the dielectric gloves, overshoes, insulating mats, and insulating supports are used.

5.1.5. Noise, vibration and acceleration

Noise. As for safety of vital activity, noise is any undesirable sound or set of sounds adversely influencing the organism of a person. Noise sources are both a person and machinery causing impacts, sliding of solids, emission of liquids and gases. As to noise, psychophysics of noise, and its influence on a person, everything is fully described in the first part of the abstract. Here we will only stop to discuss such sound ranges as ultrasound and infrasound.

Infrasound is a sound in a frequency range up to 16 Hz. The basic source of infrasound is the manufacturing equipment working with number of cycles fewer than 20 seconds (internal combustion engines, jet engines, fans, piston compressors, etc.).

Possible consequences of infrasound influence on a person are the following: hearing loss, mainly at low and medium frequencies; at the level of 110 dB and higher – changes in the central nervous system, cardiovascular and respiratory systems and vestibular apparatus.

The basic measures on infrasound control are machines speed increase; large-sized structures rigidity increase; elimination of low-frequency vibrations; installation of mufflers of a jet type.

Ultrasound is a sound in a frequency range of above 20 kHz, which is widely used in mechanical engineering, including aerospace industry. Sources of ultrasound are oscillators used for technological purposes, in medicine and for scientific research, manufacturing equipment having high-frequency components in a noise spectrum.

Influence of ultrasound on a person is as following:

– At a low level of action (80...90 dB) and small doses it is expressed in acceleration of exchange processes; a level increase is followed by a change

of a functional condition of the central nervous system, and arterial pressure suppression;

- Action with a level of more than 120 dB gives shock effect;
- At a single action there is a diphasic change of functions of an organism: on the day of action and between the third and fifth days, and the second phase lasts about two weeks;
- Pulse increase and breathing decrease, rise in temperature of a body and skin and increase in heat emission from a body surface.

Ultrasound normalization is carried out in accordance with GOST 12.1.001-83 are shown in table 5.10.

Table 5.10

Ultrasound normalization					
f, kHz	12.5	16	20	26	31,5...100
L, dB	80	90	100	106	110

Measures on protection of a person from ultrasound influence are as follows: use of higher frequencies for which allowable levels of sound pressure are higher; manufacturing of the equipment radiating ultrasound, in a soundproofing design; installation of screens between the equipment and working; placement of ultrasonic units in special rooms. At operation of the ultrasonic equipment a direct contact of hands working with a liquid, ultrasonic instrument and processed details where ultrasonic oscillations are raised, should be completely excluded. Loading, unloading and other manipulations in ultrasonic baths should be carried out only after oscillations sources turn-off.

Vibration. Vibration is mechanical oscillatory movements of the system with elastic connections. Vibration sources are machines of a shock, shock-rotary and rotary action.

Vibrations have significant biological activity. Character and orientation of functional shifts on the part of various systems of an organism are determined with a level, spectral structure and dose of vibrating influence, as well as resonant phenomena of a human body. Areas of resonance are: for the whole body in a "sitting" position – 4...6 Hz; for a head in "sitting" position – 20...30 Hz at vertical vibrations, 1.5...2 Hz at horizontal vibrations; for organs of sight – 60...90 Hz.

Oscillations (for example, of machine) are transferred to the trunk and the head through legs, buttocks or hands. The whole body and particular organs are exposed to oscillations, depending on their resonant frequencies (f_0). For the whole body of a sitting person $f_0 = 4...7$ Hz; resonant frequencies of some organs and parts of the body are shown in table 5.11.

Table 5.11

Resonant frequencies (f_0) fluctuations of various parts of the body and organs of a person (oscillation along the vertical axis of the body)

Part of the body (position "laying")	f_0 , Hz	Part of the body (position "sitting")	f_0 , Hz
Head	1...4	Backbone	3...5
Stomach	1.5...6	Stomach	4...5
Foot	1...3	Eye	20...25

Vibrating loadings influence basically drivers of various vehicles.

Possible consequences of vibrations influence are a sharp fall of work capacity; reduction in visual acuity; vestibular frustration: dizziness, headaches. At long influence there are a vibrating illness described by frustration of sensitivity, vascular frustration, occurrence of whining, breaking, nagging pains in the top finiteness, mainly at night and during the rest; changes of bone tissues; chronic injuries of joints and joints of a backbone.

Acceleration. Modern vehicles generate both positive and the negative forces causing acceleration which can operate along all three axes of a human body. Acceleration along a line going through the center of the Earth is called d-loading. Acceleration which we are to face when using means of transport can cause diseases known as kinetosis, or sicknesses of movement (sea, air, space ones, etc.).

At flight the organism is exposed to influence of especially big forces of acceleration. They impact a sitting person in a forehead-occipital direction when forward flight speed varies. Forces of acceleration act in various directions at flight along a complex trajectory, and they operate along a long axis of a body at flight on a curve. During flights on jet fighters overloads up to 10 g are registered, that is 10 times as much as terrestrial gravitation. These changes of acceleration are usually sudden and short-term; they cause a number of effects: 1) aeroembolism; 2) touch illusions with disorder of visual and vestibular orientation in space; 3) critical fall of arterial pressure, when under action of acceleration, directed on a long axis of a body, blood moves to the lower limbs in damage to the intrathoracic system with low pressure (orthostatic faint).

At space flight almost full absence of gravitation (microgravitation) results in various physiological reactions: 1) space sickness accompanying with a nausea, and sometimes vomiting, especially within first three days; 2) blood volume decrease caused by regulating mechanisms which counteract with initial overflow of intrathoracic part of the system with low pressure; 3) atrophy of muscles; 4) loss of calcium from bones and disbalance of electrolytes. Motion and work require an essential change of stereotypes of movements, which is acquired only as time goes by.

5.1.6. Electromagnetic radiation and its action on the person

Sources of electromagnetic radiation are various electrical devices, electrical transport, ignition systems of internal combustion engines, high-frequency installations of industrial, scientific and medical equipment, transmission equipment, electric power substations, lights with discharge lamps, devices of wire communication, television and radio receivers. The spectrum of electromagnetic radiations is shown in fig. 5.2. We will consider electromagnetic radiation as sources of danger to vital activity of a person.

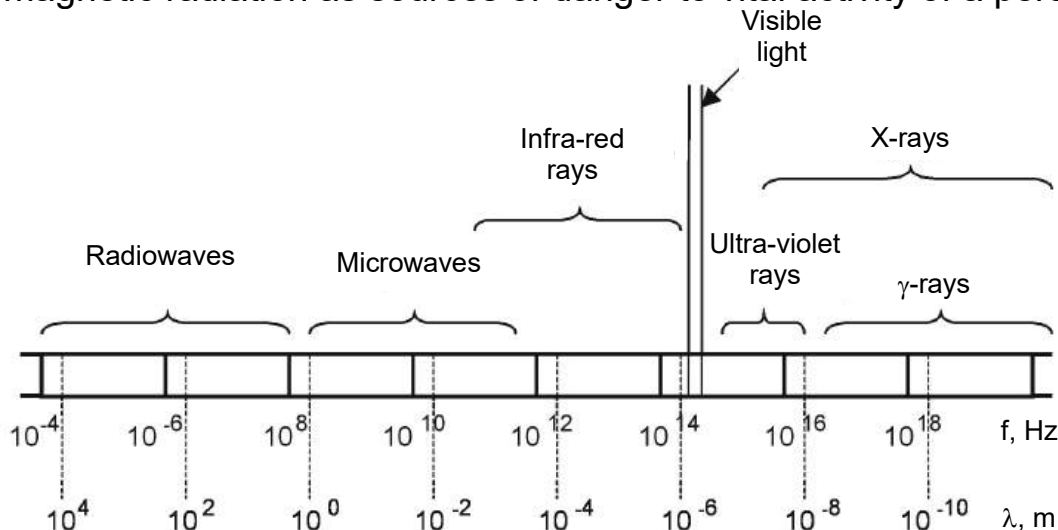


Fig. 5.2. Electromagnetic radiations

Basic phenomena at absorption of electromagnetic radiation:

- Absorption of energy in tissues due to ionic conductivity and molecular polarization accompanied by relaxation oscillations of molecules;
- Non-uniform absorption of energy when different layers of tissue have unequal conductivity and unequal dielectric permeability;
- Microheating of tissues;
- Chemical reactions.

Biological action of electromagnetic radiation depends on absorbed energy; physical parameters of field; duration of influence; area of irradiated surface; kind of tissue exposed to irradiation (tables 5.12, 5.13).

Table 5.12

Possible consequences of electromagnetic radiation influence on a person

Consequences of influence	1	2	3	4
Functional disorder of nervous activity	+	+	+	+
Disorder of cardiovascular activity	+	+	+	+
Disorder of central nervous system			+	+
Disorder of exchange processes			+	+
Change of blood condition and disorder of immunologic reactions				+
Disorder of endocrine system				+

- 1 – field of motionless charge and direct current;
- 2 – electromagnetic radiation of current of industrial frequency;
- 3 – low-frequency impulse electromagnetic radiation;
- 4 – radio-frequency electromagnetic radiation.

Table 5.13

Clinical displays of electromagnetic radiation influence on a person's organism

Clinical displays	1	2	3	4
Headache, irritability, sleep disorder	+	+	+	+
Depression, apathy		+	+	+
Increased fatigability		+	+	+
Memory impairment			+	+
Visual impairment	+	+	+	+

- 1 – field of motionless charge and direct current;
- 2 – electromagnetic radiation of current of industrial frequency;
- 3 – low-frequency impulse electromagnetic radiation;
- 4 – radio-frequency electromagnetic radiation.

5.1.7. Ionizing radiation

At interaction with substance the energy of radiation is taken on ionization (electron detachment) of substance atoms through which radiation passes. Ionization results in break of molecular bonds. Two kinds of radiations are distinguished: x-radiation and radioactivity.

X-radiation arises at sharp braking of quickly moving electrons at their passing through the screen. Wave length is from $0.006 \cdot 10^{-10}$ up to $2.5 \cdot 10^{-10}$ m (or from 0.006 up to 2.5 angstrom).

Radioactivity. The phenomenon of radioactivity consists in spontaneous disintegration of the substance nucleus, accompanied, as a rule, by radiation. Nucleuses of new elements are formed, and the number of radioactive elements decreases. Radioactive substances at disintegration let out:

–Alpha particles form a stream of nucleus of the helium consisting of two protons and two neutrons (energy of particles is from 3 up to 9 Megaelectronvolts, run in air is from 3 up to 12 centimeters, run in an organism of the person is of about 0.1-0.01 millimeters);

–Beta particles form a stream of electrons or positrons (energy of particles is from 0.03 up to 3.5 Megaelectronvolts, run in air is from 8 up to 14 centimeters);

–Neutrons form a stream of non-charged particles which interact only with nucleuses of atoms and can turn to protons letting out electron and causing gamma-radiation (electromagnetic radiation arising at transition of a nucleus of an atom from one power condition to another, its wave length is from 10^{-9} down to 10^{-12} centimeters).

Various kinds of radiations are accompanied by liberation of different amount of energy, have different penetration capability and so they cause unequal influence on tissues of a living organism. Alpha-radiation which is a stream of heavy particles consisting of protons and neutrons is stopped, for example, with a sheet of paper and practically is not capable to penetrate through the external layer of the skin formed with dead cells. Therefore it does not represent danger until the radioactive substances letting out alpha particles get inside of an organism through an open wound, with food or inhaled air. Then they become extremely dangerous. Beta-radiation has a greater penetration capability: it passes through tissues of an organism on depth from 1 up to 2 centimeters. Penetration capability of gamma-radiation, which propagates with speed of light, is very big; so, it can only be stopped with thick leaden or concrete plate (fig. 5.3).

Activity of a radioactive substance is determined with quantity of atoms which break up in a unit of time. A unit of measurements is curie (1 curie = $3.7 \cdot 10^{10}$ disintegrations per second).

Radioactive irradiation can be external (direct irradiation) or internal one (radioactive substances get inside at inhalation, drinking, smoking, etc.; less often they get through the skin).

Ionizing capability of ionizing radiation is characterized with specific ionization determined as a number of pairs of the ions created on a unit of distance. At passing through air for x-radiation it is determined with several pairs of ions on 1 centimeter; for alpha-radiation it is of about 3000 pairs of ions on 1 millimeter of run; for beta-radiation it is equal to several tens of pairs of ions on 1 millimeter of run; for gamma-radiation it is determined of several pairs of ions on 1 millimeters of run. Thus, one pair of ions in air demands 33 electronvolts of energy for its formation.

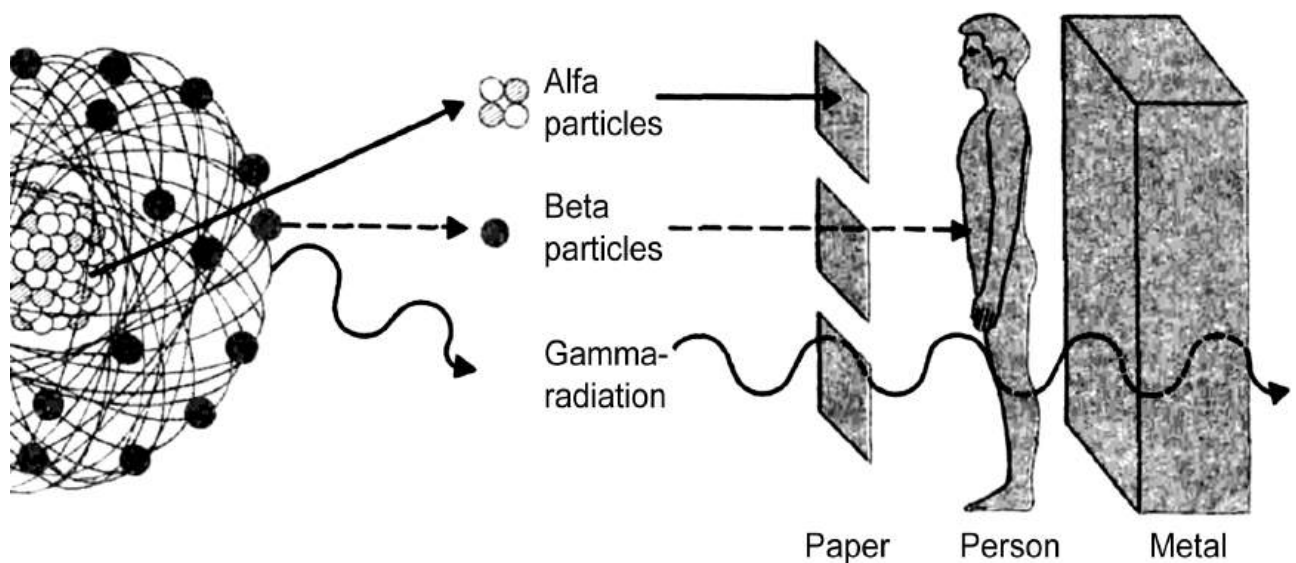


Fig. 5.3. Three kinds of radiations and their penetration capability

5.1.8. Influence of ionizing radiation on a person

Effect of ionizing irradiation on a person depends on the absorbed dose, sizes of irradiated surface of a body, specific features of an organism, kind of radiation, half-life period (for radioactive radiation). As a result the following consequences come:

- break of molecular bonds resulting in change of chemical structure of compounds;
- disintegration of water in living tissues to H^+ and OH^- ions. These products of splitting have high chemical activity and make compounds with other substances. These compounds are not characteristic to a living tissue, thus metabolism is broken.

Possible lesions are:

- sharp ones at big doses in a short time interval,
- chronic lesions at influence of small doses for a long period of time.

Consequence of lesion with ionizing radiation is radiation sickness having the following attributes: at the 1st stage there are a headache, slackness, weakness, disorder of sleep and appetite; at the 2nd stage there are cardiovascular changes and disorder of metabolism; at the 3rd stage there are changes in central nervous system.

Factors of radiating risk for different tissues and organs of a person at a uniform irradiation of all body are shown in table 5.14. They are recommended by the International commission on radiating protection for calculation of an effective equivalent dose.

Table 5.14

Factors of radiating risk

Factors of radiating risk	Tissues and organs of a body of the person
0.12	red bone marrow
0.03	bone tissue
0.03	thyroid gland
0.15	mammary gland
0.12	lungs
0.25	ovaries or testicles
0.30	other tissues and organs
1.00	organism as a whole

It is necessary to emphasize that the organism transmits series of small doses better than the same total dose of irradiation perceived at once. Doses of about 100 gray cause serious lesion of the central nervous system and then death within several days. Doses of about 10...50 gray cause death after 1 or 2 weeks from a hemorrhage in a gastroenteric path. At doses of about 3...5 gray serious injuries are not observed, but the death comes in several months because of destruction of cells of a red bone marrow. At doses of about 0.5...1 gray cells of a red bone marrow lose ability to function;

however if the dose of irradiation is insignificant, they are capable of being regenerated. Doses of about 0.1...2 gray result in temporary and constant sterility of men, and up to 3 gray – in sterility of women.

5.1.9. Influence of ionizing radiation on tissues of a person

Charged particles. After penetrating in tissues of an organism alpha and beta particles lose energy owing to electric interactions with electrons of those atoms near which they pass. (Gamma-radiation and X-rays transfer their energy to substance in several ways which finally result in electric interactions, too.)

Electric interactions. In 10^{-11} seconds after penetrating radiation achieves an atom in a tissue of an organism, an electron is broken off this atom. It is negatively charged; therefore other part of initially neutral atom becomes positively charged. This process is named ionization. Broken off electron can ionize other atoms further.

Physical and chemical changes. Both free electron and ionized atom are usually not able to stay in such a condition for a long time, and furthermore in following 10^{-8} second they participate in a complex series of reactions, as a result of which new molecules are formed, including such extremely reactionary-capable ones as free radicals.

Chemical changes. In following 10^{-6} second the formed free radicals react both with each other, and with other molecules and through series of the reactions, which have been not yet investigated up to the end, can cause chemical modification of the molecules important in the biological meaning, which are necessary for normal functioning of a cell.

Biological effects. Biochemical changes may take place both in several seconds, and in ten years after irradiation and so they can be a cause of immediate destruction of cells or such changes in them which can lead to cancer.

General principles of protection against ionizing radiations. Protection of people working with radioactive substances is accomplished with the system of technical, sanitary-and-hygienic and treatment-and-prophylactic actions:

- determining of maximum allowable doses of irradiation for various kinds of ionizing radiation;
- application of time and distance protection;
- use of devices of the personal and general control for determining of intensity of radioactive irradiation;
- application of personal protective equipment (working clothes, overalls, half-overalls, caps made of unpainted cotton fabric, film clothes – oversleeves, trousers, aprons, etc.);
- accomplishment of general protective actions, such as ventilation, damp cleaning of working area, etc.

5.2. Chemical factors of danger

Chemical factors of danger are toxic substances of various aggregative states which are capable to cause any kinds of general, local or remote negative influence on an organism of a person. Factors are subdivided as follows:

- by character of influence on a person there are toxic, cancerogenic, mutagen, irritating, sensitizing ones, as well as substances influencing a genesial function;
- by a way of transition to an organism there are substances coming through respiratory organs, through the gastroenteric path, through skin and mucous membranes.

Substances penetrate into an organism through respiratory organs in the form of gases, steams, aerosols and their mixes; then they are soaked up through mucous membranes of the respiratory system. It is the fastest way of substances transition to an organism because of a large surface of air cells (100...120 square meters) and also because of constant stream of blood in pulmonary capillaries.

Substances are soaked up through the gastroenteric path in the following ways: 1) in an oral cavity, coming directly to blood; 2) in a stomach, thus the sour environment of gastric juice can considerably increase toxicity of poisonous substances which are badly dissolved in water, but quite well in gastric juice; 3) in thin bowels. The poisonous substances similar by a structure to natural compounds (such as nutrients) are especially well soaked up in the gastroenteric path.

The substances penetrate in the skin through its top layer (epidermis), hair follicles, out-going channels of grease and sweat glands, as well as through mucous membranes (substances having irritating action). In an organism there is a propagation of chemically dangerous substances on tissues of an organism, their transformation, accumulation into an organism, emission out of an organism; thus the influence of these substances depends on their escape out of an organism.

Chemical substances escape through the following tissues and organs:

- Lungs (flying substances such as ammonia and chlorine escape with exhaled air);
- Gastroenteric path (escape of metals basically occurs in a mouth with a saliva, and then through a liver with bile in bowels);
- Kidneys (escape of acids, alkalis, some metals occurs with urine);
- Skin (acetone, phenol carbon bisulfide escape with sweat).

Toxicity is a measure of incompatibility of chemical substance with a life, its ability to cause a negative physiological effect consisting in disorder of one or many functions of an organism or its activity as a whole, leading to its destruction. Toxicity of substance is determined through toxic effect which is classified as following:

- by frequency of influence:

- a) one-time influence,
- b) repeated influence;
- by time of occurrence:
 - a) at influence or right after it,
 - b) delayed toxic effect coming in the course of a life time of the present generation or in life of the subsequent generations (table 5.15).

Table 5.15

Distant toxic effect	
Action	Characteristic of action
Gonadotropic action	Disorder of genesial function of a person – ovogenesis of women and spermatogenesis of men
Embryotropic action	Disorder in fetal development, sometimes toxic effect for mother is not shown (nicotine, etc.)
Mutagen action	Changes of hereditary properties of the organism shown at descendants
Ageing of an organism	Acceleration of ageing process of cardiovascular system of a person

Toxic effect depends on the following parameters: structure, physical and chemical properties of substance; amount of substance which is in an organism; joint action of several substances at simultaneous (sequential) penetration in the same way; object of influence, gender, age, individual sensitivity; temperature, humidity and other parameters of the environment; physical loading of object of influence.

Amount of substance in an organism depends on:

- concentration of substance or density of infection (amount of substance contained in a volume unit of air, liquid, or in an area unit accordingly);
- duration of influence (period of substance influence on an organism).

Maximum allowable concentration (maximum concentration limit) is concentration of harmful substances in the air which cannot cause any disease or deviation in a state of health, which can be detested by modern methods, at work or in a distant time of life of the present or the subsequent generations. Value of maximum concentration limit is determined according to the following formula:

$$\text{Maximum Concentration Limit} = \text{Lim}_{\text{ch}} / K_R, \quad (5.1)$$

where K_R is a reserve coefficient determined for each substance individually by means of an expert assessment. In other words, maximum concentration limit is the greatest concentration of the given substance in the air of the working area where (as far as it is known now) this substance is not harmful to health of working people and does not cause any undesirable reactions

even at a repeated and long influence (as a rule, during 8 hours a day at an average 40-hour work week).

5.3. Biological factors of danger

Biological factors of danger are as following:

1. Pathogenic microorganisms:

- Bacteria are monocelled microbes of a vegetative form whose sizes vary within the limits of several microns. Volume of 1 ml of a nutrient medium may contain up to 550 billion bacteria;
- Viruses are the smallest microbes whose sizes are hundreds of times as little as sizes of bacteria and are equal to about 10-3 microns. Viruses in contrast to bacteria may exist and reproduce in living tissues only;
- Rickettsia form a special group of microorganisms with attributes and properties inherent both to bacteria and viruses. By appearance and sizes rickettsia are close to bacteria, and by conditions of existence they are viruses (living tissue is necessary for their growth and reproduction);
- Fungi are microorganisms of the vegetative nature having a complex structure and form; their sizes vary from several microns up to hundreds of microns. Fungi grow and reproduce well both in living tissues and artificial nutrient media and cause a disease named mycosis. Superficial fungi (lichen) affect skin, hair, nails. At deep mycosis there is fungi penetration deeply in an organism;
- Toxins are products of vital activity of microbes, having extremely high toxicity. Microbe toxin poisoning causes death of a person in 90 cases from 100. Formation of toxins occurs in different periods of existence of microbes, thus, toxin can be closely connected to a microbic cell and escape to the environment after destruction of the cell (for example, pathogens of plague) or during life of a microbe (for example, botulism). Toxins can play the basic role in lesion of a person;

2. Microorganisms including plants and animals.

Pathogenic microorganisms are microorganisms which cause infectious diseases or infections and represent big danger to a person. Pathogenic microorganisms are capable of resulting in biological lesion of a person at the following phenomena:

- Increase in concentration of pathogenic microorganisms in the environment at certain combinations of natural and climatic conditions and social factors;
- Emissions of biologically dangerous substances in the environment at accidents and also in case of their application in the military purposes and at acts of terrorism.

Pathogenic microorganisms can exist and reproduce in living tissues and artificial nutrient medium – specially prepared mix of nutrients.

Macroorganisms including animals and plants usually represent danger in daily conditions. They concern influence of rodents, insects and plants. Ways of penetration of microbes into an organism are as following:

- 1) gastroenteric path – an alimentary way,
- 2) through respiratory organs – an aspiratory way,
- 3) through the skin surface – a household way,
- 4) with stings of insects – a transmission way.

Each microbe has its way of penetration into an organism, and some microbes can penetrate into an organism in several ways. The way of penetration of a microbe into an organism is closely connected with a place of its allocation in an organism after penetration. By location of a pathogen, infectious diseases classification into four basic groups is established:

- 1st group – enteric infections,
- 2nd group – infections of respiratory ways or respiratory infection,
- 3rd group – blood infections,
- 4th group – skin diseases.

The beginning of a disease depends on protective functions of an organism. At insufficient protective functions of an organism the certain time interval passes before occurrence of the first symptoms of disease. It is an incubatory (latent) period during which there is reproduction and accumulation of microbes in an organism. Then the first uncertain symptoms of unhealthy condition appear. Usually they are weakness, indisposition and a small rise in temperature quite determined further during an illness.

At sufficient protective functions of an organism a disease does not come with the help of the influence of immunity (immunity of an organism at the beginning of infection or any substance foreign to an organism) which can be both hereditary received (natural, inherent) and individually got. There can be distinguished active immunity of an organism as a result of the previously suffered disease, or passive one based on introduction of ready protective antibodies in an organism from the immune person or an animal.

Propagation of microbes is accomplished by means of elements of the environment (people, animals, air, water, subjects of use) and infected carriers of disease (ill people, animals, rodents). Occurrence of mass diseases of people (epidemic), animals (epizootic) and plants (epiphytic) is possible.

5.4. Psychophysiological factors and their influence on a person

Psychophysiological factors are all factors influencing psychological, physiological and psychophysiological state of a person, such as the following:

- physical overloads;
- static and dynamic loadings;
- hypodynamia and hyperdynamia;
- nervous-emotional loadings;

- intellectual overstrain;
- exhaustion and overfatigue;
- overstrain of sensors perceiving the information (skin, visual, acoustical ones, etc.).

It is obvious that these factors are always present in human life. Therefore at solving the questions of a person's protection in the given aspect the problem is formulated as support of harmony of a person's existence in the man-caused environment, i.e. the system "person – machinery – environment". This approach differs from the traditional task of safety of vital activity, which is formulated as normalization of parameters of the environment and adaptation of a person.

Support of harmony of coexistence of all three components of the system "person – machinery – environment" is named ergonomicity. Ergonomicity of a system is a system characteristic, a generalized parameter including a hierarchical structure of a number of properties: controllability, serviceability, settleability and habitability. It is clear that all properties are directed to maintenance of convenient and safe work of a person in the system "person – machinery – environment". The first three parameters characterize seamlessness of machinery inclusion in corresponding kinds of activity of a person or a group of people. Habitability of a person near machinery characterizes closeness of working conditions to biologically optimal parameters of the environment when normal development, good health and high work capacity are provided to a working person, as well as reduction or liquidation of harmful consequences of its operation for the environment is achieved.

Ergonomicity implies studying of the system "person – machinery – environment" as the functional whole in such way that each of its components submits in operation to laws peculiar only to it, and efficiency of functioning of system as a whole is determined with measure of revealing and taking into account all features of given subsystems, especially its restrictions and potential. Thus, it is necessary to emphasize movement in two directions simultaneously: both from abilities of a person to potential of machinery and conditions of its effective functioning, and, on the contrary, from machinery and its potential to a person. To find optimal solutions it is not enough to use only separate recommendations of psychology, physiology, labor hygiene, anthropology, and engineering sciences – it is necessary to coordinate these dissimilar recommendations among themselves, to coordinate them in a uniform system corresponding to requirements of this or that kind of researched and projected activity, and also particular conditions of its realization.

Depending on how a person's activity process goes, how much it is connected with personal and professional interests and functionalities, results and efficiency of work, state of health, as well as their attitude to professional tasks.

Preservation of people's health in any manufacturing conditions, increase of work productivity and personality development concern those basic results of labor activity, which may serve as criteria of estimation of its optimal organization.

What aspects of labor activity are connected with formation of its basic qualities? Health of a person during labor activity depends first of all on a value of loading, stress, which is felt by an organism under influence of various manufacturing factors. The value of loading may serve as a reason for irreversible changes and even full disorder of general psychophysiological condition of a person, or may cause negative shifts in work capacity. On the contrary, it may support an optimum of functional condition and stimulate amplification and development of functionalities of a person.

Thus, the range of changes of working condition of a person under influence of loading is wide enough. Therefore the task of optimization of the system "person – machinery – environment" optimization includes determination and organization of such a structure of the given system, which would keep health of a person as good as possible and would raise work capacity, thus keeping and raising their efficiency.

5.4.1. Concept of professional selection

Efficiency of functioning of a person as a link of the system "person – machinery – environment" is achieved due to support of conformity of the person's opportunities with requirements of the given particular work. Each person has greater or smaller abilities, predilections, bents, and talent of accomplishment of this or that work. At their presence a person is much easier trained for a certain specialty, and having received it, such a person works highly productively and creatively.

Research has shown that 7...8 % of young people are unable to assemble small parts; work in chemical manufacturing is restricted to 15...20 % of workers; 20...40 % of people are unsuitable for accomplishment of work at height. Besides, for the work demanding enhanced attention and accuracy high level of skill is achieved only for 2...40 % of industry workers. Accomplishment of work by a worker having no necessary abilities, may create some risk for health and his life and lives of other people except for a low work efficiency; the risk of greater or smaller material losses is also real. Such a person has dissatisfaction with work that results in staff turnover and losses related to it. Besides, cases of occurrence of professional diseases, traumatism, and failures are possible.

Career-guidance activity which has a nation-wide character is intended to provide a solution to these problems. According to scientific research, a well operating system of career-guidance contributes to an increase of work productivity depending on the following parameters: sphere of activity includes about 10...30 %, reduction of turnover of staff gives 20...25 %, a

decrease in a breakdown rate and traumatism is 35...45 %, continuation of the period of work capacity makes up 8...10 %.

Career-guidance activity provides formation of professional prospects for a person –vital plans developed in time and directed to a choice of profession (self-determination), and affirmation as a subject of professional work (self-affirmation).

Process of professional self-determination is conditionally subdivided into four stages:

1. Occurrence and formation of professional intentions under influence of general development, initial orientation and involving in different spheres of activity in a school of general education. Psychological criterion of this stage is socially and psychologically proved choice of profession.

2. Own professional training, i.e. stage of purposeful preparation for the chosen professional activity during productive intellectual and practical activity, including manufacturing one. The psychological criterion of this stage is professional formation of the person.

3. Occurrence in a profession, which is characterized with active profession acquirement, formation of individual style of activity, inclusion in system of manufacturing relations and finding of the special place in the organization of the staff.

4. Full realization of the person in independent professional activity.

Thus, professional self-determination is considered as process, which penetrates whole life of the person, covers the period of his professional activity from occurrence of professional intentions till the moment of the end of Labor activity. Professional self-determination and formation of the person in conditions of training, education and work is one of the central problems of psychology of professional training and education.

One of the results of professional selection is a composition of psychological profile of a person, i.e. the all-round characteristic of his/her development level, including professional interests and bents. A psychological profile of a person takes into account the following groups of properties:

- Physical (expenses of muscular force, rate of energy expenses, endurance);
- Psychophysiological (general mobility and swiftness, flexibility of hands and fingers, touch, visual and acoustical distinction of objects, coordination of movements, sensomotrics);
- Mental processes (concentration, division and switching of attention, perception of the sizes and forms of objects, type of memory, thinking, imagination);
- Temperament and character (emotional stability, self-control, persistence, initiative, diligence, ability to management and cooperation).

Conformity of a psychological profile of a person to a psychological profile of a profession is a basis for estimation of a person's suitability for the given profession. Psychological professional unsuitability is determined not

only by insufficiency of these or those abilities, but with presence of negative features for the given kind of Labor activity in structure of the person, for example, emotional-motor instability, carelessness, tendency to unjustified risk, etc.

Professional suitability is a person's possessing of professionally important properties and qualities which provide successful work in one or several professions. Professionally suitable people who successfully acquire a profession by training are improved in chosen activity by themselves, and also improve their work.

5.4.2. Organization of rational work and rest schedule

With increase of the level of mechanization and automation of work the overwhelming majority of manufacturing processes is accomplished more intensively and continuously. Machines and equipment are used more effectively if they stand idle less and operate without interruption for a whole operation time. In particular it concerns the modern high-efficiency machinery equipped with automated control systems.

However the person cannot work continuously. During the working day the level of his work capacity changes under influence of two basic groups of factors – social and biological ones. Factors of the first kind (labor motivation, presence of corresponding means and Labor purpose) induce the working person to accelerate and condense operation time to maximum. Biological factors (exhaustion, development of boundary and pathological conditions of the basic psychophysiological functions of an organism of a person) reduce work capacity and productivity. Therefore there is a necessity of periodic breaks for a short-term rest.

So, there is a problem: how it is possible to achieve the highest level of work productivity of a person at the given rate and the loading coordinated with characteristics of mechanisms and equipment, thus having provided an opportunity of a high-grade rest, and restoration of the spent strength? The solution to this problem is probable due to development of work and rest schedules allowing to find an optimum proportion between duration of the working periods and duration and quantity of breaks for rest.

Work and rest schedule is the order established at the enterprise, organization or institution, which regulates corresponding duty and duration of the periods of work and rest during the working day, week, month, and year for each kind of work. It is determined by such factors as duration of the working day; time of the beginning and ending of work; time and duration of lunch break and other regulated breaks (micro- and macropauses); total quantity of days and working hours, periodicity and duration of the basic and additional holidays.

In practice, insufficient attention to work and rest schedule results in non-productive expenses of working time and labor potential of the enterprise, including reduction of manufacturing per hour in the second half of a working

day, increase in disease incidences of workers because of excessive fatigue, increase in quantity of events of manufacturing traumatism, etc.

Basic requirements for rationalization of work and rest schedules are as follows:

1. Rational alternation of work and breaks for rest as important means of exhaustion prevention and increase in work capacity should be accomplished for all works without exception.

2. Breaks for rest should be strictly regulated, their contents and duration submit to a uniform purpose – to the maximum possible restriction of exhaustion and support of sufficiently high and good work capacity.

3. During the breaks set with rational work and rest schedules physiological functions of the worker should be restored to become as near to before-working condition as possible.

4. Distribution of breaks at work should provide fast coming to work, a long period of high work capacity and its least reduction at the end of work.

5. Rational work and rest schedules should warn development of deep stages of manufacturing exhaustion, which may further proceed in frustration of health, and occurrence of professional diseases.

Estimation of rationality of work and rest schedule for a particular kind of manufacturing is accomplished taking into account three groups of criteria:

- Economic criteria: level of products manufacturing, dynamics of individual work productivity, quality of products, in-shift stand times of equipment, loss of working time, staff turnover, etc.;

- Psychophysiological ones: condition of acoustical and visual analyzers, strength and endurance, coordination of movements, a state of the cardiovascular system, level of perception, memory, thinking, disease incidence of workers, level of traumatism, etc.;

- Social criteria: satisfaction (or dissatisfaction) of workers with the set schedule; number of people who complain of fast development of weariness; the number of people having initial attributes of weariness (sleep frustration, headaches, annoyance).

So, at making daily work schedules the following data are taken into account. It is known that in connection with a daily rhythm of psychophysiological functions of an organism in different time intervals the organism of the person reacts unequally to physical and nervous loadings, therefore their work capacity and work productivity significantly change. According to a daily cycle, the best level of work capacity is in the morning and in the afternoon from 8 a.m. till 20 p.m. At 4 a.m. it is reduced down to the minimal value. Taking into account the daily periodical press of work capacity of a person it is necessary to determine the rhythm of work of the enterprise, the beginning and ending of work, breaks for rest and sleep. At one-shift and two-shift schedules it is recommended to begin work at 8 or 9 o'clock, at three-shift ones – not earlier than 6 or 7 a.m. Night time is favorable for sleep. Such a rest is preconditioned by a physiological need of an organism for full rest, which is realized during night sleep with the

sufficient duration necessary for restoration of vital strength. Duration of sleep should be between 7 and 8 hours per day.

At construction of week work and rest schedules it is necessary to start from the statement that work capacity of the person is not stable and changes during a week. During the first days of week, work capacity gradually rises, and achieves the highest level for the third day. After that it starts to reduce and gets the minimal value on the last day of a working week. The amplitude of oscillation of work capacity during a week depends on difficulty and conditions of work.

Studying week curve of work capacity was one of the most important physiological substantiations of transition of the manufacturing enterprises for a five-day working week. At the same time a long two-day break in work sometimes results in increase of the period of coming to work at the beginning of a week. A high level of work capacity on Tuesday, Wednesday and Thursday proves a necessity of maximal use of these days for interests of manufacturing, as they provide the highest work productivity at the least exhaustion of workers.

Yearly work and rest schedules provide rational change of work and long periods of rest. Physiological necessity of such a rest is caused with insufficiency of daily and weekly rest for removal of weariness being accumulated constantly. Therefore long rest is necessary for support of a high level of work capacity of a person, continuation of their labor activity without harm for health. This rest is established as a yearly vacation. A yearly vacation is established according to the valid legislation about work, and its duration corresponds to heaviness, complexity and responsibility of work. This period is defined in the collective agreement made by the staff of the enterprise and the owner or the institution authorized by it.

Contents of rest should provide switching of loading from the tired nervous centers and organs to those which were not actively involved during work. So, for people occupied with physical work the best rest is a quiet one with insignificant intellectual loading. For people engaged in the brainwork active rest with elements of physical loading will be useful.

5.4.3. Ways of effective rest of a person

Often there is no opportunity to provide a person with a high-grade rest to eliminate weariness and exhaustion. It takes place in such branches as astronautics, diving, flight mission controls, etc. It is a question of very fast removal of symptoms of exhaustion or stress of a person who is not able to interrupt work, despite worsening a state of health. In such cases they say about relaxation as a fast restoration of work capacity of a person by means of certain influences on their organism.

Work capacity of operators depends on plenty of factors: functional condition, professional readiness, time of a day, intensity of work, level of use of the organism resources, work and rest schedule, conditions and kind of

rest. Now there are known a series of ergonomic, organizational and technical means and methods of support of work capacity of operators at a certain level.

It is known that a state of relaxation is accompanied with a series of phenomena: decrease in a tone of the skeletal and smooth muscles, providing high-grade inflow of blood and amplification of exchange processes in various organs and sites of a body; decrease in a nervous and emotional stress; narrowing of a field of consciousness; partial switching-off from an external world and also switching of attention to experience of internal comfort and rest. Therefore to achieve a state of relaxation the following techniques are used: a complex of exercises for a nervous-muscular relaxation; a complex of ways of autogenous training; audiovisual influence; relaxation with breath regulating, in particular, rebirthing, jogging, hardening, visiting a sauna.

Such techniques are labor-consuming and do not give results very fast, therefore a series of more effective techniques of psychophysiological relaxation have been developed. They allow accelerating relaxation processes and, thus, accomplishing fast normalization of a functional condition of a person.

As the visual apparatus is one of the most vulnerable subsystems of the computer operator, studying of development of ways and methods for restoration and support of his/her visual work capacity is continuously accomplished. Efficiency of use of software products for diagnostics, preventive measures and removals of exhaustion of the computer operator has recently been proved true. Both in our country and abroad research on study of influence of computer displays on the sight of a person and also of improvement of sight characteristics by means of video training were accomplished. Results showed that daily eye-training essentially improves oculomotor functions, fusion and accommodation. For restoration of visual work capacity of the computer operators special complexes of exercises, video influence, programs of eye aerobics for removal of visual exhaustion are developed, which provide improvement of strength of eye muscles, accommodation and also of strength ciliary muscles. The results proving a positive influence of reflexotherapy on the visual subsystem of a person were published.

5.4.4. Optimization of environment in the system "person – machinery – environment"

Optimization of environment in the system "person – machinery – environment" is accomplished in the following factorial directions:

- Hygienic directions which determine conformity of the product and manufacturing or household environment to sanitary-and-hygienic norms and recommendations: illumination, ventilation, temperature, humidity, pressure, dust level, toxicity, noise, vibration, harmful radiations, etc.;

– Anthropometrical directions which establish conformity of design to sizes and form of a human body and his separate organs (conformity of control elements – (switches) to a hand, etc.);

– Physiological and psychophysiological directions which determine conformity of characteristics of the manufacturing equipment to strength, speed, visual, acoustical, tactile, olfactory abilities of the person.

Manufacturing environment is developed in terms of safety, convenience, comfort and beauty. Thus, much depends on a functional purpose of premises, and also on ergonomic requirements for premises: climatic and light-climatic conditions of a building location; peculiarities of functional processes proceeding here; sanitary-and-hygienic conditions in a premise; requirements of safety engineering, etc.

Creation of optimum working conditions is supported by factors of the manufacturing environment: physical, chemical, biological, social-psychological, aesthetic. In manufacturing premises it is necessary to exclude or lower as much as possible the emission of harmful and odorous substances, superfluous heat and moisture, presence of noise, dust, vibration, ultrasound, radio frequency electromagnetic waves, ionizing radiation. All these factors are regulated by standards on safety engineering and work hygiene (labor safety standards system called "CCBT"), which are necessary for developers, engineers and designers to familiarize with at a design stage of object.

Let us consider in more details one of the most important factors influencing the person in the system "person – machinery – environment" – color. Colors surround the person every time and everywhere. There is quite simple influence of color on psychophysiological condition of the person. Therefore at creation of a manufacturing interior it is very important to pick up correctly painting of surfaces, taking into account emotional influence of color on the person. Warm, active colors (red, orange, yellow) invigorate; cold, passive colors (dark blue, violet) calm. Long application of some colors shows a certain psychophysical influence. For example, red color increases a muscular stress, speeds up a breath rate and supports increase of a blood pressure; blue color reduces a blood pressure; yellow color stimulates cerebration; orange one causes easy excitation, accelerates blood circulation; violet color raises activity of heart and lungs. At operating for a long time excessively intensive color makes tired; bright painting bothers and irritates. If premises are small then due to blue and light green colors the impression of the greater space is created; brown and terracotta colors visually reduce a premise.

Color is an effective means of perception and processing of visual information. It is known that the person is able to identify correctly from 10 to 12 color tones. Violet, dark blue, blue, green, yellow and red colors are identified with the greatest accuracy, which should be used for color coding (see table 5.16). There is a state standard regulating warning painting and safety signs (ГОСТ 12.4.026.-76. CCBT. "Safety signs. Alarm colors").

Table 5.16

Relative clearness of combinations of colors at reflected light

Clearness estimation	Color combination
Very good	Black letters on a white background
Good	Black on yellow; dark blue on white; green on white
Satisfactory	Red on white; red on yellow
Bad	Green on red; red on green; orange on black; orange on white

According to this standard the following colors are considered to be alarm colors:

- Red color informing about danger; it is used for painting of prohibitive safety signs, alarm lamps informing on disturbance of manufacturing process or safety engineering, etc.;
- Yellow color warning people; it is used to paint a background of warning safety signs, for coloring of low beams, ledges of building designs and differences of a floor surface, which may become a cause of manufacturing traumatism, and besides, yellow color is used to mark containers with harmful substances;
- Green color informing about safety; it is used for painting of framework of ordering safety signs, alarm lamps informing about a normal operating mode of machines and automated lines, etc.;
- Dark blue color giving information; it is applied at design of indicating safety signs.

First three colors are associated with traffic lights whose signal colors are remembered by the person since childhood, and so, naturally, people react to them adequately. At color coding it is necessary to take into account illumination and optical illusions. Yellow color visually expands a surface, and so it seems more than real; white and yellow colors create irradiation effect (more dark surfaces located around them are visually lowered). Flat areas painted in dark blue, violet and black colors are visually lowered and fall in.

Color composition of operator's control panel a huge amount of devices (control panel of any manufacturing process, workplace of the airdispatcher, etc.) is especially important. The basic problem in such cases concerns concentrating for a long time and perceiving various information adequately. As a rule, color spectrum of such panels is quiet (light blue, light green, light violet); contrast colors are applied for organization of various working zones. Thus, it is necessary to take into account stereotypes of person's reaction:

- Light shades and bluish colors are associated with the sky or movement upwards; on the contrary, dark shades, and also green and brown colors are associated with the ground or movement downwards;
- Cold is associated with blue or blue-green colors, and warmth is associated with yellow or red ones;
- Very bright and fast flashing light signals cause feeling of danger and anxiety;

– Big or dark objects are associated with something bulky, and small and light painted ones are associated with something easy and weightless; big heavy objects are usual to be seen below, and small lightweight objects are usual to be above.

– It is necessary to avoid glittering coverings of panels; there should not be any foreign elements on them, which complicate work of the operator, such as ledges, deepenings, etc.

The purpose of the given consideration of the environment color influence on the person is to show that practically any factor in the system "person – machinery – environment" is important from the point of view of person's perception, that is why it cannot be ignored at construction of ergonomic (i.e. harmonious) systems "person – machinery – environment".

6. BASICS OF LABOR PROTECTION

Labor protection is a system of legal, socio-economic, organizational and technical, sanitary and preventive measures and means aimed at preserving the health and human efficiency in the labor process. From this definition it follows that the problem of labor safety is to reduce to a minimum the likelihood of injury or disease while ensuring operating comfort with maximum labor productivity.

The purpose of the subject "Labor Protection" is to give future engineers theoretical knowledge and practical skills necessary for resolving issues related to providing safe and friendly environment in the development and use of new equipment and technological processes in production, which exclude negative effects on humans and surrounding natural environment.

The scientific content of the course consists of theoretical and practical bases of labor protection management in terms of production, methods of prevention and protection of workers from dangerous and harmful working conditions.

"Basics of Labor Protection" belongs to the scientific field of "Life Safety", which also include subjects related to the safety of human and natural environment, and those elements of the human environment that may threaten their life and health.»Life Safety", "Basics of Labor Protection", "Labor Protection in Industry", "Basics of Ecology", "Civil Defense" – these are subject of significant direction.

6.1. Main terms of labor protection management

According to the definition of science "Safety of living", the system of labor protection combines a set of legal, socio-economic, organizational and technical, sanitary and medical interventions aimed at preserving the health and disability rights at work.

The object of management is the machinery, technological processes, enterprises, industries, areas of human activity and so on.

Elements of management of this facility are:

- monitoring of the object,
- determining the necessary tasks,
- matching tasks,
- development of administrative actions,
- implementation of management actions,
- monitoring of administrative actions (feedback) and others.

Considering the Labor protection management from these positions, Labor protection system management (LPSM) is the most comprehensive set of labor protection systems and control elements of its condition.

In other words, the labor protection management is preparation, adoption and implementation of measures to protect life and health of workers at work.

However, LPSM acts as a functional subsystem of control systems in the economic complex of Ukraine in general. Considering the labor protection system management at the state level, there should be noted such features as complex and multifunctional LPSM on a particular object is a multi-control system with the state top control level and with a particular area in a particular shop or business low control level. Depending on the ownership and subordination of the object intermediate levels of management may take departmental, regional administration and management or enterprise management, etc.

The main LPSM structural components are:

- object of management which is labor protection system on a particular enterprise, association, in the region, in Ukraine in general;
- elements of management, including control of the facility, development of administrative actions and their implementation, monitoring the implementation of administrative actions, analysis of similar facilities, forming health and work performance tasks, comparing ratios.

Labor Protection Service provides the following key features:

- developing effective integrated labor protection management system;
- conducting urgent methodical management of Labor protection;
- organizing the providing of manuals, standards, rules, instructions and other regulations on labor protection;
- organizing accounting, analysis of accidents, industrial diseases and accidents in the industry, as well as damage of these events.

Specialists in the following field complete Labor Protection Service as a rule:

- Engineers of the certain professions;
- Experts on occupational health;
- Lawyers, specializing on the health and safety legislation.

Labor Protection Service may include laboratories that monitor hazardous working factors at workplace.

Labor Protection management at the regional level. The main goals of Labor protection management at the regional level within the appropriate territories in accordance with the Law of Labor Protection are put on local administrations and councils of deputies who:

- provide implementation of state policies on labor protection;
- form with participation of trade unions programs of activities in labor protection, medical intervention in the working environment that are cross-sectored;
- have to organize regional rescue formation;
- monitor upholding to the regulations on labor protection;
- set the necessary funds for labor protection.

Labor Protection Service is a subdivision of local governments that is conducted by the head of state administration. Labor protection service will conduct its activities with businesses, institutions and organizations located within the appropriate territory, but first of all, with those that belong to the management of state administration, private ownership enterprises. This is primarily objects of communal property, small and medium businesses located in the appropriate territory.

Labor Protection Service, with other departments of state administration performs the following main functions:

- developing an effective integrated regional system of injury prevention of non-productive nature and organizing information support on these issues;
- preparing proposals for introduction of science and technology, increasing the level of injury prevention of non-productive nature, and presenting them to the state administration;
- conducting urgent methodical management of Labor protection;
- receiving information about businesses that are at state registration according to the established procedure;
- organizing providing of regional enterprises with rules, standards, instructions and other regulations on labor protection;
- organizing accounting, analysis of accidents, industrial diseases and accidents in the region, as well as damage of these events;
- helping businesses in the region to organize labor protection;
- supporting the implementation of the science and advanced technology, modern means of collective and individual protection of workers at the regional enterprises that would provide the reduction of injury accidents in the region and are aimed at creating a safe and friendly working conditions;
- coordinating labor protection activities with the regional social insurance against accidents and industrial diseases at workplace;
- considering letters, statements and complaints of employees on labor protection;
- promoting the best domestic and foreign experience in labor protection and promoting safe and friendly working conditions.

Structure of labor protection services in the region depends on the specific characteristics of the region:

- its administrative division,
- the specific characteristics of its structure and their saturation with state enterprises and private ownership,
- traditions that formed and established relationships between administrative units of the region.

Regional state administrations establish regional councils on life safety, and in the office of Regional State Administration – Department of Labor to coordinate all activities on the life safety of the population of regions, including labor protection. Similar units are organized at district administrations. For Labor protection management in the cities the labor protection departments are established (Labor and Social Affairs) by the city councils of deputies.

6.2. Organization of working area

In the process of work, many factors and substances affect a person.

A variety of adverse factors impact on the human during work (dust, gases, vapors, vibration, etc.) which can lead to disease and disability of the workers.

Conditions and factors that adversely affect the human body are divided into physical (temperature, noise, etc.); chemical (dust, gases); biological (infectious diseases); psychophysical. These factors are labor (occupational) hazards.

The purpose of labor protection is implementation of a set of measures aimed at improving the working conditions of labor and increasing productivity at all stages of the process, eliminating adverse effects on the health hazards and prevention of occupational diseases.

The sanitary and epidemiological welfare of the population - the optimal conditions of life, to ensure low incidence, no harmful effects of environmental factors on human health protection, as well as the conditions for the emergence and spread of infectious diseases.

There are the next requirements for organization and creation of working conditions at the enterprises, namely:

1. The organizations and citizens are obliged to maintain their existing industrial, residential, home and other premises in accordance with the requirements of sanitary regulations;
2. The operation of production and other premises and buildings, vehicles, use of technologies must comply with safe and healthy conditions of work and rest, and the owner must carry out activities aimed at the prevention of diseases, poisoning, injuries, etc.;
3. The land and territory should be maintained in accordance with the sanitary standards;

4. Measures to prevent and eliminate the causes of air pollution, water and land should be taken;

5. Placement, construction, reconstruction of enterprises must comply with the requirements of the sanitary legislation;

6. All enterprises, organizations, institutions must create such working conditions that ensure the preservation of health and eliminate the causes of possible injuries and the emergence of occupational diseases and epidemics among workers.

Design of industrial enterprises is carried out with regard to the existing sanitary norms. Every enterprise has its own sanitary protection zone. The dimensions of the sanitary protection zone are taken in accordance with the sanitary classification of enterprises (table 6.1).

Table 6.1

Sanitary protection zone

Class of the enterprise	Zone size, m	Class of the enterprise	Zone size, m	Class of the enterprise	Zone size, m
I	1000	II	500	III	300
IV	100	V	50		

The volume of production premises of the enterprise space per 1 worker is taken not less than 20 m^3 , and the area - not less than 6 m^2 . The height of the premise should be at least 3.2 m.

Sanitary facilities are generally situated in the annexes to the main production building or in separate buildings.

The air of the working area. The microclimate of the working zone. Normalization and control of microclimate parameters.

A necessary condition for normal work is clean air and normal weather conditions in the working area of the premises, i.e. space of up to 2 m above the floor or ground, where there are workplaces.

Meteorological conditions of the work space or climate of industrial premises refer to the climate which is determined by a set of values of temperature (t, C), relative humidity ($\varphi, \%$); air velocity ($V, \text{m} / \text{s}$), temperature of equipment's surface and atmospheric pressure

Optimal meteorological conditions are a set of microclimate parameters that during long time influence on human ensure the preservation of normal function and thermal state of the body without strain its thermoregulatory mechanism, create a thermal comfort i.e. provide a high level of the work capacity efficiency.

Acceptable meteorological conditions are a set of microclimate parameters that during long-term and systematic actions cause health abnormalities. But health is quickly normalized.

In the best case meteorological conditions (microclimate) have the following parameters in a production environment:

- Air temperature t , which has the value is in the range 18 - 22 °C;
- Relative humidity, which should be the value is in the range of 40 - 60 %.
- Air velocity in the workplace V , determined for comfort as 0.1 - 0.2 m/s;
- Atmospheric pressure $P = 760$ mmHg.

During its activity human body generates heat in the environment. The correspondence between the amount of heat and coolant capability characterize it as comfortable. It is in the comfort of the person does not bother feeling heat or cold. High humidity ($\varphi > 85\%$) makes it difficult thermoregulation due to lower evaporation of sweat and the low humidity ($\varphi < 20\%$) causes drying of the mucous membranes of the respiratory tract. The movement of air in a hot premise helps to increase the heat emission by the body and improves its condition, but has a negative effect in the cold season.

The optimal and acceptable meteorological conditions for operating area of the premise are set in accordance with requirements (table 6.2). Their choice takes into account the following factors:

1. The time of year - the cold period (average daily temperature is below 10 °C) and warm period (above 10 °C).
2. The category of physical work depending on physical activity - light work (less than 172 W power consumption - 150 kcal/h), average work (172 - 293 W - 150 - 200 kcal/h), hard work (more than 293 W).
3. Character of the workplace – permanent, non-permanent.

Necessary microclimate parameters are ensured by the fulfillment of a number of measures, namely:

1. Mechanization and automation of production processes, remote control.
2. Improvement of production technology (reduced heat generation of equipment, rational allocation of the equipment, reduction of emissions of harmful substances into the air, dust suppression, etc.).
3. Thermal protection (screens, change the type of heating).
4. Use of ventilation and heating device (heating / cooling air conditioning).
5. Use of personal protective equipment.

Table 6.2

Normalized microclimate parameters of the work space
(Allowable parameters are given for regular work)

Category of work	Temperature, °C		Relative humidity, %		Air velocity, m/c	
	Optimal	Acceptable	Optimal	Acceptable	Optimal	Acceptable
cold season						
light Ia	22-24	25-21	40-60	75	<0,1	<0,1
light Ib	21-23	24-20	40-60	75	<0,1	<0,2
average IIa	18-20	23-17	40-60	75	<0,2	<0,3
average IIb	17-19	21-15	40-60	75	<0,2	<0,4
hard III	16-18	19-13	40-60	75	<0,3	<0,5
warm season						
light Ia	23-25	28-22	40-60	55	<0,1	0,1-0,2
light Ib	22-24	28-21	40-60	60	<0,2	0,1-0,3
average IIa	21-23	27-18	40-60	65	<0,3	0,2-0,4
average IIb	20-22	27-16	40-60	70	<0,3	0,2-0,5
hard III	18-20	26-15	40-60	75	<0,4	0,2-0,6

6.3. Methods and means of air environment control

Ventilation it is a change of air in the premises in order to normalize the parameters of its microclimate.

The aim of ventilation is to provide clean air and normal weather conditions in production facilities. Ventilation removes impurities and heated air from the premise and supply fresh air into premise.

The types of ventilation:

According to air movement:

- Natural;
- Artificial, i.e., mechanical;
- Mixed - a combination of natural and mechanical ventilation.

According to a purpose:

- Forced ventilation;
- Exhaust ventilation;
- Forced-exhaust ventilation.

According to a place of action:

- General;
- Local.

Natural ventilation creates the necessary air exchange due to the difference in the density of warm air inside the room and colder outside, and also as a result of wind. Its types are:

- unorganized, when the intake and removal of air occurs through leaks and pores of external fences, windows – infiltration;
- organized, carried out by aeration and with the help of deflectors.

Deflectors are special nozzles installed on exhaust air ducts and using wind energy.

Aeration is an organized and regulated natural air exchange.

Mechanical ventilation ensures constant air exchange regardless of external meteorological conditions due to a complex of air duct systems and mechanical fans (centrifugal and axial). The air entering the room, if necessary, is heated or cooled, moistened or drained. Purification of air emitted to the outside is also provided.

Fresh air ventilation system extracts air from outside by a fan through the air heater, where the air is heated and humidified, and then fed into the room. The amount of air supplied is regulated by valves or flaps installed in the branches. Contaminated air is expelled uncleaned through doors, windows, etc.

Recirculation of air in the system of flow-and-exhaust ventilation is used in the cold season in order to save heat for heating the air. When recirculating, part of the air removed from the premises, after proper cleaning from the production hazards, is sent back to the room. At the same time, the following conditions must be observed:

1. The amount of clean air coming from outside must be at least 10% of the total amount of air supplied to the room;
2. Air entering the room should contain no more than 30% of harmful substances in relation to their maximum permissible concentrations (MPC).

Recycling is not applied if harmful substances of the 1st, 2nd and 3rd hazard classes, unpleasant odors and pathogens can exist in the air, or possibly a sharp increase in the concentration of harmful or explosive dusts, vapors and gases (in rooms of category A, B, C for explosion risk).

Local ventilation provides ventilation directly at the workplace, catches the harmful effects of their isolation and prevents the entry of these harmful substances into the air of the work area and production premises. When developing projects for the technological equipment of machines, mechanisms, etc. it is necessary to provide local built-in suction which must ensure the required sanitary and hygienic effect and do not interfere with maintenance, monitoring the work process, repair and installation work. Thus, local ventilation systems are associated with the design of the equipment and with the service workplaces. Suction pumps built into workplaces are used for soldering, welding, etc.

Air conditioning is creation and automatic maintenance of the temperature, humidity, purity and air speed which are the most favorable for

people or required for the normal course of the process, to be constant or change in a certain program regardless of the external conditions. Air conditioners are complete and incomplete.

When at the same time in the air of the working area there exist several pollutants of same action the sum of ratios of their actual concentrations ($C_1, C_2, C_3 \dots C_n$) to their MPC ($MPC_1, MPC_2, MPC_3 \dots MPC_n$) should not exceed 1. The calculation is performed by the formula:

$$\frac{C_1}{MPC_1} + \frac{C_2}{MPC_2} + \frac{C_3}{MPC_3} + \dots \frac{C_n}{MPC_n} \leq 1, \quad (6.1)$$

where $C_1, C_2, \dots, C_n$ is the actual (measured) concentration of harmful substances in the air of the working area, mg / m^3 . $MPC_1, MPC_2 \dots MPC_n$ is the maximum permissible concentration (Standards) of harmful substances in the air.

The effectiveness of the ventilation system is determined by the rate of air circulation (K) [1/hour]

$$K = \frac{V}{V_p}, \quad (6.2)$$

V is amount of air removed from the premises per hour, m^3 / hour ;

V_p is volume of premises, m^3 .

To determine the volume of air that must be removed from the premises we need to know:

V_1 – volume of air, taking into account its heating, m^3 / hour ;

$$V_1 = \frac{Q}{\rho \cdot C(t_{out} - t_{in})}, \quad (6.3)$$

where

Q is the total amount of heat, kJ / hour

C is heat capacity of air, $kJ / kg \text{ } ^\circ C$,

ρ is air density, kg / m^3

T_{out} is removed air temperature, $^\circ C$

T_{in} is inlet air temperature. $^\circ C$

V_2 is volume of air taking into account the harmful substances, m^3 / hour

$$V_2 = \frac{K}{K_{out} - K_{in}},$$

K is total amount of harmful substances escaped in 1 hour, g / hour ,

K_{out}, K_{in} – concentration of pollutants in the removed air and inlet air, g / m^3 .

By the nature of the effect on the human body, harmful substances are divided into the following groups:

1. general toxic - cause poisoning of the whole organism (lead, mercury, benzene)
2. irritating - irritate the respiratory tract and mucous membranes (chlorine, ammonia, nitrogen oxides)
3. sensitizing – allergens (solvents, varnishes)
4. carcinogenic - nickel, amines, chromium oxide, asbestos
5. mutagenic - leading to a change in hereditary information (lead, manganese, radioactive substances)
6. affecting the reproductive function (lead, mercury, styrene).

By the degree of exposure on the human body, harmful substances are divided into 4 classes:

1. extremely dangerous (MPC to 0.1 mg/m³);
2. highly dangerous (MPC from 0.1 to 1.0 mg/m³);
3. moderately hazardous (MPC from 1 to 10 mg/m³);
4. little dangerous (MPC more than 10 mg/m³).

Air cleaning systems. Depending on the residual concentration of pollutants, air cleaning systems are divided into:

- primary purification (>100 mg/m³);
- average purification (100 - 1 mg/m³);
- fine purification (> 1 mg/m³).

6.4. Methods for cleaning air

Mechanical:

- dust collectors – When air purification is achieved by the forces of gravity and inertia;
- filters are devices that use materials that tend to keep the dust (paper, cloth, electrical, ultrasonic, oil, hydraulic, or combined).
- Physical and chemical
- sorption:
- adsorption,
- absorption.
- catalytic.

Air conditioning is creation and automatic maintenance of temperature, humidity, cleanliness and air velocity that is the most comfortable for people

The control of air pollution parameters is usually conducted with a:

- thermometer (temperature)
- hygrometer (humidity)
- anemometer (air velocity)
- actinometer (intensity of thermal radiation)
- gas analyzer (concentration of pollutants).

6.5. Lighting of working area. Basic lighting values

Visible light is an electromagnetic radiation with a wavelength of 380 ... 760 nm. Sensitivity of human is maximum to yellow-green color (wavelength 555 nm).

Efficient lighting organization process is one of the mainly tasks of the labor protection. In case of insufficient lighting conditions, the labor capacity sharply decreases possibility of accidents increases and fatigue becomes. Depending on the source of light, the industrial lighting can be of three types: the natural, artificial and combined.

The number of qualitative and qualitative factors characterize lighting:

Quantitative factors:

Light Flux (Φ) is part of the radiant flux that is sensed by person's vision as light (measured in lumens, lm).

Intensity (I) is the value of estimating the space density of the light flux and represents the ratio of the light flux to solid angle of light flux distribution. (measured in candela, cd):

$$I = \frac{dF}{d\omega}. \quad (6.4)$$

Illumination (E) is the surface density of light flux and is equal to the ratio of incident light flux dF on the element dS of the surface to the area of this element

(measured in Lux, Lx):

$$E = \frac{dF}{dS}. \quad (6.5)$$

Brightness of the surface (L) is the ratio of light intensity in this direction, to the area of the illuminated surface:

$$L = \frac{I}{S}. \quad (6.6)$$

In case of side light source:

$$L = \frac{dl}{dS \cos \theta}, \quad (6.7)$$

where dl is the light intensity emitted from the surface in the direction of θ .

Reflection coefficient is defined as the ratio of the light flux reflected from the surface to incident light flux on it:

$$\rho = \frac{F_{\text{ref}}}{F_{\text{inc}}}. \quad (6.8)$$

The main qualitative factors of lighting include:

- background is the adjoined surface to the object, in which it is examined;
- visibility is the ability of the human eye to perceive the object at illumination of 0.1 to 100 000 lux;

•blindness factor is a criterion of blinding action created by the lighting system.

The lighting system must meet the following requirements:

1) Lighting of the workplace should correspond to the nature of visual work, which is determined by three parameters: the differentiation object; background; contrast;

Contrast is ratio of difference between object's brightness and background brightness to background brightness (L_0 and L_b are the brightness of the object and the background, respectively):

$$K = \frac{L_0 - L_b}{L_b}; \quad (6.9)$$

2) It is necessary to provide the uniform brightness distribution on the working surface and also within the surrounding area;

3) There must be no sharp shadows on the work surface;

4) Absence of the direct and reflected glare in the field of view (High brightness of luminous surfaces causes blindness);

5) The illumination value must be constant in time;

6) It is necessary to select the optimal direction of light flux and desired spectral composition of light;

7) All elements of lighting equipment must be long-lived;

8) The lighting system must be simple and easy to use that meet the requirements of aesthetics.

6.5.1. Natural lighting

Natural illumination is characterized by high diffuse (dispersion) of daylight from the sky, which is very favorable for visual environments.

Natural lightning:

- Side lighting;
- Overhead lighting;
- Combined

Natural lighting is characterized by the fact that this illumination is measured in an extremely wide range, depending on: times of the day, year, and weather conditions. Therefore, natural lighting is impossible to be quantitatively determined by the illumination value. The relative value of daylight factor is adopted as the rated values for natural lighting, which is expressed as a percentage illumination ratio at a given point (E_b) in space to the outdoor horizontal luminance created by light is fully open (clear) sky, i.e.:

$$DF = \frac{E_{in}}{E_{ext}} \cdot 100\%. \quad (6.10)$$

Thus, daylight factor assesses dimensions of window openings, type of glazing and casements, and their pollution. Calculation of natural lighting is carried out by determination of the area of windows.

6.5.2. Artificial lighting

Artificial lighting is provided in all residential and industrial premises, where there is insufficient natural lighting, as well as to illuminate the room during the night shifts.

Main classification of the artificial lighting

- common:

- local;

- combined.

By a functional purpose, artificial lighting is divided:

- working,

- emergency,

- special:

- evacuation,

- security,

- tell-tale,

- signal,

- bactericidal,

- erythema.

Working lighting is designed to ensure the production process, passage of people, traffic and is mandatory for all production premises.

Emergency lighting is provided to continue the work when sudden disconnection of working lights can cause accidents. Minimum illumination of work surfaces with emergency lighting should be 5% of the normalized light working lights, but not be less than 2 lux.

Evacuation lighting is designed to ensure evacuation of the personal during accidents from premises. Minimum illumination should be not less than 0.5 lux.

Security lighting is arranged along the borders of the territory of the object, which is protected by a special staff. Minimum illumination at night is 0.5 lux.

Signal lighting is used for fixing the borders of dangerous areas indicate the presence of danger or safe way.

Bactericidal lighting is used to disinfect the air, water, food.

Erythema lighting is arranged in production spaces areas where sunlight is insufficient.

There are 8 categories and 4 subclasses of work, depending on the degree of eyestrain. All these categories are normalized for lighting.

Main harmful impacts on human vision are:

1. Inadequate illumination of the workspace.

2. Absence or insufficiency of natural light.
3. Increased brightness.
4. Eyestrain.
5. Blinking.
6. Reflected light.

Factors that should be considered for artificial lighting normalization:

- characteristic of visual work;
- minimum size of the object, its difference from the background;
- kind of visual work;
- lighting system.
- the contrast of the object with the background;
- characteristics of the background;
- type of light source.

Main methods of artificial lighting calculation:

- method of light flux
- method of specific power;
- point method.

The device of the lighting control is illuminometer.

6.6. Methods of studying occupational injuries

The development of measures to prevent accidents at work is conducted on the basis of data obtained in the study of the causes of injuries. To study injuries in practice, there are applied the following methods: statistical, group, topographic, monographic and economic.

1. Statistical. It provides an opportunity to assess the quantitative and qualitative levels of injury through two indicators - the frequency factor and the severity of accidents.

The frequency factor F_f is calculated per 1000 people of the staff, i.e. expresses the number of accidents per 1000 people for the reporting period - year, half year, quarter at the given enterprise:

$$F_f = (n / P) \cdot 1000,$$

where n is the number of considered accidents, i.e. cases with disability for three days or more; P - the list of employees working in the reported period, which takes into account all employees.

Severity factor S_f expresses the average number of disability days for one accident in the reporting period:

$$S_f = T/n,$$

where T is the total number of disability days according to the completed sick leaves. N is the number of accidents taken into account during the reported period. The severity factor does not include the death and severe cases that led to disability. Therefore, to characterize the state of injury, it is necessary,

in addition, to have in mind such separate NSs, if they occurred at the enterprise.

In addition to these indicators, the report provides information on the number of disability days per 1000 workers, which is expressed by the coefficient of minimum material losses.

The loss factor is the product of the coefficients of frequency and gravity:

$$K = F_f S_f = (T / P) \cdot 1000.$$

These indicators allow you to compare the state of injury in various shops, enterprises and individual industries. Thus, identify the production processes, which, due to some conditions, give the maximum number of injuries.

The statistical method makes it possible to fully characterize the state of traumatism, drawing attention to occupations with the most unfavorable working conditions, but without revealing the causes of injury. For the prevention of injuries, it is necessary to know the technical and organizational factors that caused it or contribute to its occurrence.

2. Group method. It is based on the recurrence of accidents regardless of the severity of the lesions. All accidents are analyzed by groups: the age of the victims, the tools of labor, the nature of the work, etc. The method is good because it makes it possible to identify professions and jobs for which a greater number of accidents.

3. Topographic method. It consists in studying the causes of the accident at the place of their occurrence. All accidents are fixed on the plans of the workshops and the enterprise as a whole with conditional signs in the places where they occurred

4. Monographic method. It includes a detailed study of the entire set of conditions in which the accident took place: labor and technological processes, basic and auxiliary equipment, materials to be processed, general conditions of production, workplaces, trajectories of people and objects, personal protective equipment, clothing and work , The mode of work and rest, psychological factors, etc. Thus, through careful examination of the entire complex in general and in detail, the state of the individual parts of the plant's production sites is revealed from the point of view of safety engineering. And what is especially important are not only the causes of the accidents that are revealed, but also potential hazards that are hidden and not manifested, which can have a harmful effect on workers not only in the event of a technological process violation but also in the normal course of the process. This method makes it possible to most fully determine the ways of preventing injuries.

5. Economic method. It consists in determining the losses caused by occupational injuries, as well as in assessing the socio-economic effectiveness of measures to prevent accidents.

7. CIVIL DEFENCE

Civil defense or civil protection is an effort to protect the citizens of a state (generally non-combatants) from military attacks and natural disasters. It uses the principles of emergency operations: prevention, mitigation, preparation, response, or emergency evacuation and recovery. Programs of this sort were initially discussed at least as early as the 1920s and were implemented in some countries during the 1930s as the threat of war and aerial bombardment grew. It became widespread after the threat of nuclear weapons was realized.

7.1. Emergency classification

The emergencies are divided into natural, social and anthropogenic

Natural emergencies include natural processes of space, lithosphere, hydrosphere, atmosphere, biosphere or several processes occur simultaneously and independently of human intervention.

Social emergencies occurring in society: the state of war, crime, revolution, ethnic conflicts, the proliferation of man-hate ideologies and others.

Man-made emergencies related to the material sphere, which is created by man.

As a result of natural, social or anthropogenic emergency, their interactions or negative human activities of mankind could appear the environmental consequences equal to the emergency.

Natural emergencies (in scale and depth of emergencies) are divided into:

- local,
- regional,
- objects,
- city,
- national
- global.

Local emergencies are limited by frames of production facilities.

Object emergencies are limited to the object.

City emergencies are limited to the human settlement, region or area.

Regional emergencies are limited to the few areas in the land or adjacent countries.

National emergencies Implications cover large areas of the state, but not beyond its borders.

Global emergencies. The area under threat of their occurrence and the effects is a continent or a significant part thereof, or the planet as a whole.

Emergencies which caused the accident can be classified into:

- Essence and nature of the event;
- Place of origin;

- Most important factors;
- Main reasons;
- Nature of the damaging factors and hazards;
- Intensity of the behavior;
- Scale of damage and influence;
- Nature of the influence.

One and the same emergencies may occur in peacetime and in wartime. Military time is characterized by the use of a large number of usual weapons, the ability to use the mass-destruction weapons and influence equal to the natural disasters or even exceed them.

7.2. Causes of emergencies

Each of emergencies may cause another emergency.

In each case, emergencies arise because of a number of causes that can be summarized as it shown in fig. 7.1.

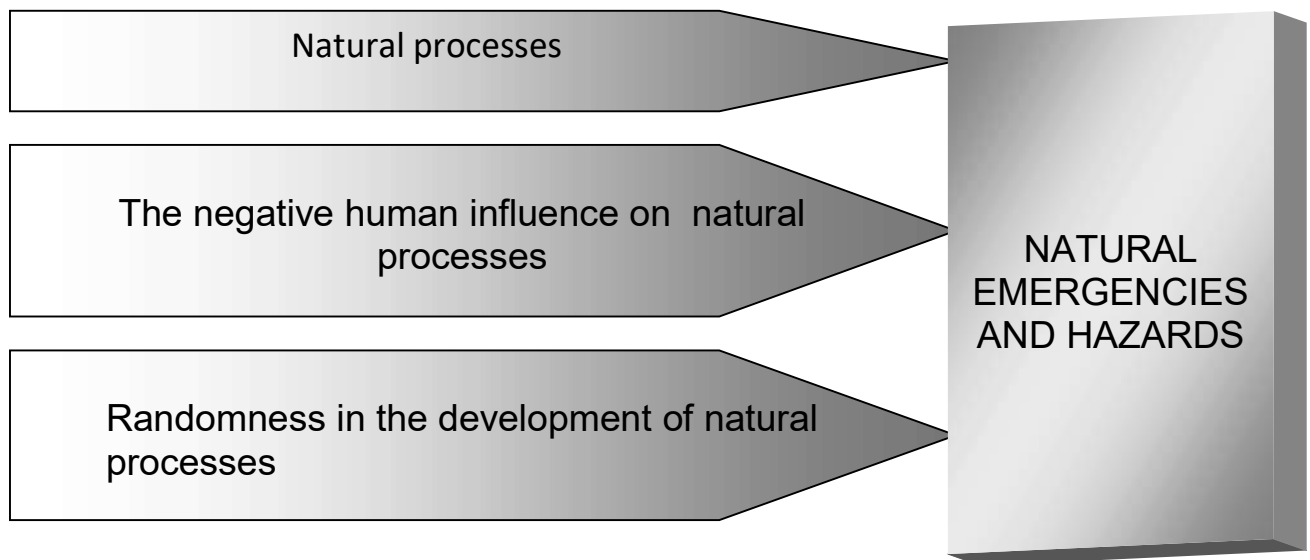


Fig. 7.1. Causes of the natural emergencies and hazards

Classification of social emergencies causes:

- political causes;
- economic causes;
- national causes;
- religious causes.

Anthropogenic emergencies could happen for the causes:

- failure to the safety rules;
- imperfection in design;
- criminal elements and terrorism;
- military actions;
- phenomena.

In peacetime, there may be emergencies of all kinds, even those specific to wartime emergencies as nuclear explosions, chemical and bacteriological contamination due to accidents and terrorist activities.

7.3. Natural emergencies

Natural disasters are dangerous natural phenomena, processes of lithospheric, atmospheric, hydrological, biosphere or other origin on such scales that cause catastrophic situations with sudden violation of the life support system, devastation and destruction of property, real economy.

Types of disasters:

Meteorological:

- drought;
- increase or decrease in temperature;
- storm;
- hurricane;
- tornado.

Tectonic:

- earthquake;
- tsunami;
- eruption;
- shift.

Topological:

- mudflow;
- flood;
- avalanche;
- rockfall;
- snow drifts;
- fire.

Space:

- increased ionizing radiation;
- impact of large space objects.

Biological:

- abnormal increase in the macro-biological objects;
- epidemic.

Natural hazards are processes that can lead to negative effects on a small area and cause emergency situations of natural or anthropogenic origin

Types of natural hazards:

- lightning;
- downpour;
- sleet;
- hail;
- strong wind.

Global natural, and in some cases, anthropogenic emergencies, environmental effects, which impact the whole or the most part of the planet, are called disasters.

7.4. Anthropogenic emergencies

Anthropogenic emergencies appear because of sudden failure of machines, mechanisms and assemblies, accompanied by significant violations of the manufacturing process, explosions, fires, radioactive, chemical or biological contamination, which have led or may lead to material losses or death.

Types of accidents and disasters:

- transport;
- fire;
- explosions;
- destruction facilities;
- demolition equipment;
- destruction in violation of energy, water, heat and other life-support systems of population and production;
- destruction with the release of radioactive substances;
- destruction with the release of toxic substances;
- destruction with the release of dangerous microorganisms.

By the size and the damage accidents are divided into:

- light;
- averages;
- heavy;
- especially heavy.

7.5. Fire and its causes

Fire is uncontrolled burning that has moral and material damage, sometimes causes death.

Main causes of fire:

- failure in fire safety regulations;
- careless handling of fire;
- electrical fault;
- accident, disaster;
- natural phenomenon.

The burning process is possible with presence of:

1. Combustion agent;
2. Oxidant;
3. Ignition source.

Combustion agent – could be solid, liquid or gaseous substance that can oxidize with heat and light radiation.

Oxidant – oxygen, chlorine, fluorine, sulfur and other substances.

Ignition source – means the influence fuel and oxidant substance that can cause burns. Ignition source could be open and hidden.

In the absence of one of the three factors of combustion does not occur.

Inflammable materials are the materials and substances with properties to appear and spread of fire.

Ignition is burning under the influence of the source of ignition.

Flash is quick combustion of combustible mixture that is not accompanied by the formation of compressed gases.

Spontaneous combustion is the phenomenon of a quick increase of exothermic reactions rate that leads to the burning.

Inflammation is ignition, accompanied by the appearance of the flame.

Spontaneous fire is spontaneous combustion, accompanied by the appearance of the flame.

Explosion is a quick transformation of matter, accompanied by the release of energy and the formation of the compressed gases front.

Flash point is the lowest temperature of the substance at which the stable burning is possible.

For flammable substances and materials properties are divided into 3 groups:

1. Combustible - have property of spontaneous combustion, or burn up because of a source of ignition and burn yourself when removing a source of ignition;

2. Hard-combustible - can burn up in the air because of the source of ignition, but do not burn in the absence of a source of ignition;

3. Noncombustible - cannot burn in air.

Fire resistance of buildings is the ability to maintain carrier and protective functions in case of fire.

Classification of manufactures according to fire and explosion safety:

- Non-explosion-proof and fire-hazardous;
- Fire-hazardous;
- The enterprises where there are roasted incombustible materials or solid, liquid or gaseous substances to be burned for utilization as fuel.
- Enterprises, where there are substances in cold state only.
- Explosion-proof.

The space of the premises or its part where explosive mixtures can appear, or there could be combustible materials is called an explosion and flammable hazard zone.

7.6. Organization of fire protection in production

Duties of managers and officials concerning fire safety:

1. To develop a set of measures to ensure the fire safety of the enterprise or organization;

2. According to government regulations on fire safety, to design and approve regulations, instructions and other regulations in force within the enterprise;

3. To organize the training of employees on fire safety;

4. To keep in good condition of fire protection means and communication, fire equipment, machinery and stocks. Do not use it for other purposes;

5. To carry out an official investigation in case of fire.

General requirements for fire safety:

- Each employee must know the rules of behavior in case of fire, escape routes, to be able to use the primary means of firefighting, to know their location.

- Flammable and combustible liquids must be stored in designated areas separate from other materials.

- In case of fire, employees must immediately notify the fire department by special phone number and the company's management, and immediately initiate the elimination of fire with all available means.

Government fire safety inspectorate develops and executes the complex of technical, operational, organizational and operational measures to prevent fires. Representatives of Government fire safety inspectorate have a right to check the status of fire protection of buildings, warehouses, request documents and information, to bring to book those guilty of violating the statutes, rules, regulations, instructions, partially or completely prohibit the operation of the enterprise in the presence of fire danger.

7.7. Fire prevention measures

Fire prevention measures can be:

1. Constructive;

2. Security;

3. Explanatory.

Fire Prevention is a complex of organizational and technical measures to ensure fire safety of workers, preventing fires, creating conditions for quick and effective firefighting.

Fire safety is the state of object in which the emergence and development of fire; effect on people fire hazards are excluded with certain probability.

Fire safety is usually ensured by:

1. Warning system of fire prevention

2. Fire protection system

3. Organizational and technical measures

An indicator of the *efficiency of evacuation* is the period of time during which people can, if necessary, leave some premises and house.

Safety of evacuation is achieved only if the duration of the evacuation of people from buildings and premises less than the critical time of the fire, which is dangerous to humans.

Crash time of fire is the time of reaching temperatures dangerous to human and reducing oxygen content in the air.

Rules of behavior in case of fire at the objects:

- In case of fire it is necessary to call the fire department and inform management and staff.

- Use the necessary measures to extinguish the fire themselves.

- Evacuate people and property. Primarily evacuate most valuable and flammable materials.

- It is necessary as soon as possible to leave the premises through the fire exits if extinguish the fire themselves is impossible.

- Leaving the premises where the fire is occurred, personnel have to close the doors tightly to reduce the oxygen supply to the premises.

The main danger from which people are killed by fire - the smoke and hot air, so in the smoke-filled premises personnel must breathe only through a wet thick cloth, remembering that near the floor the concentration of smoke is the lowest.

7.8. Extinguishing means

The primary means of extinguishing are usually placed on special boards. These boards are set so that the distance to the farthest building is no more than 100 m, and from storage of flammable materials - no more than 50 meters, or the rate - one board on 5000 m²

Extinguishing means are painted in red, and the inscriptions on them and on boards are made in a contrasting white color.

Extinguishing substances:

Water. The main effect of extinction is cooling combustible items below combustion temperature. Disadvantages extinguishing water: water freezing at negative temperatures, water does not extinguish flammable liquid with a boiling point below 80 C, causing significant damage to equipment and buildings, it is possible the electrical shock hazard, poorly wets some fibrous and solids, so when they are extinguished by water the effect is absent.

Foam could be chemical and air-mechanical. Chemical foam consists of bubbles of carbon dioxide; air-mechanical contains air bubbles. Extinguishing foam effect is the cooling of the upper layer and insulation flammable objects from the air. Foam is used to extinguish the electrical energized and active substances such as potassium, sodium, carbon disulfide, with which it reacts.

Carbon dioxide (CO₂) is used mainly for extinguishing electrical installations. Carbon dioxide cannot extinguish ethanol, in which it is dissolved, and celluloid, termite, burning without air. When extinguishing by carbon dioxide the concentration of CO₂ increases.

Powders. Powder cloud provides protection against thermal radiation, so the fire can be extinguished without special protective clothing. Interaction of powders and roasted items cause the appearance of salts and discharge flammable gases that increases the extinguishing effect powder. But in premises the extinguishing powder creates a high air dust, powders also have weak cooling effect, which may lead to re-ignition.

7.9. Communication and fire alarm

For communication in case of fire personnel usually use the phone, radio, cordless devices of automatic and semi-automatic connection. To inform people in the premises there may be used special communication system, internal Broadcasting network, and sound warning system.

The main components of automatic alarms are sensors installed in buildings or in objects territory for the alarm in case of fire, the receiving devices (stations) to ensure reception of signals from sensors, communications line connecting the sensors with acceptance devices, sources of supply.

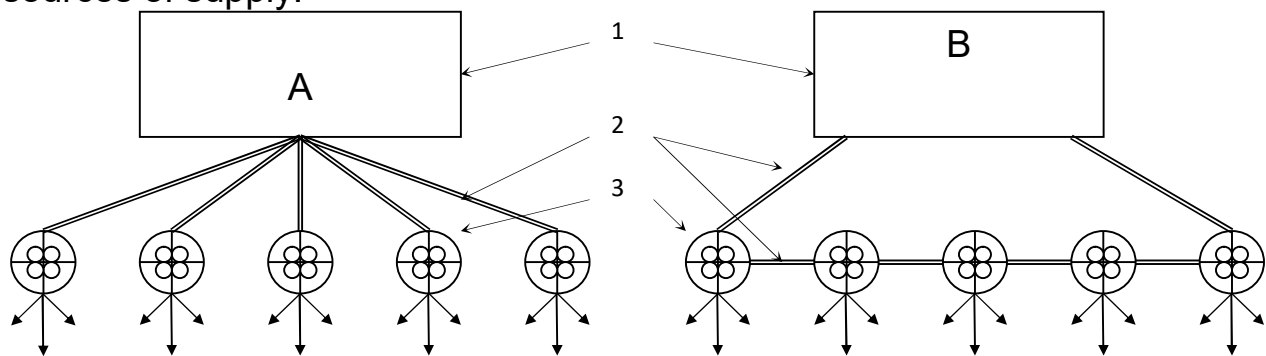


Fig.7.1. Circuit connection of sensors with control station:

A – radiation connections; B – ring connections;

1 – receiving station; 2 – line connection; 3 – sensors

According to the principle of the sensors operation, they are divided into:

- heat;
- smoke;
- light;
- combined.

Heat sensors respond to the temperature increase and are divided into: maximum actuated by raising the temperature to the set of critical importance; differential actuated by the temperature of the environment at a certain speed, maximum-differential.

Smoke sensors are divided into ionization and photoelectric. Smoke sensors must not be installed in areas with temperatures low - 30 °C and more than 60 °C, relative humidity above 80% and in very dusty areas and places where there can be acid vapor.

Light sensors react to ultraviolet or infrared radiation.

Combined sensors are created by the principles of operation of heat and smoke sensors.

The signals coming from the sensors from receiving stations fire alarm, automatic fire extinguishing.

7.10. Prediction of ecological and socio-economic consequences of emergencies

One of the main objectives of Civil Defense is the "prediction and estimation of socio-economic consequences of emergencies"

Prediction of social and economic consequences of Emergencies is preliminary detection of possible progress of events (that cause human casualties and material losses) on the researched object territory of economy in case of the emergency situation (ES) occurrence. Goal of prediction of social and economic consequences of emergencies is establishment of the needs of power, funds, financial and material resources for prevention of the Emergencies occurrence or for minimization and effective elimination of possible consequences.

The main components of prediction include identification and exposure:

- list of anthropogenic (natural, social, political and military) emergencies that can appear in the territory of the researched object or cover it;
- the possible level of the risk of each emergencies situation;
- the results of the identification and estimation of the expected operational situation that can appear in the objects territory in case of each emergencies situation realization (for convenience of carrying out of this work the expected operational situation is divided into engineering, fire, radiation, and chemical one).

Identification and estimation of expected operational situation are carried out with help of special documents: "Card of expected (engineering, fire, radiation or chemical) operational situation. The document includes: name of the object, name and location of the event, which leads to the ES, main classification of the ES characteristics and parameters). The document includes the plan of the object and the plan of the surrounding territory.

The main operations of identification of expected ES (engineering, fire. Radiation or chemical) are detection and mapping (using tactical signs and explanatory notes) the following:

- names of the primary destructive factor of specific ES;
- location and main characteristics of this factor source;
- shape, dimensions and spatial location of the external borders of areas of possible damage (for example: zones of full, strong, medium and weak damage, or areas of primary and secondary fires, or radiation hazard zones and zones of moderate, strong, dangerous and extremely dangerous radioactive contamination or chemical contamination zone, respectively);

- possible negative impact of destructive factor on the elements of the object (such as a full, strong, medium or weak destruction of specific elements or areas of secondary fires, or of the territory of the object to be contaminated by radioactive or hazardous chemicals and so on, with designation of the intensity of this contaminations).

- The main operations of estimation of expected (engineering, fire, radiation or chemical) ES is detection and mapping (with explanatory notes):

- possible values of common and sanitary losses of objects staff (population);

- possible level of damage;

- possible level of specific ES;

List of urgent work in the ES area that has to be carried out for elimination of ES consequences elimination (with the designation of the volume of each of these works, as well as manpower and resources needed for its execution).

The results of the Identification and estimation of the expected operational situation that can appear in the researched object (in case probable ES) are the basis for the development of following mandatory documents for each potentially dangerous object:

- Safety program of the industry enterprise;

- Plans on localization and liquidation of emergency situations and accidents;

- Plans on responds to ES;

- Research materials of the existing operation of the industrial object;

- Plan on responds to the threat of ES;

- Declaration of the industrial enterprise safety.

7.11. Elimination of emergencies

Elimination of emergencies is all types of rescue and emergency operations in the area of the E and the surrounding areas that are conducted by forces and means of civil defense (CD) as well as the organization of life support of the affected population and rescuers. There are immediate response to the E and the planning period of elimination. The main measures of immediate emergency response are the organization and conduct of reconnaissance (R) and emergency operations (EO) in the E area.

Reconnaissance in a E zone is collection and transmission of data about actually existing operational situation to management and forces of CD. It is necessary for the effective performance of EO in the E area life support of population. There are several types of reconnaissance: engineering (engineering and visually detect fire conditions), biological, radiological, sanitary-epidemiological and chemical. Thus, first of all, the reconnaissance of rescue work regions and safety of their movement routes are carried out in the E area.

Urgent work in the E area include emergency (search) - rescue, emergency - restoration works, the provision of immediate medical care, the implementation of sanitary and epidemiological measures and protection of low in the E area.

Emergency (search) rescue work in the E area is action of the CD forces with objective of finding, protection and rescue of people, material and cultural values and the protection of the environment during the immediate response to the E, and the localization of the zone of damaging factors influence that appear in the condition of accidents, catastrophes and natural disasters.

Emergency restoration work in the area of the E is the priority work for restoration of individual structures and buildings, removal of faults in networks and communication systems in order to make the minimum necessary conditions for the successful implementation of reconnaissance and rescue works and works in field of population life support, sanitary cleaning and areas decontamination.

Urgent medical care (NMD) in the E area is carrying out of urgent medical diagnostic, hygienic, anti-epidemiological, evacuation, medical and other activities that are carried out in the shortest possible time in case of losses, injuries and diseases of people.

The most important of hygienic, anti-epidemiological activities in the E area are the sanitization of people (animals), sanitary cleansing and disinfection of the territory.

Sanitization of people is a mechanical cleaning and washing of the skin and mucous membranes of humans, their clothing, footwear and personal protective equipment (that have experienced contamination (pollution) biological, radiological and chemical), as well as in case of exit from the E zone.

Sanitary cleansing of territories in E zone is the action of Special Forces with the goal to find and pick up the hazardous items and products of organic and inorganic origin, which were formed as a result of the Emergency, for further burials in specially designated areas and decontamination of their location.

Decontamination is the action of special forces for reducing to a maximum permissible norms of pollution (contamination) surfaces and areas by chemical, biological, radioactive substances through decontamination, decontamination, disinfection and detoxification.

Protection of low in the E zone is the action of the security forces on the organization and regulation of the transports movement, protection of material value of any form of property, personal property of people, as well as providing the emergency status of the order of exit and entry into the zone of the E of people and vehicles.

The authorized person (head) is usually assigned for directly management and implementation of measures to eliminate the particular

Emergency situation. Authorized head forms the headquarters of the E elimination, with the main task to organize and coordinate activities to respond immediately to a specific E.

7.12. The main methods in the field of civil defense

In case of an emergency the authority and the CD forces must do the following: warning and information; monitoring and laboratory control; shelter in protective structures, evacuation, engineering protection, medical protection, psychological protection, biological protection, environmental protection, radiation and chemical protection.

Warning and informing include operational delivery to the population about the occurrence or possible threat, emergency or disasters (through a national, regional and local automated system of centralized notification) timely development and organizational and technical association of permanent local warning systems and public notification with special monitoring systems and control in the areas of possible lesion, the use of centralized systems of communication, radio , television and other technical means of transmitting information, regardless of ownership and subordination.

Monitoring and laboratory control include creating and maintaining a constant readiness of state and regional networks of monitoring and laboratory control and testing, the organization of the collection processing and transmission of information about conditions of the environment, food contamination, food, fodder, radioactive water, chemicals and infectious organisms

Shelter in protective structures. The protective structures are built to provide shelter of population in cities, villages, and the staff at the workplace. It is carried out through the integrated development of underground space of settlements for accommodation inside of this space the buildings and premises of social and domestic, industrial and household purposes, taking into account the need to adapt and use of the premises for the shelter of population in case of emergency; examination of structures and facilities that meet the case of the protection structures of underground space settlements, mining, natural caverns, and providing of additional equipment to meet the case protection basement and other in-depth areas, construction of other premises for immovable objects that are adapted for CD tasks, construction of simple shelters in period of potential emergencies, construction of individual refuges and fallout shelters.

In case of a high probability of sudden emergency occurrence the shelter in protective structures is one of the most effective ways to protect the production staff and the population. The Companies protective structures is subject to the production staff of most big working shifts, and neighborhoods

protective structures is subject to the population in accordance with the regulatory legal documents about in the shelter defenses.

The CD protection structures are divided into shelters and fallout shelters, built-in structures (B) and free-standing structures (O) .

Refuge is a CD engineering structure designed to provide protection of people from exposure: air shock wave of explosions and strong winds, thermal radiation of explosions and fires, ionizing radiation, neutron radiation, radioactive contamination (pollution) chemical pollution (contamination), bacterial agents. Shelters are built with a capacity of at least 150 people and are equipped with communication systems and lighting.

Fallout shelters are CD engineering facilities designed to protect people from air shock waves and strong winds, ionizing radiation, neutron radiation and radioactive contamination (pollution) thermal radiation explosions and fires; bacterial agents. According to the protective properties are divided into 5 groups. The fallout shelters include facilities for rooms for people, facilities for the ventilation system that operating in the simple ventilation, storage room for food, medical center, toilets, and are equipped with systems of water supply, communications, and lighting.

Evacuation of population. Evacuation and placement in the areas safe for habitation are held with the lack (deficit) of shelters in the settlements, which are in the areas of possible catastrophic flooding, dangerous radioactive contamination, chemical lesions, natural disasters, accidents and catastrophes in case of threat to life and health. Evacuation can be general and partial. General evacuation is carried out in the case of radioactive contamination around the nuclear power plant, catastrophic flooding areas with less than 4 hours of running of a breakthrough waves, in the area of a military nature disaster. Partial evacuation is carried out by the decision of the Cabinet Council. First of all, evacuate people who are not employed in manufacturing, service sector of the population, students, schools, kindergarten children, and disabled persons, patients of hospitals with co-workers and members of their families. Evacuation is conducted on foot and on available transport. To prevent panic it is necessary to provide: evacuation planning , designation of zones that suitable for evacuees; warning of management of central and local executive authority, enterprises, institutions and organizations and the population about the evacuation, evacuation management, creation of the minimum conditions that necessary for the life of the evacuated population, education of the population about actions during the evacuation.

For this purpose the evacuation Commission creates assembly points, intermediate evacuation points and receiving evacuation centers.

8. LABORATORY PRACTICE WORK

8.1. Preliminary analysis of the engineering system safety

General information.

At analysis of objects from positions of safety such problems are solved:

- 1) Revealing of the dangers working on object;
- 2) Estimation and comparison of dangers;
- 3) Decision-making on protection against concrete danger;
- 4) Choice of optimum ways of protection against danger.

The key concept of such analysis is danger.

Danger is the phenomenon, the process or the object, which are capable in the certain conditions to cause damage to health of the person directly or indirectly, causing undesirable consequences.

Dangers are constantly present in the environment. Their sources are any activity or condition of the environment, which are capable to result in realization of danger as an occurrence of dangerous factors in an environment. Dangers are in all systems having energy, chemically or biologically active components, etc.

At revealing dangers we will use the following nomenclature of dangers:

- 1) an abnormal parameters of a microclimate;
- 2) an abnormal light exposure;
- 3) an increased noise level;
- 4) an increased vibration level;
- 5) a fire;
- 6) an explosion;
- 7) a lesion with the electric current;
- 8) an increased level of electromagnetic radiation;
- 9) a mechanical injury;
- 10) a burn;
- 11) a poisoning, etc.

At estimation of danger two characteristics represent the greatest interest. The value of danger is usually determined according to consequences arising from realization of this danger. The second characteristic is a frequency of danger occurrence. The risk of danger is an integrated value which takes into account both characteristics.

Risk is a complex assessment of danger, which is generally determined in quantitative expression as a product of value of danger by frequency of its occurrence.

At performance of the object safety analysis (or the analysis of risk) two stages are distinguished:

- 1) the preliminary analysis of risk,
- 2) the quantitative analysis of risk.

The purposes of the preliminary analysis of risk are revelation of all dangers effecting the object, determination of their qualitative characteristics and also development of the basic actions of protection against dangers.

Accomplishment of the quantitative analysis consists in a choice of optimum protective actions based on quantitative criteria of safety.

Qualitative characteristics of danger are a category of danger depending on a value of consequences and qualitative assessment of frequency of realization of dangers.

The category and the frequency of realization of danger can be determined according to tables 2.1 and 2.2 (p.12) of these technical recommendations accordingly.

At performance of the preliminary analysis, the rank of danger is used as a risk. The rank can accept four values which can be determined according to table 2.3 (p. 13).

After determining of qualitative characteristics of danger, the basic actions of protection against dangers are developed based on engineering logic, if it is necessary.

The order of practice accomplishment:

1. Choose variant of engineering system from table 8.1.
2. For the chosen system execute the preliminary analysis of safety according to the following algorithm:
 - accomplish decomposition of system;
 - establish interrelation between elements;
 - define dangers for system and the parts of system being sources of these dangers, using the nomenclature shown above;
 - determine qualitative characteristics of dangers and fill in the special form (table 8.2);
 - apply restrictions on the analysis of safety;
 - make conclusions and develop preliminary recommendations on protection of system.

Table 8.1

The variants of engineering system

No	The name of technical system	No	The name of technical system
1	An electric water heater	11	An electric water heater
2	An electric coffee grinder	12	An electric coffee grinder
3	An electric drill	13	An electric drill
4	An electric meat grinder	14	An electric meat grinder
5	A hair drier	15	A hair drier
6	An electric oven	16	An electric oven
7	An electric water heater	17	An electric water heater
8	An electric coffee grinder	18	An electric coffee grinder
9	An electric drill	19	An electric drill
10	An electric meat grinder	20	An electric meat grinder

Table 8.2

Determination of qualitative characteristics of dangers

No	Element of object	Danger	The characteristic of danger		
			Category	Probability	Rank

The example of practice accomplishment

The purpose is to accomplish a preliminary analysis of safety of a household electric iron.

1. Accomplishing decomposition of system (fig. 8.1).

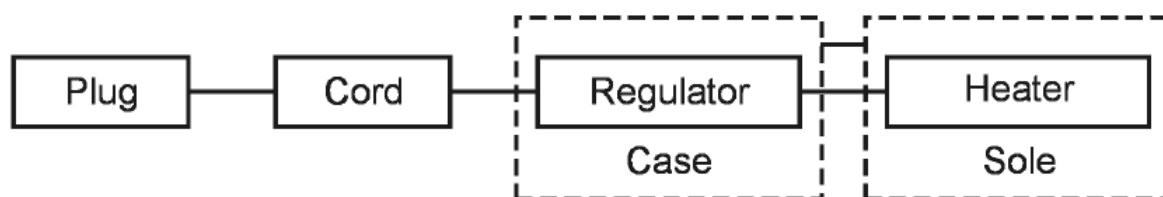


Fig. 8.1. Structure of system

2. Establishing interrelation of elements of system (fig. 8.2).

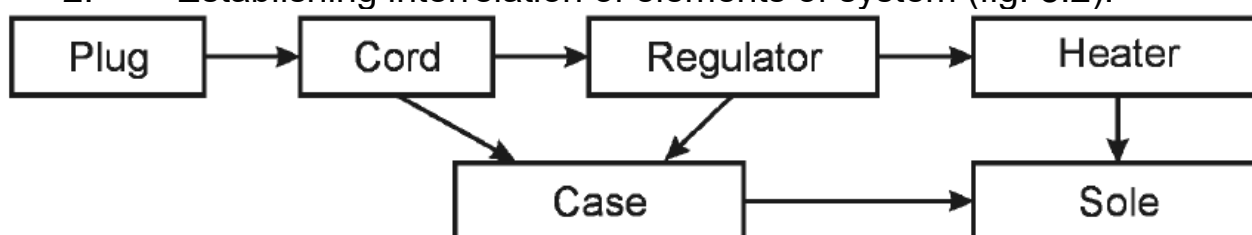


Fig. 8.2. Interrelation of the elements

3. Revealing dangers and the parts of system being sources of these dangers.

A. Danger of lesion with an electric current.

Elements: a) a plug;
b) a cord;
c) a sole.

B. Danger of the fire occurrence.

Elements: a) a plug;
b) a cord;
c) a sole.

C. Danger of a burn.

Element: a sole.

D. Danger of mechanical injuries.

Elements: a) a case;
b) a sole.

4. Determining the category, the probability and the rank of dangers and filling in a special form of the preliminary analysis (table 8.3).

Table 8.3

Determination of qualitative characteristics of dangers

No	Element of object	Danger	The characteristic of danger		
			Category	Probability	Rank
1	A plug	A lesion with an electric current	III	Infrequent failure	B
2	A plug	A fire	IV	Infrequent failure	A
3	A cord	A lesion with an electric current	III	Infrequent failure	B
4	A cord	A fire	IV	Infrequent failure	A
5	A sole	A lesion with an electric current	III	Infrequent failure	B
6	A sole	A fire	IV	Infrequent failure	A
7	A sole	A burn	II	Probable failure	C
8	A sole	A mechanical injury	I	Possible failure	D
9	A case	A mechanical injury	I	Possible failure	D

5. Entering restrictions on the analysis of dangers.

Mechanical injury dangers are not considered.

6. Making conclusions and developing preliminary recommendations on protection of working with an iron.

A. Conclusions:

- the considered engineering system is a source of dangers of three kinds and three ranks;
- one danger of the highest rank (A) is revealed;
- other dangers have ranks B and C;
- actions on decreasing of ranks of danger are needed.

8.2. Construction of a tree of failure

General information.

The purpose of accomplishment of the quantitative analysis of safety is a choice of the most effective system of protection against considered danger.

The decision on accomplishment of the quantitative analysis of some danger is taken at a stage of the preliminary analysis on the basis of qualitative criteria.

The following quantitative characteristics are determined for the chosen danger:

- a probability P ;
- expected losses at realization of danger E (more often this value is measured in money);
- a criticality measure (or risk) R : $R = P \cdot E$.

After that several variants of protective actions so called alternatives are chosen. Then new values of probability and a criticality measure are determined considering danger with protective action introduced for each alternative. The conclusion on efficiency of any alternative is made according to the value of decreasing of a criticality measure, taking into consideration expenses for introduction of a protective measure.

A technique of construction of a tree of failure is used at performance of the quantitative analysis for calculation of P value, and also for choice of the most effective methods of protection against danger.

The tree of failure is a structural-logic chain connecting dangerous event so called head event with the basic or initial events having caused occurrence of head event. The basic events are at the bottom of a tree of failure; thus, it is supposed that the probability of their occurrence is known.

Tree of failure is built applying so called "inverse" logic. So it is needed to reply a question what is a cause of inverse event.

At construction of a tree of failure two kinds of symbols are applied:

A. Logic symbols:

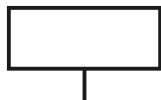


– "and" – outgoing event occurs, if all ingoing events take place simultaneously,



– "or" – outgoing event occurs, if any of ingoing events takes place ;

B. Event symbols:



– event entered by a logic symbol,



– basic event whose probability is known.

Tree of failure is started to be built with the head event. Thus, the events determined as «a failure of an element» are developed under the circuit shown in fig. 8.3.

Primary failure is a non-working condition of an element which reason is this element itself. Primary failures are caused with ageing of an element.

Secondary failure is a non-working condition of an element, which reason is an influence of superfluous stresses on an element. These stresses

can be caused by various energy sources: thermal, mechanical, electric, chemical, etc.

Mistaken commands are represented as an element which is in a non-working condition because of a wrong control signal or a noise.

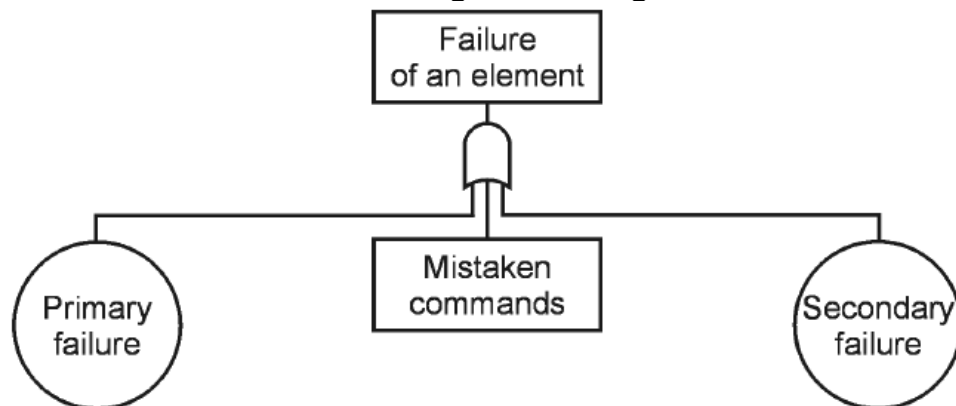
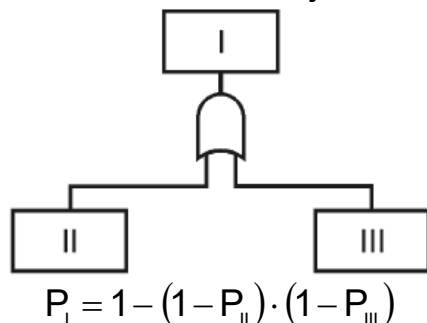


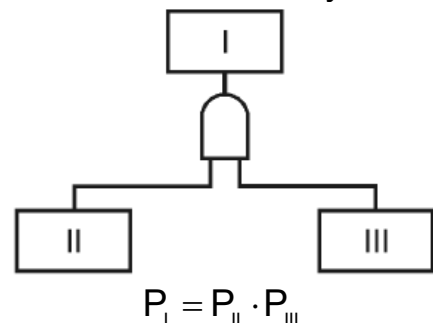
Fig. 8.3. Kinds of failures of an element.

After construction of a tree of failure the probability of the head event occurrence is determined. For this purpose they make the logic expression connecting probability of the head event with probabilities of the basic events. Thus, it is supposed that the events included in a tree of failure are independent, i.e. occurrence of any event does not influence probability of occurrence of another one. In this case it is possible to use the following dependences:

A. For “or” symbol



B. For “and” symbol



The order of practice accomplishment

1. Choose the head event, using the results of the preliminary analysis accomplished in practice No.1.
2. Construct a tree of failure for the head event.
3. Make a logic expression for determining of probability of the head event.
4. Determine probability of the head event. For this purpose you should set values of probabilities of the basic events with the help of the lecturer.
5. Offer protective actions (two or three ones) and specify effect of introduction of actions.
6. Determine a new value of probability of the head event for each of protective actions.

7. Make conclusions.

An example of practice accomplishment

1. "Fire" is accepted as a head event. A considered engineering system is a household electric iron. At the stage of the preliminary analysis it was established that this danger has a rank A (IV category, rare failure).

2. Building a tree of failure for dangerous event "fire" (fig. 8.4).

3. Making logic expression for determining of probability of the head event:

$$P_I = P_{II} \cdot P_{III}; \quad (8.1)$$

$$P_{II} = 1 - (1 - P_{IV}) \cdot (1 - P_V) \cdot (1 - P_{VI}); \quad (8.2)$$

$$P_{III} = P_1; \quad (8.3)$$

$$P_{IV} = 1 - (1 - P_2) \cdot (1 - P_3); \quad (8.4)$$

$$P_V = 1 - (1 - P_4) \cdot (1 - P_5); \quad (8.5)$$

$$P_{VI} = P_6. \quad (8.6)$$

Substituting (8.2) – (8.6) in (8.1), we receive

$$P_I = P_1 \cdot [1 - (1 - P_2) \cdot (1 - P_3) \cdot (1 - P_4) \cdot (1 - P_5) \cdot (1 - P_6)]. \quad (8.7)$$

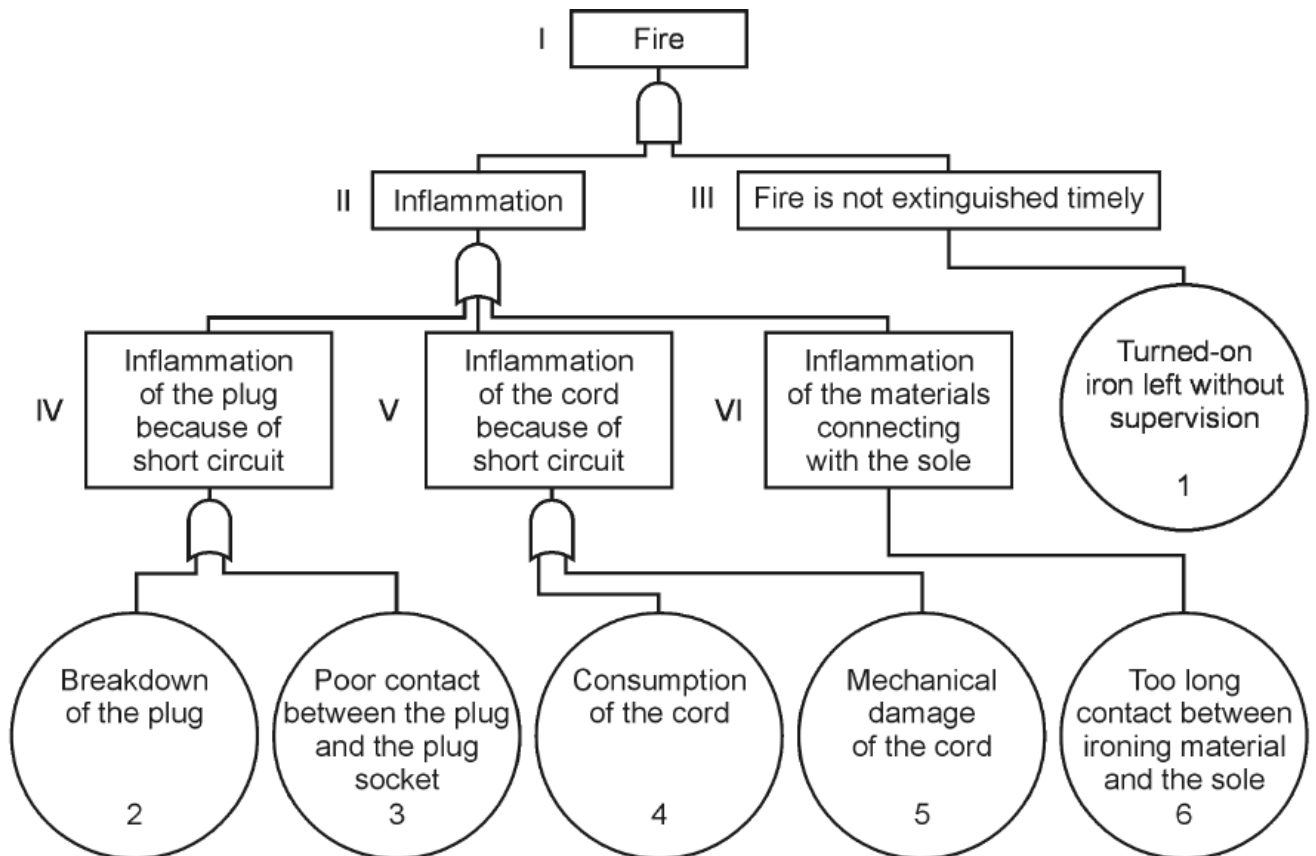


Fig. 8.4. The tree of failure for the dangerous event "fire"

4. Setting probabilities of the basic events:

$$P_1 = 0.1; P_2 = 0.02; P_3 = 0.1; P_4 = 0.005; P_5 = 0.005; P_6 = 0.1. \quad (8.8)$$

Then $P_I = 0.0214$.

8.3. Determination of a biorhythmic type of work capacity of the person

General information.

Many factors which determine physical and intellectual work capacity periodically change according to biorhythms. A biological rhythm is a self-sustaining independent process of a periodic change of conditions of an organism and oscillations of intensity of physiological processes and reactions.

Biological rhythms play a huge role in self-regulating of living systems and regulation of environmental communications. Rhythmic oscillations of the certain conditions in living systems are registered with frequency from one time per millisecond up to one time per several years. At interaction of an organism with an environment there is a continuous imposing of "external" rhythms on "internal" ones, and the result of such summation finally determines a physiological condition of various organs and tissues. The oscillatory biological system has advantages over the "rigid" system by stability, energy and speed of response.

The phenomenon of biorhythmically changes is observed at all kinds of loading – intellectual, emotional and physical. Circadian rhythm, as it is known, takes a leading place among biological rhythms. Among the factors resulting in a mismatch of biorhythms they name:

- Change of time zones (transmeridian flights, moving on significant distances in a latitudinal direction);
- Steady mismatch by a phase with local gauges of time of a rhythm "dream – wakefulness" (work in evening and night shift),
- Partial or full exception of geographical gauges of time (conditions of Arctic, and Antarctic Region, etc.);
- Influence of various stressors among which there can be pathogenic microbes, painful and physical irritants, mental or amplified muscular stress, etc.
- Imbalance of biological rhythms of the person with rhythms of his industrial and social activity.
- Factors making a way of life of a person – his work and rest schedule.

It is established that work capacity of a person most frequently changes according to the M-like curve – physiological curve of work capacity. Two main periods of activity are precisely traced on it: the level of physiological functions is high from 10 till 12 o'clock and from 16 till 18 o'clock, but from 12 till 14 o'clock and in the evening the work capacity falls. Nevertheless, not all people feel the same oscillations of work capacity during the day. Some of them work better in the first half of the day, others in the evening. The first variant concerns so-called "larks": they wake up in the morning, in the first half of day feel vigorous and work-capable, feel drowsiness in the evening and go to sleep early. Others – "owls" – fall asleep late at night; wake up late and hardly, as the deepest period of dream for them in the morning. There are differences between these two kinds of people:

1. Different threshold of excitability. Excitability of "larks" grows together with a rise in a body temperature. "Larks" achieve optimum of excitability right after awakening; therefore they work well in the first half of the day. In the evening the general level of excitability falls, therefore their work capacity is reduced. "Owls" have a higher threshold of excitability. It takes more efforts to wake them in the morning; they perform badly dosed out in the morning, as their excitability is low. They achieve optimum only in the evening, and then they have high work capacity.

2. Differences in dynamics of physiological functions: a pulse rate, body temperature, arterial pressure, work capacity, muscular force. So, for people of the morning type the maximal parameters of a body temperature, state of health, activity, mood, muscular force, etc. were observed in the first half of the day, and this was preceded by a very early rise of functions – at 6 o'clock in the morning. For the evening type of people parameters were minimal at this time as for them 6 a.m. means late night. The low parameters inherent for people of the evening type are a reason for their block in the first half of the day and slow achievement of an active condition.

3. Differences in disease: the probability of hypertonic illness or unstable increase of arterial pressure depends on a biorhythmic type. It is proved that probability of disease is higher for students of the morning type. An explanation is the following: students – "larks" have the organism which is more quickly and actively adjusted from rest to work – for these students the level of functions starts to increase already to 6 o'clock in the morning, more of biologically active substances, adrenaline, and noradrenalin is thrown out in blood, which lifts arterial pressure. For students of the evening group the internal mechanisms "responsible" for increase of pressure, work more slowly, therefore the big intellectual loading, surplus of information, emotional stress, which are attributed to play the basic role in the development of arterial hypertension, is little leveled.

4. Differences in a psycho-emotional condition and behavior. Representatives of the morning group are more vigorous, with readiness to hold to the accepted sights, public norms; their perception of concrete situations is marked with originality. Failures will easily cause doubt in the forces in them, there is an alarm and excitement, the mood and persistence promptly worsens. They relate their problems or conflicts to a bad state of health, especially in those cases when it could help to prevent any troubles. They try to prevent different conflicts, quarrels, and unpleasant emotional problems. Representatives of the evening group also have high activity, but over morning ones they easily forget all failures and emotional problems. They are not frightened by possible difficulties, conflicts and emotional problems. They worry before examinations less and very precisely catch a character and peculiarities of behavior of their colleagues.

These investigations have allowed making an important conclusion: differences in the rhythm of work capacity, which characterizes representatives of the morning and evening groups, are caused by the certain

peculiarities of hormonal and mental spheres of an organism. These peculiarities of biological rhythms are attributes immanent to an organism, and it is to be taken into account at the organization of work and rest schedules.

It is experimentally established that three rhythms operate for all people from the moment of their birth: 23-day physical, 28-day emotional and 33-day intellectual cycles, whose initial phases coincide with the moment of birth. Probability of disease or death depends on these rhythms. It is considered that such traits of a person as bravery, resistance, will, physical strength are connected with the 23-day period fluctuations; sensitivity, emotional existence, intuition are connected with the 23-day ones.

Any of these three periods has two half-cycles: a positive and negative half-cycle. Being, for example, in a positive half-cycle of a physical rhythm, the person feels inflow of forces, work capacity raises, the person easily copes with tasks demanding such physical efforts which in a negative half-cycle, most likely, would be not on forces. In so-called critical days cycles "change a sign", that means to pass a change of half-cycles. It doesn't matter, which transition passes – whether from a positive phase in negative or the contrary. In critical days of the given person the function entering into "sphere of action" of corresponding rhythm achieve a minimum. It is especially dangerous, if critical days of two or all three rhythms coincide.

Correct periodicity of these rhythms allows calculating critical days of the person beforehand by the date of birth. In such days it is recommended to abstain from decision-making, to treat with special attention the situations in which the organism is under these or those influences.

The order of practical work accomplishment.

Determine individual biorhythms.

It is essential for calculation of phases of biological rhythms, how many whole periods of cycles have passed from birthday till the day we are interested in: the phase of cycles is determined by a remainder of division of the number of days passed from the birthday during this period.

Tables 8.4-8.7 of remainders of division of completely lived years and number of completely lived months during the period of a corresponding cycle is given for simplification of subtraction. Summing up these rests and adding to them the number of days passed from the beginning of a month till the day we are interested in, we receive the full rest for a corresponding cycle. As a rule, the full rest is longer than the period of the cycle; therefore, it is to be divided by the period of a cycle to make it less. This number is necessary for us further.

At summing of tables we take into account only a usual, not leap year. So, at subtraction of remainders of division of number of completely lived years and completely lived months during the period it is necessary to add the number of leap years spent in the given time interval (i.e. to take into account, how many times 29th February came). Leap years are all of them

that are divided by 4, except for those, which come to an end with two zeros, but are not divided by 400 (for example, 1800 or 1900).

In table 8.4 determine remainders of division of the number of completely lived years for the period of a corresponding cycle. The received values bring in the table.

Table 8.4

Remainders of division of number of completely lived years for the period of a corresponding cycle

Physical cycle					Emotional cycle				Intellectual cycle			
Quantity of years				Rem.	Quantity of years			Rem.	Quantity of years			Rem.
1	24	47	70	20	1	29	57	1	1	34	67	2
2	25	48	71	17	2	30	58	2	2	35	68	4
3	26	49	72	14	3	31	59	3	3	36	69	6
4	27	50	73	11	4	32	60	4	4	37	70	8
5	28	51	74	8	5	33	61	5	5	38	71	10
6	29	52	75	5	6	34	62	6	6	39	72	12
7	30	53	76	2	7	35	63	7	7	40	73	14
8	31	54	77	22	8	36	64	8	8	41	74	16
9	32	55	78	19	9	37	65	9	9	42	75	18
10	33	56	79	16	10	38	66	10	10	43	76	20
11	34	57	80	13	11	39	67	11	11	44	77	22
12	35	58	81	10	12	40	68	12	12	45	78	24
13	36	59	82	7	13	41	69	13	13	46	79	26
14	37	60	83	4	14	42	70	14	14	47	80	28
15	38	61	84	1	15	43	71	15	15	48	81	30
16	39	62	85	21	16	44	72	16	16	49	82	32
17	40	63	86	18	17	45	73	17	17	50	83	1
18	41	64	87	15	18	46	74	18	18	51	84	3
19	42	65	88	12	19	47	75	19	19	52	85	5
20	43	66	89	9	20	48	76	20	20	53	86	7
21	44	67	90	6	21	49	77	21	21	54	87	9
22	45	68	91	3	22	50	78	22	22	55	88	11
23	46	69	92	0	23	51	79	23	23	56	89	13
					24	52	80	24	24	57	90	15
					25	53	81	25	25	58	91	17
					26	54	82	26	26	59	92	19
					27	55	83	27	27	60	93	21
					28	56	84	28	28	61	94	23
									29	62	95	25
									30	63	96	27
									31	64	97	29
									32	65	98	31
									33	66	99	0

Table 8.5

Leap years from 1900 up to 2016

1908	1912	1916	1920	1924	1928	1932	1936	1940	1944	1948
1952	1956	1960	1964	1968	1972	1976	1980	1984	1988	1992
1996	2000	2004	2008	2012	2016					

Table 8.6

Remainders of division of number of full months lived in the year of birth

Month	PH. C.	E. C.	I. C.	Month	PH. C.	E. C.	I. C.
January	12	26	4	July	15	13	21
February	7	26	9	August	7	10	23
March	22	23	11	September	0	8	26
April	15	21	14	October	15	5	28
May	7	18	16	November	8	3	31
June	0	16	19	December	0	0	0

Table 8.7

Remainders of division of number of full months lived in the considered year

Month	PH. C.	E. C.	I. C.	Month	PH. C.	E. C.	I. C.
January	0	0	0	July	20	13	16
February	8	3	31	August	5	16	14
March	13	3	26	September	13	19	12
April	21	6	24	October	20	21	9
May	5	8	21	November	5	24	7
June	13	11	19	December	12	26	4

An example of practical work accomplishment

Let's calculate phases of cycles of the person, which was born on February 20, 1952 for March 17, 1980. The result of calculations is brought in the table 3.5.

The calculated phase shows, on which day of a cycle – physical, emotional, intellectual – the day for which calculation was accomplished, falls.

So, for the given example, on March, 17, 1980 the person will be in a negative half-cycle of physical and intellectual cycles and a positive half-cycle of an emotional cycle. On the basis of the calculations (table 8.8) made it is possible to construct schedules of curve of biorhythms of a person (fig. 8.5).

Table 8.8

Calculation of physical, emotional and intellectual cycles
of a person

STAGES OF CALCULATION	PH. C.	E. C.	I. C.
1. We determine number of completely lived years: 1980-1952 = 28-1 = 27. On table 8.4 we find a remainder of division for three cycles	11	27	21
2. On table 8.5 we determine number of completely lived leap years	6	6	6
3. On table 8.6 we determine remainder of division of number of months, completely lived in a year of birth	7	26	9
4. On table 8.7 we determine remainder of division of number of full months, lived in considered year	13	3	26
5. If considered year is a leap one, and February is already lived, then we add 1	1	1	1
6. We determine quantity of days, lived in a month of birth: 29-20 = 9 days	9	9	9
7. We determine quantity of days, lived in a month for which cycles are calculated	17	17	17
8. We calculate the sum of all certain factors	64	89	89
9. We divide the sum on length of the period of each cycles and we determine remainder of division	64:23=2 remaind er: 18	89:28=3 remaind er: 5	89:33=2 remaind er:23
10. We determine a phase of individual cycles	1+18=19 th day	1+5=6th day	1+23=24 th day

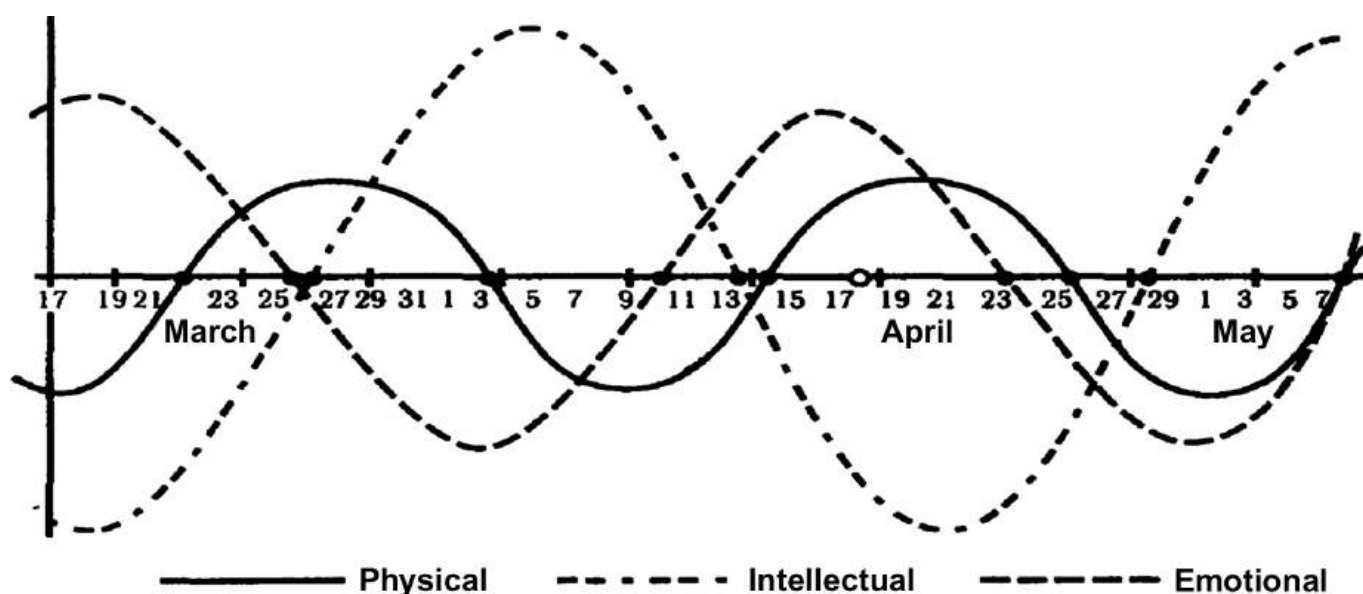


Fig. 8.5. Curves of biorhythms of a person

8.4. Determination of an individual risk

The purpose of the practical work:

- determination of an individual risk of accident without fatal outcome, individual risk to die, general individual risk for an employee of an Enterprise according to accidents statistic during N years (table 8.9);
- estimation of the calculated safety level if the maximal permissible level is 0.000001 1/year.

General information.

When we determine an individual risk, we have to calculate the statistic possibility of accidents and possibility of danger for N years. Statistic possibility of accidents is calculated as a ratio of numbers of injuries (dead, general quantity of injured persons) to quantity of employees, taking into account the observation period. Possibility of danger is calculated as a ratio of a period of employee presence at an enterprise per year (it is necessary to take into account the absence of an employee because of all reasons including even shifts) to duration of working time per year. There are 52 weeks per year. The individual risk is determined as multiplication of all finding results.

Then, the individual risk is compared to the given maximal permissible level. According to this result, it is necessary to make a conclusion.

Table 8.9

The initial data for the task

Parameter	Variant									
	1	2	3	4	5	6	7	8	9	10
Quantity of employees	10^3	$2 \cdot 10^3$	$3 \cdot 10^3$	$4 \cdot 10^3$	$5 \cdot 10^3$	$6 \cdot 10^3$	$7 \cdot 10^3$	$8 \cdot 10^3$	$9 \cdot 10^3$	10^4
Observation period, years	2	2	4	4	6	6	8	8	1	1
Numbers of injuries	3	4	4	3	5	5	6	5	7	6
Dead person	1	1	1	2	3	3	2	2	3	2
Number of shifts	1	2	3	1	2	3	1	2	3	1
Duration of holiday (weeks)	3	3	3	4	4	4	3	3	3	4
Duration of business trips (weeks)	1	1	2	2	3	3	4	4	4	3
Duration of sick-leave period (weeks)	1	2	2	3	3	4	4	5	5	4

The order of practice accomplishment.

The initial data for the tasks (example):

Quantity of employees	3000
Observation period, years	3
Numbers of injuries	5
Dead person	1
Number of shifts	2
Duration of holiday (weeks)	2
Duration of business trips (weeks)	4
Duration of sick-leave period (weeks)	1

1. Determination of possibility of injuries:
 $P1=5/(3000 \cdot 3)=5,6 \cdot 10^{-4}$.
2. Determination of possibility of death:
 $P2=1/(3000 \cdot 3)=1,1 \cdot 10^{-4}$.
3. Determination of possibility of danger for person:
 $Pd=(52-2-1-4)/(52 \cdot 2)=0,43$.
4. Determination of individual risk of injuries:
 $Ri=P1 \cdot Pd=5,6 \cdot 10^{-6} \cdot 0,43=2,4 \cdot 10^{-4}$.
5. Determination of individual risk of death:
 $Rd=P2 \cdot Pd=1,1 \cdot 10^{-4} \cdot 0,43=4,8 \cdot 10^{-5}$.
6. General risk is calculated according to the condition of occurrence of any unwanted event (injury or death):
 $Rg=1-(1-Ri)(1-Rd)=1-(1-2,4 \cdot 10^{-4}) \cdot (1-4,8 \cdot 10^{-5})=2,9 \cdot 10^{-4}$;
 $Rg=2,9 \cdot 10^{-4} > 0.000001$ (maximal permissible level).

Conclusion:

In the enterprise work, safety does not satisfy a claim because the general individual risk exceeds the maximum permissible level.

8.5. Determination of a social risk

General information.

The first step of social risk calculation is ordering in growth the quantity of injured persons N (table 8.10) and determination of accidents frequency F in which the injured people number was not less than N (fill tables 8.11-8.13). The second step of social risk calculation is drawing of F/N diagram (fig 8.6). The horizontal axis is quantity of injured people ($N1, N2, N3, N4, N5, N6, N7$ – according to initial data), the vertical axis is frequencies of accidents ($F1, F2, F3, F4, F5, F6, F7$ – results of statistical initial data manipulation).

Table 8.10

The initial data for the task

Variant	Date of an accident (D2 later than D1; D3 later than D2 and so on)						
	D1	D2	D3	D4	D5	D6	D7
1	13	12	21	38	21	13	2
2	2	4	2	6	5	8	7
3	11	11	4	2	6	6	9
4	8	7	8	6	13	2	13
5	4	14	8	5	5	8	3
6	2	12	4	2	8	4	6
7	6	3	4	3	6	3	5
8	8	3	5	3	3	8	9
9	6	2	2	5	5	4	9
10	2	3	5	1	8	7	2

Table 8.11

Statistical initial data manipulation

Quantity of injured people - N	Numbers of events in which the injured people were N	Frequency of events in which the injured people were N	Numbers of events in which the injured people were not less N	Frequency of events in which the injured people were not less N
Nmin				Fmax
...				...
Nmax				Fmin

Table 8.12

The order of practice accomplishment

Variant	Date of an accident (D2 later than D1; D3 later than D2 and so on)						
	D1	D2	D3	D4	D5	D6	D7
0	12	7	2	8	9	2	10

1. Ordering in growth the quantity of injured people N: 2, 2, 7, 8, 9, 10, 12
2. Maximal numbers of injured people is 12.
3. Numbers of events in which the injured people were N (the same quantity): 2, 2, 1, 1, 1, 1, 1.
4. Frequencies of events with the same number of injured people for each accident respectively: $2/50=0,04$; $2/50=0,04$; $1/50=0,02$; $1/50=0,02$; $1/50=0,02$; $1/50=0,02$; $1/50=0,02$.
5. Numbers of events in which the injured people were not less N respectively: 7, 7, 5, 4, 3, 2, 1 (it means how much times the quantity of injured people was not less than N).
6. Frequency of events in which the injured people were not less N respectively: $7/50=0,14$, $7/50=0,14$, $5/50=0,1$, $4/50=0,08$, $3/50=0,06$, $2/50=0,04$, $1/50=0,02$.

Table 8.13

Table of results

Quantity of injured people - N	Numbers of events in which the injured people were N	Frequency of events in which the injured people were N	Numbers of events in which the injured people were not less N	Frequency of events in which the injured people were not less N
2	2	0,04	7	0,14
2	2	0,04	7	0,14
7	1	0,02	5	0,1
8	1	0,02	4	0,08
9	1	0,02	3	0,06
10	1	0,02	2	0,04
12	1	0,02	1	0,02

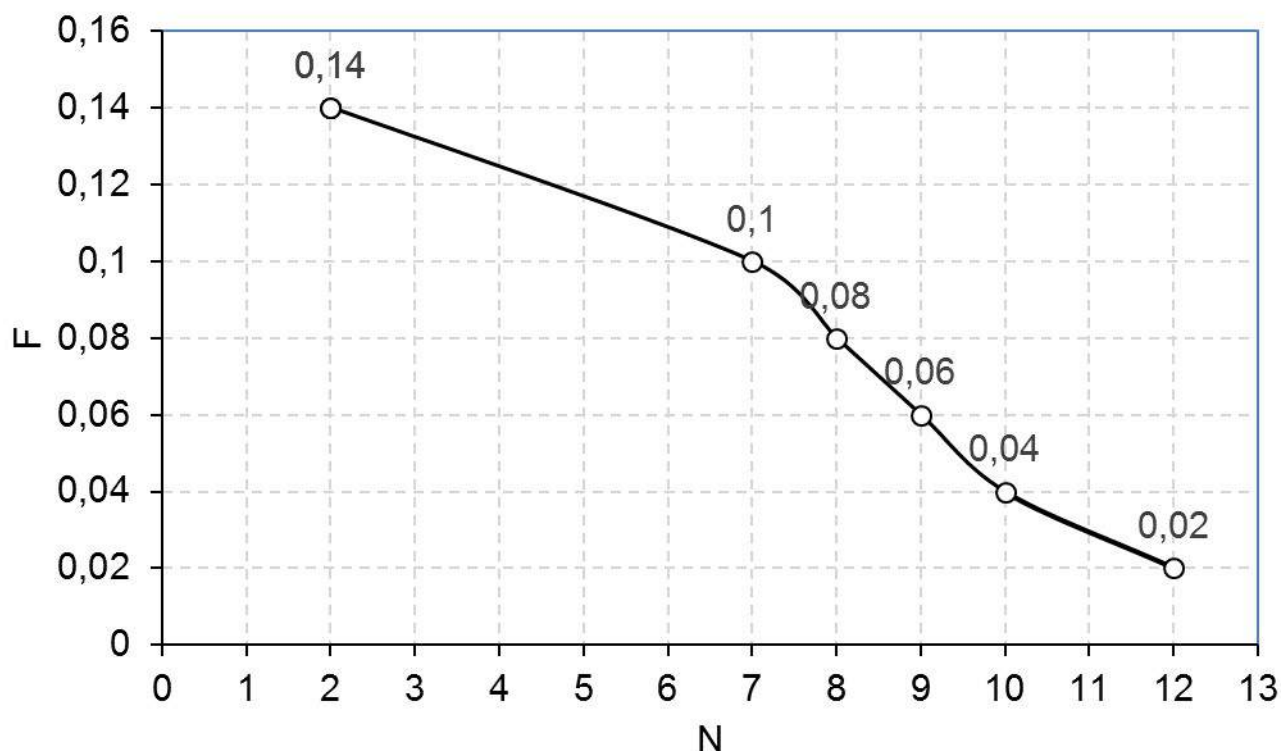


Fig. 8.6. F/N diagram for this case

8.6. Determination of a non-failure operation

Determination of non-failure operation of hardware of a life support system that consists of equal elements of reliability at the beginning (new elements) and after a life cycle (life-expired elements).

Table 8.14

The initial data for the task

Parameter	Variant									
	1	2	3	4	5	6	7	8	9	10
Type of connection	Series connection					Parallel connection				
Quantity of elements	2	3	4	5	4	3	5	6	3	5
Initial failure rate	$3 \cdot 10^{-4}$	$4 \cdot 10^{-4}$	$5 \cdot 10^{-4}$	$6 \cdot 10^{-4}$	$7 \cdot 10^{-4}$	$8 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	$9 \cdot 10^{-4}$	$6 \cdot 10^{-4}$
Final failure rate	$2 \cdot 10^{-3}$	$2 \cdot 10^{-3}$	$3 \cdot 10^{-3}$	$5 \cdot 10^{-3}$	$6 \cdot 10^{-3}$	$7 \cdot 10^{-3}$	$1 \cdot 10^{-3}$	$1 \cdot 10^{-3}$	$9 \cdot 10^{-3}$	$6 \cdot 10^{-3}$
Correction index	1	2	3	4	5	2	3	4	5	6

Instructions to the task fulfillment.

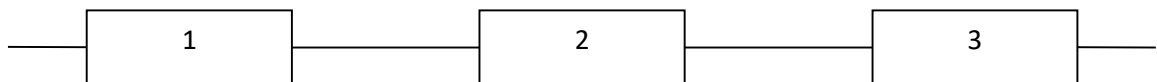
It is necessary to draw the diagram of hardware of a life support system taking into account the type of reliability elements connections. The probability of non-failure operation of hardware of life support system is determined, taking into account the type of reliability elements connections. Increasing of probability of non-failure operation during lifetime depends on particular conditions of operation and is calculated by multiplication of failure rate with a correction index (table 8.15 and table 8.16).

Table 8.15

Initial data for the example 1

Parameter	Variant
	0
Type of connection	Series connection
Quantity of elements	3
Initial failure rate, P_i	$2 \cdot 10^{-7}$
Final failure rate, P_f	$1 \cdot 10^{-5}$
Correction index, C	7

1. Diagram of hardware of a life support system, taking into account the type of reliability elements connections (Series connection):



2. All these elements have to be in operation condition for reliability control of this system. Failure may happen in case of failure of any of these 3 elements. According to the risk theory, the total probability of a failure should be calculated as follows:

$$P_1 = 1 - (1 - P_i) \cdot (1 - P_i) \cdot (1 - P_i) = 1 - (1 - 2 \cdot 10^{-7}) \cdot (1 - 2 \cdot 10^{-7}) \cdot (1 - 2 \cdot 10^{-7}) = 6 \cdot 10^{-7}.$$

3. The total probability of a failure, taking into account the particular conditions of operation should be calculated as follows:

$$P_2 = P_1 \cdot C = 6 \cdot 10^{-7} \cdot 7 = 4,2 \cdot 10^{-6}.$$

4. After increasing of failure rate up to $P_f = 1 \cdot 10^{-5}$ because of elements deterioration, the total probability of a failure should be calculated as follows:

$$P_3 = 1 - (1 - P_f) \cdot (1 - P_f) \cdot (1 - P_f) = 1 - (1 - 1 \cdot 10^{-5}) \cdot (1 - 1 \cdot 10^{-5}) \cdot (1 - 1 \cdot 10^{-5}) = 3 \cdot 10^{-5}.$$

5. The total probability of a failure taking into account the concrete conditions of operation should be calculated as follows:

$$P_4 = P_3 \cdot C = 3 \cdot 10^{-5} \cdot 7 = 2,1 \cdot 10^{-4}.$$

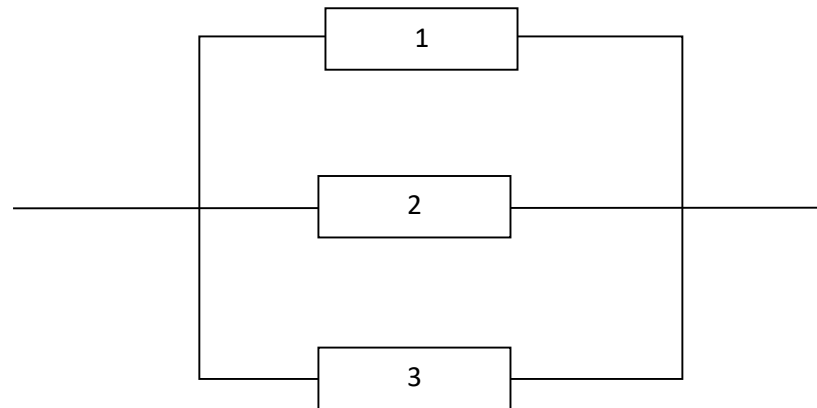
6. So, the probability of failure is increased 50 times: $P_4/P_2=50$.

Table 8.16

Initial data for the example 2

Parameter	Variant
	0
Type of connection	Parallel connection
Quantity of elements	3
Initial failure rate, P_i	$2 \cdot 10^{-7}$
Final failure rate, P_f	$1 \cdot 10^{-5}$
Correction index, C	7

1. Diagram of hardware of a life support system, taking into account the type of reliability elements connections (Series connection):



2. All these elements have to be in operation condition for reliability control of this system. Failure may happen in case of failure of all these 3 elements. According to the risk theory, the total probability of a failure should be calculated as follows:

$$P_1 = P_i \cdot P_i \cdot P_i = 2 \cdot 10^{-7} \cdot 2 \cdot 10^{-7} \cdot 2 \cdot 10^{-7} = 8 \cdot 10^{-21}.$$

3. The total probability of a failure, taking into account the concrete conditions of operation should be calculated as follows:

$$P_2 = P_1 \cdot C = 8 \cdot 10^{-21} \cdot 7 = 5,6 \cdot 10^{-20}.$$

4. After increasing of failure rate up to $P_f = 1 \cdot 10^{-5}$ because of elements deterioration, the total probability of a failure should be calculated as follows:

$$P_3 = P_f \cdot P_f \cdot P_f = 1 \cdot 10^{-5} \cdot 1 \cdot 10^{-5} \cdot 1 \cdot 10^{-5} = 1 \cdot 10^{-15}.$$

5. The total probability of a failure taking into account the concrete conditions of operation should be calculated as follows:

$$P_4 = P_3 \cdot C = 1 \cdot 10^{-15} \cdot 7 = 7 \cdot 10^{-15}.$$

6. So, the probability of failure is increased in $1,25 \cdot 10^5$ times: $P_4/P_2 = 1,25 \cdot 10^5$.

8.7. Methods of calculating the zones of damage from man-made explosions, fires and chemical situations

Forecasting of environmental and socio-economic consequences of emergencies (EM) is an early determination of the possible course of events (leading to human and material losses and deterioration of the environment) on the territory of the investigated object economy. In case of the emergence of specific EM in order to establish the need for the forces, means, material and financial resources necessary to ensure the prevention of the emergence of the specified emergency situations or for the minimum and effective elimination of their possible consequences.

Detection of the operational situation created as a result of an emergency is carried out using the special forms "Map of the expected (engineering, fire, radiation or chemical) conditions that may occur on the territory (the name of the investigated object), as a result (event name, which will lead to the EM, the main classification characteristics of this EM), "which reflect the plan of the object under study and the plan of the surrounding area, starting with the preliminary registration of each of the forms.

The main operations to identify the expected (engineering, fire, radiation or chemical) environment are the detection and reflection (using tactical signs and explanatory inscriptions):

- names of the primary observer factor of a specific EM;
- location and main characteristics of the source of this factor;
- forms, geometric sizes and spatial location of external boundaries of possible damage (for example, zones of full, strong, medium and weak destruction, or zones of continuous and separate secondary fires, or areas of radiation hazard, and zones of moderate, strong, dangerous and extremely dangerous radioactive contamination, or zones of chemical pollution, respectively);
- a possible degree of negative influence of the striking factor on the elements of the object being studied (for example, full, strong, medium or weak destruction of specific elements, or location of secondary fires, or areas of the site that will be contaminated with radioactive or hazardous chemicals, etc. designation of the intensity of this contamination).

8.7.1. Detection of the expected engineering environment that may occur on the territory of the investigated object as a result of the explosion

The work is carried out using information of the document "Identification of the potential dangerous objects (PDO) of the investigated economical objects (EO)" and the standard form "Map of the expected (engineering, fire, radiation or chemical) situation that may occur on the territory (the name of

the investigated object) as a result (name and place of the event which will lead to NA) "in the following sequence:

- pre-registration of the form;
- among the identified PDOs that are part of the investigated EO, the most negative consequence is after the explosion of a gas liquefied gas with a liquefied propane;
- defining and displaying the name of the primary damaging factor;
- defining and displaying the location and main characteristics of the source of this terrible factor;
- definition and display of the form, geometric dimensions and spatial location of external boundaries of zones of possible full, strong, medium and weak destruction;
- Determination and display of the possible degree of destruction of each element of the investigated object; At the same time, the reflection of the results of these operations is carried out using tactical signs (blue color of the corresponding form) and explanatory inscriptions (which are executed in black in the drawing type).

Pre-registration of the form provides for the corresponding "spaces" in the header of the form of explanatory inscriptions: "engineering"; "Pavlovsky Aviation Plant"; "An unprovoked explosion of gas gauge - 10211 (liquefied propane - q kg). In addition, in the frame "Finished" you should complete the last name, initials, group number, personal signature and date of execution of the document.

Determine and display the name of the primary damaging factor. The primary shocking factor of the unprovoked explosion is an air shock wave. Therefore, to be free from other images of the plan of the form "Maps ..." should be accompanied by an explanatory inscription in the form - "the primary shocking factor - the air shock wave."

Defining and displaying the location and the key characteristics of the source of the horrible factor. The source of the air shock wave is the center of the explosion of a cloud of an air-explosive gas mixture, which is formed in the vicinity of the gas supplier (element 6 in the plan of the aviation plant "Maps...") in the event of its unauthorized depressurization. Therefore, the location of the source of the primary damaging factor is reflected using the tactical sign "Epicenter of the explosion" (in the form of a circle of blue color with a diameter of 5 mm), which is placed on the symbol of the element - 6 on the plan of the aviation plant.

Along with this tactical sign, an explanatory inscription is written in the form of a fraction (in the numerator the name of the combustible substance ("liquefied propane") and its mass ("q kg") are recorded, and in the denominator astronomical time (C) and the date (D) of the possible occurrence of NA): for example: « $\frac{\text{liquefied propane} - 27000\text{kg}}{T - D}$ ».

Definition and reflection of the form, geometric dimensions and spatial location of the outer boundaries of zones of possible full, strong, medium and weak destruction. Since a possible unprovoked explosion of the gas gauge will take place on the open ground, the air shock wave will spread within the upper half-sphere from the explosion center in all directions under the same conditions. Therefore, for terrestrial objects, the outer boundaries of the zone of possible complete destruction (where the excess pressure at the front of the air shock wave ΔP_{asw} is 50 kPa), the zone of possible strong collapse ($\Delta P_{asw} = 30$ kPa), zone of possible average destruction ($\Delta P_{asw} = 20$ kPa) and the zone of possible weak collapse ($\Delta P_{asw} = 10$ kPa) are in the form of concentric circles with centers in the epicenter of the explosion.

Considering the information mentioned above, it is recommended to display the outer boundaries of zones of possible full, strong and average destruction using tactical symbols in the form of concentric circles of blue color (with radii R50, R30 and R20 respectively), in the rupture of which the explanatory inscriptions should be black in color, "50", "30" and "20" respectively.

The tactical blue sign to represent the outer boundary of the zone of possible weak destruction consists of circle arcs with a radius R10 of length (by chord) of 15 mm and "teeth" (the height and foundation of which is 4 mm and the tip is directed to the epicenter of the explosion). The arcs of the external boundaries between the zones of possible destruction should only be reflected within the framework of the Plan of the aviation plant "Cards ..." (that is, "to leave" outside the conditional image of the fence of the plant - 19 is forbidden). In this case, the values of R50, m, R30, m, R20, m and R10, m, are determined using the following ratios:

$$R_{50} = 4,23 r_l, \quad (8.9)$$

$$R_{30} = 5,69 r_l, \quad (8.10)$$

$$R_{20} = 7,29 r_l, \quad (8.11)$$

$$R_{10} = 11,28 r_l, \quad (8.12)$$

$$r_l = 1,75 \cdot \sqrt[3]{q_{np}}, \quad (8.13)$$

where R_{50} , R_{30} , R_{20} , R_{10} are the radii of the outer boundaries of zones of possible full, strong, medium and weak damages, respectively (m) (it is assumed that within the boundaries of each of these zones, the excess pressure at the front of the air shock wave decreases linearly); r_l - the radius of the outer boundaries of the zone of detonation wave m; q_{pr} - the mass of "stocks" of liquefied propane contained in the gas cylinder, kg. It should also be noted that the mapping of the outer boundaries of zones of possible full, strong, medium and weak destruction on the plan of the Aviation Plant "Cards ..." must be made taking into account the scale of this Plan (1: 5000). Note. All calculations (using the indicated and the following ratios) should be performed on the back of the "Cards ..." form or on a separate sheet.

Map of the expected engineering condition that may appear in an aviation plant as a result of a gas holder explosion

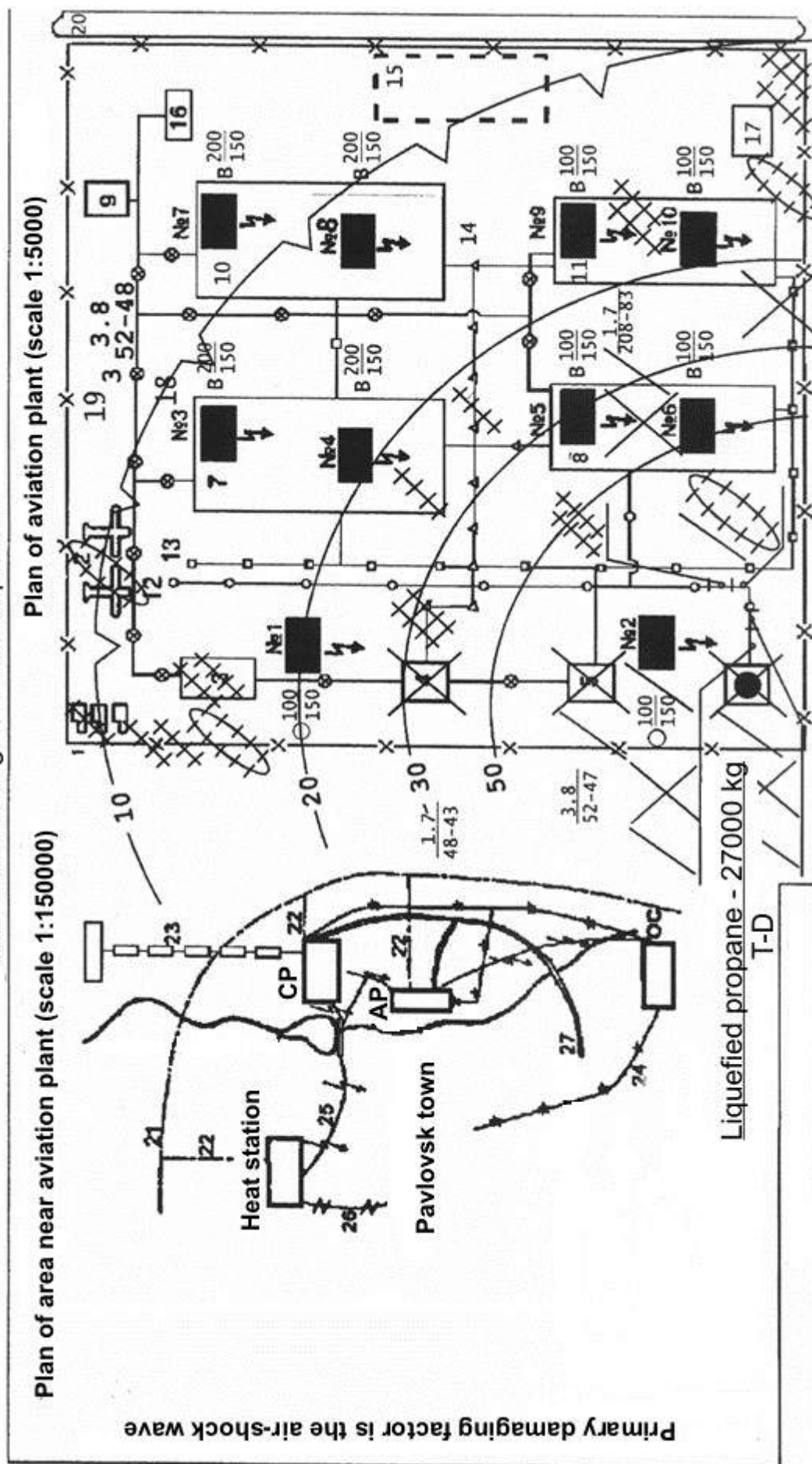


Fig. 8.7. Results of engineering conditions forecasting

Determination and reflection of the possible degree of destruction of each element of the aircraft plant is carried out by means of alternate execution (in respect of each of the elements) of the complex of such operations:

- determination of the particular (maximum possible) value of the excess pressure of the air shock wave in the area of the "location" of the next element of the plant - P_{elmax} , kPa (P_{elmax} value is determined by the "location" of a particular element relative to external zones of full, strong, medium and weak destruction, using them as their own erotic "ruler");
- determination of the type and basic characteristics of a building (structure) of a particular investigated element using the information in the section "Characteristics of the object being studied";
- determination of a possible degree of destruction of this element, using the table 1 (according to the P_{elmax} , kPa, type and characteristics of the building of a particular investigated element);
- displaying the specified degree of destruction of a particular explored element with the help of tactical blue symbols in the form of: two inclined straight lines crossing each other, $10 \div 15$ mm in length each, in case of complete destruction; Oval (the tangent large axis of which has a length of $10 \div 15$ mm) with transverse risks (the lengths of which and the distance between them is between 3 and 4 mm) - in the case of strong destruction; two mutually parallel inclined straight lines (length $10 \div 15$ mm) with transverse risks (length 3-4 mm) - in case of average destruction; one inclined straight line (length $10 \div 15$ mm) with transverse risks (3-4 mm long) - in case of weak destruction.

The indicated tactical marks should be "applied" to the conditional image (on the plan of the aviation plant "Cards ...") of the particular investigated element. It should also be noted that in case of weak destruction of the building (building) its roof is damaged, the windows and doors are damaged, the partitions between the separate premises begin to collapse, partially the plaster coating is destroyed, and therefore people in these rooms can get injuries and even perish, and equipment and property may be damaged; when the average destruction of the building (buildings) to the signs of weak destruction is added to the complete destruction of the roof of the building, the complete destruction of non-bearing partitions, partial destruction of bearing walls and ceilings, the complete destruction of plaster coating (as a result of which the fire may be in the building due to damage to the electrical grid), therefore in these people (which are inside of zone) can perish or get injuries, injuries, burns and poisoning with carbon monoxide, and equipment and property - destruction and damage; in case of strong destruction of the building (structure), only the damaged bearing structures of the first and sometimes the second floor remain, but everything else turns into fragments of building constructions that make up a blockage, therefore people perish or get serious injuries, injuries, burns and poisoning, and they also find themselves under the blockage, and equipment and property - is

destroyed; when completely destroyed, the entire building (except basements) turns into fragments of building structures that form a blockage, so people die, get serious injuries, injuries, burns and poisoning, fall under the rubble, and equipment and property collapse.

Table 8.17

Degrees of destruction of elements
(depending on the value of ΔP_p , kPa)

Element names	Destruction			
	Weak	Average	Strong	Full
Massive industrial buildings with metal frame and crane equipment with a carrying capacity of 60 ... 100 t	20...40	40,1...50	50,1...60	more 60
Massive industrial buildings with a metal frame and crane equipment with a carrying capacity of 20 ... 50 t	20...30	30,1...40	40,1...50	more 50
Brick buildings are one-, two-storey	8...15	15,1...25	25,1...35	more 35
Buildings brick multi-storey	8...12	12,1...20	20,1...30	more 30
Boiler houses	7...13	13,1...25	25,1...35	more 35
Reinforced concrete fences	8...12	12,1...15	15,1...20	more 20
Gas storages and ground tanks	15...20	20,1...30	30,1...40	more 40
Transformer substations of the closed type	30...40	40,1...60	60,1...70	more 70
Protective structures of class A-IV	100...140	140,1...180	180,1...220	more 220
Roads with asphalt covering	120...300	300,1...1000	1000,1..2000	more 2000
Runways (Concrete)	300...400	400,1...1500	1500,1..2000	more 2000
Railways	100...150	150,1...200	200,1...300	more 300
Deep grooved utility networks (water pipe, heating main, sewer, gas pipeline)	100...400	400,1...1000	1000,1..1500	more 1500
Pipelines on metal and reinforced concrete platforms	20...30	30,1...40	40,1...50	more 50
Cable underground lines	200...300	300,1...600	600,1...1000	more 1000
Cable ground lines	10...30	30,1...50	50,1...60	more 60
High voltage power lines	25...30	30,1...50	50,1...70	more 70
Tanker trucks and trucks	20...30	30,1...55	55,1...65	more 65
Transport planes and parking lots	7...8	8,1...10	10,1...15	more 15

Table 8.18

Variants of initial data for the control tasks

Option number (determined by the value of the last digit of the student's student account number)	0	1	2	3	4	5	6	7	8	9
The total mass of liquefied propane contained in the gas cylinder is q, kg	30000	32000	34000	36000	38000	40000	42000	44000	46000	48000

8.7.2. Detection of the expected fire situation that may occur on the territory of the investigated object as a result of a fire

Among the identified PDOs, which are part of the investigated EO, the most disadvantaged by the consequences of the emergency can cause fires in the parking of refueling cars and aircraft parking. The work is carried out using information of the document "Identification of the PDO of the investigated EO" and the standard form "Map of the expected (engineering, fire, radiation or chemical) situation that may occur on the territory (the name of the investigated object) as a result (name and place of the event which will lead to NA, the main classification features of this NA) "in the following sequence:

- pre-registration of the form;
- defining and displaying the name of the primary damaging factor;
- defining and displaying the location and main characteristics of the source of this terrible factor;
- defining and displaying the shape, geometric dimensions and spatial location of the primary combustion zone and the outer limits of the zone of possible continuous secondary fires and the zone of possible individual secondary fires;
- identification and display of possible individual secondary fires; At the same time, the reflection of the results of these operations is carried out using tactical signs (red color of the corresponding form) and explanatory inscriptions (which perform a black color in the drawing).

Preliminary registration of the form provides for the corresponding "blanking" of the form of explanatory inscriptions: "fire"; "Pavlovsky Aviation Plant"; "Fires in the parking lot of refueling cars - 10211 (aviation kerosene - Q kg)" In addition, in the frame "Finished" you should complete the last name, initials, group number, personal signature and date of execution of the document.

Determine and display the name of the primary damaging factor. The primary destructive factor (which creates a fire situation) is the thermal radiation of the primary fire. Therefore, an explanatory inscription in the form of "the primary shock factor - thermal radiation" should be added to the image of the "Maps ..." area, free from other images.

Detecting and displaying the location and main characteristics of the source of the primary damaging factor. The source of heat radiation is the

combustion zone (CZ) of the primary fire, the location of which (the element - 1 on the plan of the aviation plant "Maps ...") is designated using the tactical sign "Center of ignition" in the form of a circle with a diameter of five millimeters of red color. Along with this tactical sign, an explanatory inscription is made in the form of a fraction (in the numerator the name of the combustible substance ("aviation kerosene") and its mass ("Q kg") are recorded, and in the denominator astronomical time ("T") and the date (D) of possible occurrence of NA): $\frac{\text{aviation kerosene}-Q \text{ kg}}{T-D}$.

Detection and display of the shape, geometric dimensions and spatial location of the primary combustion zone and the outer limits of the zone of possible continuous secondary fires in the zone of possible individual secondary fires. The zone of combustion of the primary fire is the area of space where the physical and chemical reactions of the combustion of a combustible substance with an oxidant (usually oxygen with atmospheric air) occur, which is accompanied by, in particular, intense thermal radiation. In the phase of stable combustion of the primary fire, the horizontal intersection of the flame in the GG in its shape, geometric dimensions and spatial arrangement completely coincide with the corresponding parameters of the horizontal intersection of the "stocks" of the combustible substance. In the event of a primary fire at the parking lot of refueling cars (element 1 on the Plan of the Aviation Plant "Maps ..."), the most serious consequences of such a NTC will be in the case of unauthorized "spill" of aviation gas from tanks of refueling cars on a horizontal parking area with the formation of "puddles of fuel supplies" in the form of a circle with a radius of r , m, a depth of 0.05 m (due to the effect of the surface tension forces). Therefore, the burning zone of such a primary fire is recommended to be predicted in the form of a circle (centered at the location of the tactical sign "Center of ignition") with a radius r , m, the magnitude of which is determined using the ratio:

$$r = \sqrt{Q/\pi \cdot \rho \cdot 0,05}, \quad (8.14)$$

where Q is the total mass of "supplies" of a combustible substance, kg ($Q = 120000$ kg); ρ is the density of the combustible substance, kg / m³ (for aviation kerosene - $\rho = 800$ kg / m³).

The described combustion zone of the primary fire is reflected using the tactical sign "CZ" in the form of a circle of red color, the internal "field" of which is shaded by inclined parallel straight lines of red color. At the same time, the geometric size of this tactical sign is reflected in the scale of the Plan of the aircraft plant. It is precisely around the combustion zone of the primary fire that a zone of possible damage to thermal radiation (ie, electromagnetic radiation in the infrared, visible and ultraviolet bands) is formed – $ZPD_{\text{therm.rad}}$, within which:

- people can almost immediately get burns (first degree, if the intensity (density) of the thermal radiation of the $I_{\text{therm.rad}} = 30 \dots 60$ kW / m², the second degree - with $I_{\text{therm.rad}} = 60 \dots 150$ kW / m², the third degree - at $I_{\text{therm.rad}} = 150 \dots 220$ kW / m², or the fourth degree - with $I_{\text{therm.rad}} > 220$ kW / m²);

- at material objects made with the use of combustible substances (materials), secondary fires may occur in the case of the ratio of $I_{\text{therm.rado.concrete.ob}} \geq I_{\text{threshold.C.S.flare}}$, where $I_{\text{therm.rad.concrete.ob}}$ is the intensity of thermal radiation of the primary fire in the vicinity of the location of a particular material object, kW / m², $I_{\text{threshold.C.S.flare}}$ is the threshold value of the thermal radiation intensity in which a specific combustible substance (material) flares, kW / m². Therefore, within the limits of the $ZPD_{\text{therm.rad}}$ there are distinguished:

- a zone of possible continuous secondary fires (where secondary fires occur on almost all material objects), on the outer boundary of which $I_{\text{therm.rad}} = 30 \text{ kW / m}^2$;

- a zone of possible separate secondary fires (where secondary fires occur only on separate material objects), on the outer boundary of which $I_{\text{therm.rad}} = 10 \text{ kW / m}^2$.

The forms of the external boundaries of the zone of possible continuous and secondary fires and the zone of possible individual secondary fires coincide with the form of CZ, and the values of their radii - R_{con} , m, and R_{sec} , m, accordingly it is recommended to determine using the relations:

$$R_{\text{con}} \leq \sqrt{0,5 \cdot Q \cdot H_{\text{T.conc.CS}} / 2\pi \cdot 30 \cdot 10^3 \cdot T_{\text{flame}}}, \quad (8.15)$$

$$R_{\text{sec}} \leq \sqrt{0,5 \cdot Q \cdot H_{\text{T.conc.CS}} / 2\pi \cdot 10 \cdot 10^3 \cdot T_{\text{flame}}}, \quad (8.16)$$

The description of the combustion zone of the primary fire reflects with the use of where $H_{\text{T.conc.C}}$ is the calorific value of a concrete combustible substance, J / kg (see Table 2); T_{flame} is the term of burnout of "stocks" of a specific combustible substance, p. The value of the value of T_{flame} , s, is recommended to be determined using the relationships:

$$T_{\text{flame}} = h_{\text{CSdepth}} / V_{\text{line}}, \quad (8.17)$$

where h_{CSdepth} is the depth of the combustible substance layer, mm (for the studied fire at the parking lot of refueling cars (when spill aerated kerosene on the asphalt covering of the parking lot) - $h_{\text{CSdepth}} = 0,05 \text{ m} = 50 \text{ mm}$); V_{line} is the linear burning velocity of a specific combustible substance, mm / s.

Table 8.19

Heat capacity	
Names of combustible substances (materials)	H_T , J / kg
Kerosene (including air kerosene)	$50,0 \cdot 10^6$
Gasoline	$47,9 \cdot 10^6$
Oil (diesel fuel)	$41,9 \cdot 10^6$
Oil fuel	$39,9 \cdot 10^6$
Natural gas (methane, butane, propane)	$36,0 \cdot 10^6$
Acetone	$28,8 \cdot 10^6$
Ethyl (methyl) alcohol	$27,3 \cdot 10^6$

Map of the expected engineering condition that may appear in an aviation plant as a result of a fire in the parking lot of refuellers

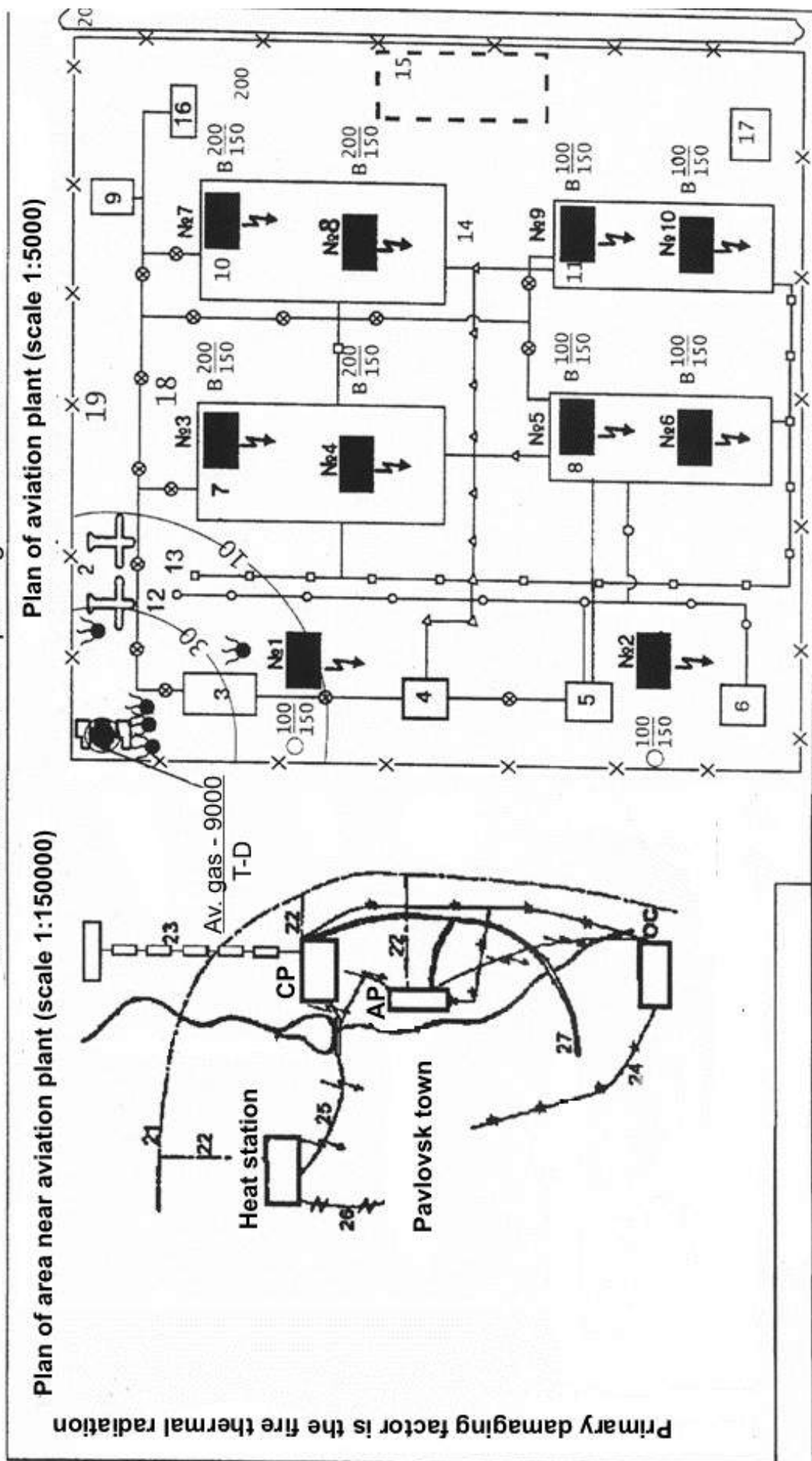


Fig. 8.8. Results of fire conditions forecasting

Table 8.20

The values of the rate of burnout

Names of combustible substances (materials)	V_{line} , mm/s
Gasoline	0,075
Gaseous	0,06
Acetone	0,055
Sulfur Carbon	0,036
Oil fuel	0,037
Ethanol	0,042
Methyl alcohol	0,035
Oil (diesel fuel)	0,027
Oils (oils)	0,025

The external boundaries of the zone of possible continuous secondary fires and the zone of possible individual secondary fires are recommended to be displayed using tactical symbols such as concentric circles (with radiuses R_{con} and R_{sec}) red in the rupture of which the explanatory inscriptions "30" and "10" respectively, necessarily taking into account the scale of the Plan of the Aviation Plant.

Determination and display of possible locations of individual secondary fires is carried out by performing the following operations:

- Determination of the value of the $I_{\text{therm.rado. concrete.ob}}$, kW / m², heat flux, which irradiates a specific element of the investigated object in the location of the "location" of this element relative to the outer limits of the zone of possible continuous secondary fires and the zone of possible individual secondary fires (considering that the intensity of thermal radiation of the primary fire varies within the zone of possible individual secondary fires (from 30 kW / 2 to 10 kW / m²) almost linearly, and in the zone of possible solid secondary fires - in inverse proportion to the square of the distance from the tactical sign "CD" to a particular element and always exceeding 30 kW / m²);

- determination of the value of the $I_{\text{threshold.C.S.flare}}$ (according to Table 8.20) for a specific element of the investigated object, using the information on the combustible substances (materials) of this element, given in the "Characteristics of the investigated industrial object";

- The specified element may explode and it may result in a separate secondary fire in the case of the following $I_{\text{therm.rado. concrete.ob}} \geq I_{\text{threshold.C.S.flare}}$. The possibility of a separate secondary fire reflects using a tactical red color in the form of a 3 mm diameter circle with three tongues of the flame that is placed on the Plan of the Aviation Plant "Maps ..." along with the conditional image of the particular investigated element.

Table 8.21

Thresholds of intensity (density of power flux) of thermal radiation

Names of combustible substances (materials)		I _{threshold.C.S.flare} , kW / m ² depending on the period of radiation		
		3 min	5 min	15 min
Technical cardboard (paper)		18,0	15,2	10,8
Cotton fabrics (fibers) of dark color		11,0	9,7	7,5
Khaki Tarpaulin		48,0	45,0	38,0
Dermatin of dark color		20,0	16,0	11,0
Fabrics for upholstery		55,0	52,0	48,0
Wood (pine, pine boards with a moisture content of 12% and a non-structured and unpainted surface)		20,6	17,5	12,9
Boards are designed and painted with oil paint of dark color		26,7	22,3	17,5
Plywood		25,0	22,0	17,0
Plastic		—	—	15,4
Ruberoid		—	—	28,0
Rubber products		—	—	14,5
Slate (splits, collapses)		—	—	52,0
Combustible gases and flammable liquids with flash point	150°C	—	—	8,9
	300°C	—	—	12,1
	350°C	—	—	15,5
	400°C	—	—	19,9
	500°C and more	—	—	28,0

Variants for initial data for the control tasks

Option number (determined by the value of the last digit of the student's account number)	0	1	2	3	4	5	6	7	8	9
The total mass of aviation kerosene contained in tank-vehicles is Q, kg	170000	165000	160000	155000	150000	145000	140000	135000	130000	125000

8.7.3. Detection of the expected chemical situation that may occur on the territory of the investigated facility as a result of the accident at the Pavlovsky Chemical Plant with chlorine emissions

The work is carried out using the standard form "Map of the expected (engineering, fire, radiation or chemical) situation that may occur on the territory (name of the investigated object) as a result (name and place of occurrence of the event leading to the EM, the main classification features of this EM) "in the following sequence:

- pre-registration of the form;
- defining and displaying the name of the primary damaging factor;
- defining and displaying the location and main characteristics of the source of this terrible factor;
- definition and display of the form, geometric dimensions and spatial location of the external boundaries of the zone of possible damage.

At the same time, the reflection of the results of these operations is carried out using tactical signs (corresponding shapes and sizes of blue and yellow colors) and explanatory inscriptions (which are executed in black in drawing type).

Preliminary registration of the form provides for the inclusion in the appropriate "blank spaces" of the header of the form (see Figure 1) explanatory inscriptions: "chemical"; "Pavlovsky Aviation Plant"; "Accidents at the Pavlovsky Chemical Plant (PCP) with the release of chlorine. In addition, in the frame "Finished" you should complete the last name, initials, group number, personal signature and date of execution of the document.

Determine and display the name of the primary damaging factor. The primary damaging factor (creating a chemical situation) is chemical pollution. Therefore, an explanatory inscription in the form of: "the primary deteriorating factor is chemical pollution" should be added to the "Maps ..." area, free from other images in the Plot area of "Maps ...".

Defining and displaying the location and key characteristics of the source of the striking factor. The source of the terrible factor is the chlorine stocks - Q_0 , t contained in the technological system (located on the western part of the territory of the PCP), the accidental depressurization of which may result the emergence situation. Therefore, it is recommended to locate this source (on the western part of the territory of the PCP) from using the tactical sign "chemical accident" in the form of a circle with a diameter of five millimeters of blue, the internal field of which is shaded by parallel lines, mutually intersecting, yellow. Along with this tactical sign, an explanatory inscription is written in the form of a fraction (in the numerator the name of the dangerous chemical ("chlorine") and its mass (" Q_0 , t") are recorded in the numerator, and in the denominator astronomical time (" $Ч$ ") and the date " $Д$ ") possible occurrence of NTC): $\frac{\text{chlorine}-Q_0}{T-D}$.

Determination and mapping of the zone of possible damage. The zone of possible damage (ZPD) induced by an accident with the release of chlorine is recommended to be predicted in the form of a sector whose axis of symmetry coincides with the direction of the prevailing winds. According to the "Characteristics of the object under study", the dominant winds in the Pavlov Region are "northern" and have a velocity - $V_{pr} = 7 \text{ m / s}$. Therefore, it is necessary from the center of the tactical sign "chemical accident" to conduct (in the direction from north to south) a dash-dotted straight axis of symmetry of the ZPD sector. In turn, the magnitude of the angle at the vertex of the specified sector (ψ) depends on the value of V_{pan} , m / s (at $V_{pr} < 0.5 \text{ m / s}$ - $\psi = 360^\circ$; at $V_{pr} = (0.5 \dots 1.0) \text{ m / s}$ - $\psi = 180^\circ$; with $V_{pr} = (1,1 \dots 2,0) \text{ m / s}$ - $\psi = 90^\circ$; with $V_{pr} > 2 \text{ m / s}$ - $\psi = 45^\circ$).

Map of the expected chemical condition that may appear in an aviation plant as a result of chemical plant accident

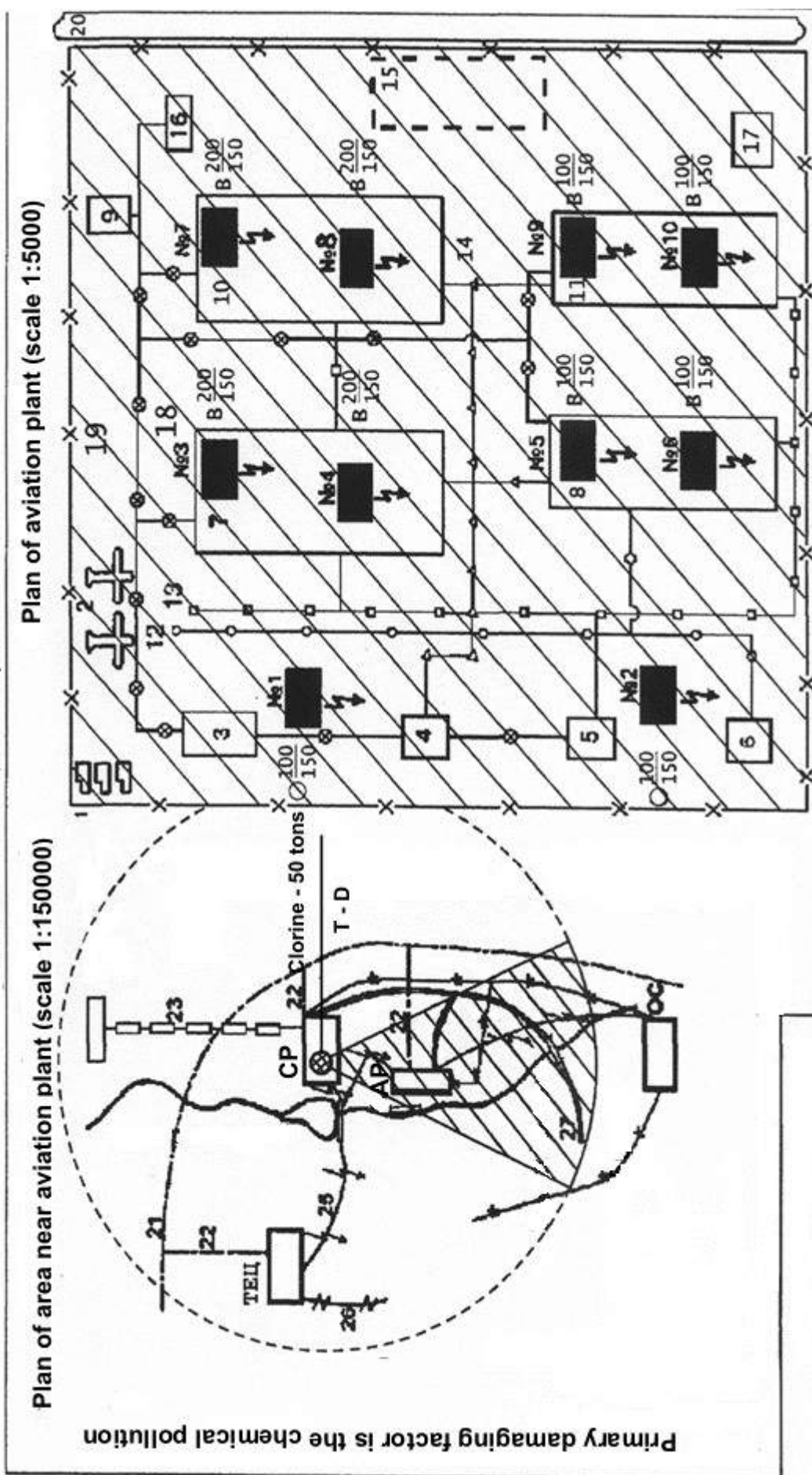


Fig. 8.9. Results of chemical conditions forecasting

Therefore, in order to reflect the lateral sides of the ZPD sector from the center of the tactical sign "chemical accident", it is necessary to lay rays at angles ($\psi/2 = 22,5^\circ$) ($-\psi/2 = -22,5^\circ$) relative to the direction of the axis of the ZPD sector. To complete the construction of the ZPD sector, it is necessary to arrange an arc with radius G , km (where Γ - total depth of distribution of contaminated air, km) between the indicated rays. The modern method for determining the possible value of G , km, involves the following operations:

Defining and displaying the location and key characteristics of the source of the striking factor. The source of the terrible factor is the chlorine stocks - Q_0 , t contained in the technological system (located on the western part of the territory of the PCP), the accidental depressurization of which may result in the emergence situation. Therefore, it is recommended to locate this source (on the western part of the territory of the PCP) from using the tactical sign "chemical accident" in the form of a circle with a diameter of five millimeters of blue, the internal field of which is shaded by parallel lines, mutually intersecting, yellow. Along with this tactical sign, an explanatory inscription is written in the form of a fraction (in the numerator the name of the dangerous chemical ("chlorine") and its mass (" Q_0 , t") are recorded in the numerator, and in the denominator astronomical time (" $Ч$ ") and the date "D") possible occurrence of NTC): $\frac{\text{chlorine}-Q_0}{T-D}$.

Determination and mapping of the zone of possible damage. The zone of possible damage induced by an accident with the release of chlorine is recommended to be predicted in the form of a sector whose axis of symmetry coincides with the direction of the prevailing winds. According to the "Characteristics of the object under study", the dominant winds in the Pavlov Region are "northern" and have a velocity - $V_{pw} = 7 \text{ m / s}$. Therefore, it is necessary from the center of the tactical sign "chemical accident" to conduct (in the direction from north to south) a dash-dotted straight axis of symmetry of the ZPD sector. In turn, the magnitude of the angle at the vertex of the specified sector (ψ) depends on the value of V_{pw} , m / s (at $V_{pw} < 0.5 \text{ m / s}$ - $\psi = 360^\circ$; at $V_{pw} = (0.5 \dots 1.0) \text{ m / s}$ - $\psi = 180^\circ$; with $V_{pw} = (1,1 \dots 2,0) \text{ m / s}$ - $\psi = 90^\circ$; with $V_{pw} > 2 \text{ m / s}$ - $\psi = 45^\circ$). Therefore, in order to reflect the lateral sides of the ZPD sector from the center of the tactical sign "chemical accident", it is necessary to lay rays at angles ($\psi / 2 = 22,5^\circ$) ($-\psi / 2 = -22,5^\circ$) relative to the direction of the axis of the ZPD sector. To complete the construction of the ZPD sector, it is necessary to arrange an arc with radius G , km (where Γ is total depth of distribution of contaminated air, km) between the indicated rays. The modern method for determining the possible value of G , km, involves the following operations:

- determination of the values of the equivalent amount of chlorine forming the primary (Q_{e1} , t) and secondary (Q_{e2} , t) clouds of air contaminated with chlorine (the primary cloud is formed during 1 ... 3min from the moment of depressurization of the system with a pair of chlorine contained in this system, and the secondary cloud is formed during the entire time of

evaporation of the liquid chlorine which is poured out of the depressurized system into the pallet or on the substrate surface. Thus, if the emergency system contains compressed gases it produces only primary cloud);

- determination of depths of distribution of primary (Γ_1 , km) and secondary (Γ_2 , km) clouds of contaminated air;

- determine the total depth (G , km) of the spread of contaminated air. The values of Q_{e1} , tons and Q_{e2} , tons, are recommended to be determined using the relationships:

$$Q_{e1} = K_1 K_3 K_5 K_7 Q_0, \quad (8.18)$$

$$Q_{e2} = (1 - K_1) K_2 K_3 K_4 K_5 K_6 K_7 Q_0 / h \cdot \rho, \quad (8.19)$$

where K_1 is a coefficient, the value of which depends on the storage conditions of chlorine (determined according to Table 8.21); K_2 is a coefficient which depends on the physical and chemical properties (Table 8.21); K_3 is a coefficient equal to the ratio of the threshold chlorine toxidose to the threshold toxidose of a specific chlorine (Table 8.21); K_4 is a coefficient which depends on the wind speed in the surface layer of the atmosphere (Table 8.24); K_5 is a coefficient which takes into account the degree of vertical stability of the atmosphere (which is determined according to the data of Table 8.23): with inversion $K_5 = 1$, with isothermism $K_5 = 0.23$, with convection $K_5 = 0.08$; K_6 is a coefficient which depends on the time elapsed from the moment of the accident to the beginning of pollution of the object under study - $T_{beg} = D / V_{cloud}$ (where D is the distance from the accident site to the object under study, km; V_{cloud} is velocity of clouds of contaminated air, km / h (Table 8.24). At $T_{beg} \leq 1$ year - $K_6 = 1$); K_7 is a coefficient that takes into account the influence of ambient air temperature (Table 8.21). In this case, in the ratio (8.16), the values of K_7 are given in the numerator, and in the ratio (8.17) - the values given in the denominator).

The values of the depth distribution of the primary cloud (G_1 , km) and the depth of propagation of the secondary cloud (G_2 , km) should be determined using the values determined in this way by Q_{e1} , t and Q_{e2} , t , using the data of Table 8.25. The total depth of the zone of possible chemical pollution of chlorine - G , km (due to the influence of the primary and secondary cloud) is determined using the ratio:

$$\Gamma = \Gamma' + 0,5\Gamma'', \quad (8.20)$$

where Γ' is the largest of the quantities Γ_1 or Γ_2 , km, Γ'' is the smallest of the quantities Γ_1 or Γ_2 , km.

It is with a radius equal to G (taking into account the scale of the Terrain Plan "Maps ...") the arc of the ZPD sector is executed. In this case, the external boundaries of the indicated ZPD are blue, and its internal field is dipped in inclined parallel straight yellow. The people of the production personnel (population) who "fall" within the limits of this ZPD can perish or get poisoning, and material objects - damage. Therefore, on the Plan of the Aviation Plant "Maps ...", the inclined dashed parallel lines of the territory of the plant are dashed, which, according to the forecast, "fall" into the ZPD.

Table 8.22

Characteristics of NHR and auxiliary coefficients for determining the depth of pollution zones

The names of the NHR	Density		Boiling point of NHR, °C	Thresh old toxoid, $\frac{\text{mg} \cdot \text{min}}{\text{l}}$	GDKrz, mg / m^3	Value of auxiliary coefficients			
						K ₁	K ₂	K ₃	K ₇ for air temperature
	Gas	Liquid							
Ammonia (under pressure)	0,0008	0,681	-33,42	15	6,25	0,18	0,02	0,04	0/0,9 0,3/1 0,6/1 1/1 1,4/1
Ammonia (isothermal)	—	0,681	-33,42	15	6,25	0,01	0,02	0,04	0/0,9 1/1 1/1 1/1 1/1
Acetone	—	0,726	-48	12	5,85	0,2	0,06	0,5	1,2/0, 0,5/1 1/1 1/1 1/1
Hydrogen is arsenic	0,035	1,64	-62,47	0,2	0,17	0,17	0,05	0,85	0,3/1 0,5/1 0,8/1 1/1 1,2/1
Hydrogen bromide	0,036	1,49	-66,77	2,4	1,99	0,13	0,05	6,00	0,2/1 0,5/1 0,8/1 1/1 1,2/1
Methyl chloride	0,0023	0,983	-23,76	10,8	9	0,12	0,04	0,05	0/0,5 0,1/1 0,6/1 1/1 1,5/1
Hydrogen sulfide	0,0015	0,964	-60,35	16,1	6,7	0,27	0,04	0,03	0,3/1 0,5/1 0,8/1 1/1 1,2/1
Sulfur Carbon	—	1,263	46,2	45	18,7	0	0,02	0,01	-0/1 -0/2 -0,4 -1 -1,2,1
Hydrochloric acid (concentrate)	—	1,198	52,0	2	8,33	0	0,02	0,3	-0 -0/1 -0,3 -1 -1,6
Phosgene	0,0015	1,432	8,2	0,6	0,25	0,05	0,06	1,0	0/0,1 0/0,3 0/0,7 1/1 2,7/1
Fluorine	0,0017	1,512	-188,2	0,2	0,17	0,96	0,03	3,0	0,7/1 0,8/1 0,9/1 1/1 1,4/1
Chlorine	0,0032	1,553	-34,1	0,6	0,25	0,18	0,05	1,0	0/0,9 0,3/1 0,6/1 1/1 1,4/1
Chlorcian	0,0021	1,22	12,6	0,75	0,32	0,04	0,04	0,8	0/0 0/0 0/0,6 1/1 3,9/1

Table 8.23

The value of the coefficient K4 depending on V_{pr}, m/s

V _{pr} , m / s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
K ₄	1,0	1,23	1,67	2,0	2,34	2,67	3,0	3,34	3,67	4,0	4,34	4,67	5,01	5,34	5,68

Table 8.24

Degrees of vertical stability of the atmosphere

V_{pr} , m / s	Day			Night		
	Cloudiness			Cloudiness		
	Is absent	Average	Continuous	Is absent	Average or continuous	
1	convection	convection	isotherm	inversion	isotherm	
2	convection	convection	isotherm	inversion	isotherm	
3	convection	isotherm	isotherm	inversion	isotherm	
4	convection	isotherm	isotherm	inversion	isotherm	
5	isotherm	isotherm	isotherm	isotherm	isotherm	
6 and more	isotherm	isotherm	isotherm	isotherm	isotherm	

Table 8.25

The velocity of the front edge of the cloud

V_{pw} , m / s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
V_{cloud} , km / h	Inversion														
	5	10	16	21	—	—	—	—	—	—	—	—	—	—	—
	Isotherm														
	6	12	18	24	29	35	41	47	53	59	65	71	77	82	88
	Convection														
	7	14	21	28	—	—	—	—	—	—	—	—	—	—	—

Table 8.26

The values of the depth distribution of the primary - Γ_1 , km (or secondary Γ_2 , km) of the cloud of air contaminated with chlorine, depending on the value of V_{pw} , m / s, and the values of the equivalent quantity of the contaminated air - Q_{e1} , t (or Q_{e2} , t)

	Q_e, T															
	0,01	0,05	0,1	0,5	1	3	5	10	20	30	50	70	100	300	500	1000
1	0,38	0,85	1,25	3,16	4,75	9,18	12,53	19,20	29,56	38,13	52,67	65,23	81,91	166	231	363
2	0,26	0,59	0,84	1,92	2,84	5,35	7,20	10,83	16,44	21,02	28,73	35,35	44,09	87,79	121	189
3	0,22	0,48	0,68	1,53	2,17	3,99	5,34	7,98	11,94	15,18	20,59	25,21	31,30	61,47	84,50	130
4	0,19	0,42	0,59	1,33	1,88	3,28	4,36	6,46	9,62	12,18	16,43	20,05	24,60	48,18	65,92	101
5	0,17	0,36	0,53	1,19	1,68	2,91	3,75	5,53	8,19	10,33	13,68	16,39	20,32	40,11	54,67	83,60
6	0,15	0,34	0,46	1,09	1,53	2,66	3,43	4,88	7,2	9,06	12,14	14,79	18,13	34,67	47,09	71,70
7	0,14	0,32	0,45	1,00	1,42	2,46	3,17	4,49	6,48	8,14	10,87	13,17	17,16	30,73	41,63	63,16
8	0,13	0,30	0,42	0,94	1,33	2,30	2,97	4,20	5,92	7,42	9,90	11,98	14,66	27,75	37,49	56,70
9	0,12	0,28	0,40	0,88	1,25	2,17	2,80	3,96	5,60	6,86	9,12	11,03	13,50	25,39	34,24	51,60
10	0,12	0,26	0,38	0,84	1,09	2,06	2,66	3,76	5,31	6,50	8,50	10,23	12,54	23,49	31,61	47,50
11	0,11	0,25	0,36	0,80	1,13	1,96	2,53	3,58	5,06	6,02	8,01	9,61	11,74	21,91	29,14	44,12
12	0,11	0,24	0,34	0,76	1,08	1,88	2,42	3,43	4,85	5,94	7,67	9,07	11,06	20,58	27,61	41,30
13	0,10	0,23	0,33	0,74	1,04	1,80	2,37	3,29	4,66	5,70	7,37	8,72	10,48	19,45	26,04	38,30
14	0,10	0,22	0,32	0,71	1,00	1,74	2,24	3,17	4,49	5,50	7,10	8,40	10,04	18,46	24,69	36,81
15	0,10	0,22	0,31	0,69	0,97	1,68	2,17	3,07	4,34	5,31	6,86	8,11	9,70	17,60	23,50	34,98

Table 8.27

Variants for initial data for the control tasks

Option number (determined by the value of the last digit of the student's account number)	0	1	2	3	4	5	6	7	8	9
The total mass of chlorine contained in the emergency system is Q_0 , tons	30	32	34	36	38	40	42	44	46	48

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