International Journal of Safety and Security Engineering
Vol. 13, No. 5, October, 2023, pp. 871-881
Journal homepage: http://iieta.org/journals/ijsse

Assessing Occupational Risk: A Classification of Harmful Factors in the Production Environment and Labor Process

Sholpan Abikenova[1], Gulnara Issamadiyeva[1], Elmira Kulmagambetova[1], Gulzhan Daumova[2*], Nazgul Abdrakhmanova[1]

[1] Republican Research Institute for Occupational Safety and Health, Astana 01000, Kazakhstan
[2] East Kazakhstan Regional Branch of the Republican Research Institute for Occupational Safety and Health, Ust-Kamenogorsk 070018, Kazakhstan

Corresponding Author Email: Gulzhan.daumova@mail.ru

https://doi.org/10.18280/ijsse.130511

Received: 24 June 2023
Revised: 21 September 2023
Accepted: 13 October 2023
Available online: 10 November 2023

Keywords:
classification, harmful and/or dangerous production factors, production environment and labor process, factors of physical, chemical, biological nature, mechanical hazards, psychophysiological factors of the labor process, general industrial pollution

ABSTRACT

The article presents a draft unified classification of harmful and/or hazardous factors of working conditions for subsequent identification and assessment of any possible occupational risks of employees of various types of economic activity within the framework of the implementation of a risk-based approach in the organization of labor protection at enterprises. In total, 134 harmful and/or dangerous factors present in the production environment and work processes were identified, which were divided into six main groups: physical, chemical, biological, mechanical, psychophysiological, and general industrial pollution. A five-level classification of the main harmful and/or dangerous factors of the production environment and the labor process and their subspecies is proposed. The largest group consists of physical factors, such as industrial noise, vibration, various types of radiation, lighting conditions at enterprises, exposure to electric current and electric arc, the threat of fire or explosion, as well as climate and microclimate conditions and aerosol composition of the air. The conducted research and the creation of a detailed classification of possible harmful and dangerous effects on employees of enterprises formed the basis of a new concept of providing personal protective equipment against harmful factors of production in the Republic of Kazakhstan.

1. INTRODUCTION

The preservation of the life and health of an employee is the most important priority in the policy of any state in the field of occupational safety and health.

In the Republic of Kazakhstan, large-scale work is currently being carried out at the national level to ensure decent working conditions [1-3].

In accordance with Article 3 of ILO Convention No. 187 [4], the concept of occupational risk management was introduced into the Labor Code of the Republic of Kazakhstan for the first time in 2020. A new Concept of Safe Work in Kazakhstan until 2030 was developed, with one of its key objectives being the modernization of the national occupational safety management system based on a risk-based approach.

Currently, the country is conducting trilateral active work to further improve the current Concept of safe labor in Kazakhstan until 2030. Scientific institutions, enterprises, and trade unions under the leadership of state bodies are involved in the process. In this regard, in June 2023, the Deputy Prime Minister - Minister of Labor and Social Protection of the Population of the Republic of Kazakhstan approved the "Roadmap for the Development of the Concept of Safe Work". The main directions of the named Roadmap are:

1. Differentiation of the workplace according to the degree of occupational risk.
2. The choice of PPE according to the degree of occupational risk.
3. Differentiation of the insurance rate according to the degree of occupational risk.
4. Differentiation of types and volumes of social guarantees to persons employed in harmful working conditions according to the degree of occupational risk.
5. Improving the quality of training in the field of occupational safety and introducing a model for developing professional competencies, taking into account the degree of occupational risk.
6. A new format of state control and statistical monitoring in the field of labor protection.

To determine the degree of occupational risk, first of all, it is necessary to identify hazards, and their visual and quantitative assessment using appropriate techniques and devices to subsequently provide employees of enterprises with relevant personal protective equipment. The basis for the identification of hazards is a detailed classification of possible hazardous and harmful production factors for a wide range of enterprises and industries.

Existing, according to international experience, classifications of harmful and/or hazardous production factors do not fully reflect the entire available palette of varieties of possible risks in production.

The purpose of the study was to create a new unified classification of working conditions based on domestic and international experience, taking into account the effects of harmful chemical, physical, biological, psychophysiological, and/or dangerous mechanical production factors, and production specifics. Their identification at a certain enterprise or production and the subsequent determination of the degree of their impact using appropriate methods and instrumentation by the relevant organizations accredited for these activities will allow the employer to assess the occupational risk of employees.

To achieve this goal, a wide range of domestic and foreign scientific and methodological sources, regulatory legal acts, standards, and rules on the presence and influence of a variety of harmful and/or hazardous production factors on the body of workers have been analyzed.

Using the information received, a summary table has been compiled with the names of harmful and/or hazardous production factors and their subfactors, which, for the convenience of the user, have been assigned the appropriate cipher.

2. RESEARCH METHODOLOGY

The research uses generally accepted scientific methods, such as analytical, statistical methods, methods of comparison, generalization, and systematization.

The information retrieval stage involves studying scientific and methodological literature, as well as national and interstate standards. Normative documents, scientific research, and developments by domestic and foreign scientists serve as the theoretical and methodological foundation for the study. Scientific works from databases such as Science Direct, Web of Science, Elsevier, and Google Scholar, along with professional industry platforms like ILO, EU-OSHA, NEBOSH, and IOSH in the field of occupational safety and health, are taken into consideration. During this stage, existing classifications and training programs related to the assessment of occupational risks are analyzed.

The scientific and informational search for scientific and technical, regulatory documentation and other publications was carried out previously by lexical (by keywords), then by the author's (by the author's name) information request for the object of research, as well as by the regulatory framework. At this stage, methods of grouping, comparison, methods of information retrieval, and constructive and critical analysis of special literature are used in the analysis of information. The results of this stage give a conceptual description and characterization of the objects of research from the standpoint of the information field, the study, and the elaboration of the object under study.

The descriptive stage of the research is carried out to systematize the collected information and present it in the form of a theoretical review. At this stage of the research, various methods are used: system methods, generalization, analysis and synthesis, structural and functional, and other methods.

3. RESULTS AND DISCUSSION

The issue of classification of harmful and/or hazardous production factors to determine occupational hazards is very relevant. However, there is still no single reference book or manual in the world about various occupational hazards for specific professions due to their huge diversity [5].

One of the first attempts to create a practical list of dangers was the work of Brandt [6] "Industrial Health Engineering".

The author of this book presented a selection of about 1300 different professions with an indication of the relevant occupational risks for each profession. Among the listed hazards, the majority were chemically dangerous.

In the future, systematic work on this issue was not carried out, except for some partial lists relating to limited aspects of occupational risks [5].

In 1964, in Haddon's book "Accident Research: Methods and Approaches" [7], an attempt was made to classify various types of accidents. In 1973, the book by Stellman and Daum [8] "Work is dangerous for your health" presented a table of health hazards by profession ("table of health hazards listed by occupation").

The next attempts at classifications in this area were a set of incomplete lists of "potential occupational exposures" published in 1977 in the monograph of the National Institute of Occupational Safety and Health (NIOSH) "Occupational Diseases: a guide to their Recognition" [9], as well as a list of about 1,000 different potential health hazards that may exist approximately in 2000 different professions, which was compiled in 1973 by the Faculty of Medicine of Tel Aviv University [5].

However, all the listed projects cannot reflect the full extent of the hazards present at enterprises, since they are partial in nature, do not cover the entire field of labor protection, and the list of professions is unstable and varies depending on historical and technological progress.

In this regard, it became necessary and an attempt was made to create a unified classification of harmful and/or hazardous production factors, based on domestic and international experience for assessing the occupational risk of employees, on the basis of which a more complete and reliable identification of hazards in the workplace is possible.

To this end, the scientific and methodological literature in the field of occupational safety, regulatory documents, interstate standards, scientific works, and developments of domestic and foreign scientists were analyzed [10-16].

The following main groups of risks associated with the impact of factors of the production environment and the labor process on the employee's body have been identified - physical nature, chemical nature, biological nature, mechanical nature, psychophysiological nature, as well as the impact of general industrial pollution.

Thus, in the "Systematization of occupational hazards by Profession" of the ILO [14], the following classification of dangerous and harmful production factors is presented:

1. Hazards (accident hazard; mechanical and general; chemical accidents; electrical accidents; fires and chemical explosions; radiation accidents).
2. Physical hazards (ionizing radiation; non-ionizing radiation; vibration, noise; exposure to weather conditions).
3. Chemical hazard (direct/immediate effects - irritation of mucous membranes, eyes, and respiratory organs; effects on the nervous system; gastrointestinal disorders; skin effects; asphyxia; delayed, chronic or long-term effects - chronic systemic poisoning; skin, eye, inhalation effects; effects on the reproductive system; carcinogenesis and mutagenesis.
4. Biological hazards (microorganisms and their toxic products; poisonous and allergenic plants; animal exposure).
5. Ergonomic and social factors.

In the technical regulations of the Customs Union "On the safety of personal protective equipment" (TR CU 019/2011) personal protective equipment is classified depending on the protective properties [15]:

- from mechanical influences (from abrasion, punctures, cuts, vibration, noise, blows to different parts of the body, possible capture by moving parts of mechanisms; from general industrial pollution; from water and solutions of non-toxic substances; from non-toxic dust; from sliding on surfaces);

- from chemical factors (from toxic substances; from acid solutions; from alkalis; from organic solvents, including lacquers and paints based on them; from oil, petroleum products, oils, and fats);
- from biological factors (from harmful microorganisms, insects, and arachnids);
- from radiation factors (from radioactive contamination and ionizing radiation);
- from elevated and (or) lowered temperatures;
- from thermal risks of electric arc, non-ionizing radiation, electric shock, and electric electromagnetic fields, as well as from the effects of static electricity.

In the practical manual of Murtonen [16] "Risk assessment in the workplace" (Finnish experience), the following are highlighted: physical hazard factors, accident risk factors, ergonomics, chemical and biological risk factors, as well as psychological overload, which echoes the above-mentioned grouping of factors.

The analysis of the mentioned classifications allowed us to conclude that the most correct grouping of the main factors is the grouping according to the Nomenclature of personal protective equipment, depending on harmful production factors and the degree of their impact [13]: On factors of physical, chemical, biological, mechanical, psychophysiological nature, as well as the effects of general industrial pollution. In this work, for the first time, the authors proposed personal protective equipment depending on a wide range of harmful and/or dangerous factors of the production environment and the labor process, as well as the degree of their impact on the employee's body, indicating the norms, terms of wear and appropriate standards for this protective equipment.

The most numerous group of factors are physical factors. So, in the Recommendations for the classification, detection, recognition, and description of hazards (Order of the Ministry of Labor of the Russian Federation of January 31, 2022 No. 36), physical hazards include electrical, radiation hazards, noise, vibration, fire, as well as mechanical (moving parts of machines and equipment) and gravitational (falling people/objects from a height) hazards [17].

The US National Association of Safety Professionals (NASP) classifies physical hazards as loud noises, extreme pressures, magnetic fields, radiation, fire, poor lighting, unsafe equipment, misused equipment, walkway obstructions, slippery floors, etc. [18].

The largest category of physical factors is vibroacoustic, which encompasses various harmful elements. Industrial noise is the most prevalent factor, characterized by the random combination of sounds with different frequencies and intensities that arise from mechanical vibrations in solid, liquid, and gaseous media. Numerous studies have been conducted to assess the impact of noise on human health and productivity [19-22]. Noise can be classified based on frequency response (low-, medium-, and high-frequency), spectrum nature (broadband or tonal), temporal characteristics (constant or non-constant), and the type of source (mechanical, aerodynamic, electromagnetic, hydrodynamic) [19].

Vibration is another common hazardous factor in production environments. Over the past decade, therapists specializing in occupational rehabilitation have observed a significant increase in the prevalence of cumulative traumatic vibration disorders [23]. According to Semenov [24], industrial vibration can be categorized based on transmission method (general or local), direction (vertical or horizontal), exposure period (temporary or constant), frequency (low, medium, or high), and spectral nature (narrowband or broadband).

The group of vibroacoustic factors also includes infrasound and ultrasound. In infrasound, sanitary standards [25] distinguish between spectrum nature (broadband or tonal) and temporal characteristics (constant or non-constant). The sound pressure level of constant infrasound varies no more than 2 times (6 dB) during the observation period, while non-constant infrasound changes by at least 2 times (6 dB) when measured using a "linear" sound level meter scale with a "slow" time characteristic.

Ultrasound is categorized based on the method of ultrasonic vibration propagation. Hygienic classification [26] distinguishes between contact and airborne ultrasound. Ultrasonic vibrations are further categorized based on the type of source (manual or stationary), spectral characteristics (low-frequency: 16-63 kHz, mid-frequency: 125-250 kHz, high-frequency: 1.0-31.5 MHz), mode of generation (constant or pulsed), and method of radiation (ultrasound sources with magnetostrictive or piezoelectric generators).

Noise and vibration in combination with the fibrogenic effect of dust and high loads cause the greatest risk of occupational diseases [27-30].

The next, no less important group of harmful production factors are radiation (optical (non-ionizing), ionizing, electromagnetic fields, as well as lighting). According to OSHA [31], non-ionizing radiation occurs in a wide variety of occupational settings and can pose a significant health risk to potentially exposed workers. Non-ionizing radiation includes:

- extremely low-frequency radiation (ELF) - at a frequency of 60 Hz is produced by power lines, electrical wiring, and electrical equipment;
- radio frequency and microwave radiation - damage tissue as a result of heating;
- infrared radiation (IR) - sources are stoves, heat lamps, and IR lasers, excessive exposure is felt in the form of heat and pain;
- visible light radiation - excessive visible radiation can damage the eyes and skin;
- ultraviolet radiation (UV) - has a wide range of photon energies; sources are the sun, black light, welding arcs, and UV lasers;
- laser radiation - includes an IR laser on CO_2; helium-neon, neodymium YAG and ruby lasers in the visible range, as well as a nitrogen UV laser; which are hazardous to eyes and skin.

Sources of ionizing radiation include radioactive materials and radiation-generating machines [32]. A number of works are devoted to the harmful effect of ionizing radiation on the body of workers, including [33-35]. The main types of ionizing radiation are alpha, beta, gamma, and X-rays. This group of radiation also includes electrically charged air particles - air ions [12, 36]. When interacting with a person, ionizing radiation can damage living cells in the human body.

The next group of radiations consists of non-ionizing electromagnetic fields [12], which include the geomagnetic field (weakening); electrostatic field; permanent magnetic field (including hypogeomagnetic); electric fields of industrial frequency (50 Hz); magnetic fields of industrial frequency (50 Hz); electromagnetic fields at the workplace of a PC user;

electromagnetic radiation of the radio frequency range; broadband electromagnetic pulse. Electromagnetic fields cause chromosomal aberrations in lymphocytes and other cardiovascular effects in the body of workers [37-39].

Illumination is a significant factor in the production environment. The evaluation of light environment parameters for both natural and artificial lighting is conducted based on specific criteria [12]. Natural lighting is assessed using the coefficient of natural light, while artificial lighting is evaluated using various indicators such as illuminance, direct brilliance, pulsation coefficient of illumination, and other standardized measures of illumination. When assessing working conditions in terms of illumination, consideration is given to the ability to compensate for insufficient or absent natural light by creating favorable conditions for artificial lighting. Additionally, if necessary, measures can be taken to address inadequate ultraviolet radiation.

Electrical accidents are very common in the workplace and are caused by unprotected exposure to high-voltage electrical outlets. According to the International Electrical Safety Foundation, electrical hazards cause over 300 deaths and 4 injuries in American workplaces each year [40].

Electrical burns, electrical fires, and electric shocks are the 3 main types of electrical accidents. Electrical shock occurs when body contact with electricity causes current to flow through your body, and in severe cases, this can lead to heart or respiratory failure.

In many cases, electrical burns are the result of electrical shock, and they can be internal or external. Electrical fires occur when bare wiring or broken circuits come into contact with flammable materials in the workplace, such as cotton and wood shavings.

While it is crucial to address the electrical hazard of direct contact, there is another electrical hazard associated with the release of intense radiant and convective energy during an electrical arc flash. It's important to note that a person doesn't have to physically touch a live conductor or be part of an electrical circuit to be harmed by an arc flash. Even when positioned just a few feet away from energized conductors or equipment, individuals can sustain severe injuries due to the high levels of heat energy emitted by the electric arc [41]. In the United States alone, it is estimated that 5 to 10 arc flash explosions occur in electrical equipment each day. In the mining industry, non-contact electric arcs account for the largest single category of electrical injuries [42].

Specially created electric arcs, which involve an electric charge located between electrodes and emit a significant amount of energy, are commonly utilized as a heat source in welding processes [43, 44]. The welding arc has a maximum temperature of approximately +7,000°C. This level of heat is employed in the metalworking of materials that require temperatures exceeding +3,000°C for melting. When discussing the characteristics of this electric charge, it is important to understand that the welding arc functions as a conductor formed by ionized gas. The arc comprises multiple zones that release substantial thermal energy as current passes through them. The ignition of the arc establishes a galvanic circuit involving the anode, cathode, and ionized gas. This process involves the use of two electrodes. The flow of current generates the heating of the arc, and the emission of light from it is attributed to the presence of photon radiation.

Welding poses several hazards to both those performing the activity and those around them. The main types of hazards in the performance of welding work are exposure to smoke and gases; fires and explosions; electric shock; noise hazards; exposure to UV and IR radiation, as well as burns [45].

The next category of hazardous physical factors involves the risk of fire or explosion. The consequences of workplace fires or explosions can be severe, leading to loss of life, injuries, and significant damage to property and the environment. Flammable substances, including dust, liquids, and gases, pose a significant danger in this regard.

Dust from various common materials such as coal, wood, and flour, among others, has the potential to create an explosive atmosphere. Liquids such as gasoline, solvents, and certain chemicals release vapors that can ignite or explode when mixed with air. Gases, such as LPG, hydrogen, or other flammable industrial gases, are typically stored under pressure in cylinders and can easily ignite or explode if there are any fugitive releases.

Open flames or sparks, including those generated by static charges resulting from friction, can serve as ignition sources in these situations.

It is crucial to take appropriate precautions and preventive measures to minimize the risk of fire or explosion in the workplace [46, 47].

The smoke released during fires is also a great danger. Inhalation of smoke can cause problems in several ways: suffocation with carbon monoxide; poisoning of the body with toxic substances; damage to the windpipe, respiratory tract, and/or lungs with toxic chemicals, as well as burning of the mouth and throat with hot gases [48].

An important group of physical factors considered in this article are the climate and microclimate in the open area and indoors. According to the previous studies, the indicators characterizing the microclimate in industrial premises are air temperature; surface temperature, relative humidity; air velocity; the intensity of thermal irradiation [12, 49]. Microclimate indicators should ensure the preservation of a person's thermal balance with the environment and the maintenance of an optimal or permissible thermal state of the body. Hygienic requirements for microclimate indicators are established for workplaces on industrial premises. An important indicator of the microclimate is thermal radiation. It is one of the harmful production factors affecting the labor process [50]. The hyperbaric environment is an environment with high atmospheric pressure, the characteristic factor which significantly affects the human body during professional activity [51].

The aerosol composition of the air in the presence of aerosols of predominantly fibrogenic action (PFA) is also a common harmful factor of production. Inhalation of these aerosols by an employee is the cause of a number of occupational respiratory diseases (dust bronchitis, pneumoconiosis, lung cancer, etc.). All PFA are divided into high-, moderate- and weakly fibrogenic, which is reflected in hygienic rationing, taken into account in hygienic control and classification of working conditions according to indicators of harmfulness [47, 52-54].

The next large group consists of production factors of chemical nature, which are divided by toxicity, the effects, and ways of penetration of harmful substances into the human body, as well as by physical action [10, 12, 14].

Within the framework of the Globally Internationally Harmonized System (GHS) hazard Classification of chemical products, chemicals are classified according to their physical properties (explosion hazard, flammability), toxicological health hazards, and environmental hazards. Toxicological hazards are acute toxicity, irritation or corrosion activity, sensitization, carcinogenicity, mutagenicity, reproductive toxicity, and chronic or repeated dose toxicity [55]. GHS is also incorporated into U.S. regulations through a Proposed Rulemaking Notice issued in September 2009 by the Occupational Safety and Health Administration (OSHA) [56]. Any chemical or physical property of a material can be associated with information within a single molecule and its structure, thereby developing prediction models such as QSAR and QSPR [57-61].

Considerable attention in scientific literature and regulatory documents is dedicated to biological hazards [12, 14, 62-68]. According to the study in ref. [12], hazardous biological factors encompass microorganisms involved in production, living cells and spores present in bacterial preparations, and pathogenic microorganisms that act as agents of infectious diseases. The pathogenicity groups for these factors are outlined in sanitary and epidemiological rules and regulations [62]. The Decree of the Polish Minister of Health on biological agents harmful to health [63] provides a classification and list of harmful biological agents, as well as a roster of occupations that expose workers to such agents. Harmful biological factors can result in infections, allergies, and poisoning, and include cellular microbes (including genetically modified organisms), cell-free replicating or genetic material-transmitting units (including genetically modified ones), internal human parasites, and cell cultures.

The list of occupations exposing workers to biological agents includes employment in medical institutions, clinical, veterinary, or diagnostic laboratories, waste management enterprises, wastewater treatment facilities, food production enterprises, agricultural settings, and any work involving contact with animals or animal products. The concept of harmful biological factors in the production environment, "Biological hazards when working in contact with soil, livestock or crops," encompasses microorganisms and macroorganisms, as well as substances they produce that adversely affect the human body [61]. These factors include infectious disease-causing agents such as viruses, bacteria, fungi, or protozoa; allergens and toxins produced by plants, including crop and animal poisons; and carcinogens associated, for example, with wood dust or mold fungi.

The next group of factors are industrial hazards - a fall in the work area, accidents on transport and exposure to production equipment, or mechanical hazards [51]. Mechanical hazards are a very important, unique group of physical hazards generated by the workflow, the consequences of which are instantaneous. because of the combination of different aspects. People have had to contend with dangers since the advent of modern industrial civilization. The level of intensity of the negative consequences of hazards increases with the speed, mass, etc. characteristics of the working equipment.

In the Hungarian course on the promotion of occupational safety [69], the most common sources of mechanical hazards are work tools, transport, handling, movement of tools (eg forklifts, cranes), respectively. Movement of products and exposure to dyes, adhesives, oily and other substances (or labor products) [70].

Classification of production factors for occupational risk is presented in Table 1.

Table 1. Classification of production factors for occupational risk assessment

Factor Code	Name of Factors
01	**PRODUCTION FACTORS OF PHYSICAL NATURE**
01.1	**Vibroacoustic factors**
01.1.1	***Production Noise***
01.1.1.1	*Noise by frequency response*
01.1.1.1.1	Low-frequency (maximum sound pressure in the frequency range below 400 Hz)
01.1.1.1.2	Mid-frequency (in the frequency range from 400 to 1000 Hz)
01.1.1.1.3	High-frequency (over 1000 Hz)
01.1.1.2	*By the nature of the spectrum*
01.1.1.2.1	Broadband (with a continuous spectrum with a width of more than one octave)
01.1.1.2.2	Tonal (there are pronounced discrete tones in the spectrum)
01.1.1.3	*By time characteristics*
01.1.1.3.1	Constant (the level of which for an eight-hour working day varies in time by no more than 5 dBA
01.1.1.3.2	Non-permanent (the level of which varies in time by more than 5 dBA over an eight-hour working day)
01.1.1.4	*Depending on the noise sources*
01.1.1.4.1	Mechanical noise (as a result of the operation of various mechanisms)
01.1.1.4.2	Aerodynamic noise (when air moves through pipelines and ventilation systems)
01.1.1.4.3	The noise of electromagnetic origin (due to vibrations of elements of electromechanical devices – rotor, stator, core, transformer, etc.)
01.1.1.4.4	Hydrodynamic noise (due to processes occurring in liquids (hydraulic shocks, flow turbulence, etc.)
01.1.2	***Ultrasound***
01.1.2.1	*According to the spectral characteristics of ultrasonic vibrations*
01.1.2.1.1	Low-frequency ultrasound -16-63 kHz
01.1.2.1.2	Mid-frequency ultrasound -125-250 kHz
01.1.2.1.3	High-frequency ultrasound - L 0-31.5 MHz
01.1.2.2	*According to the method of propagation of ultrasonic vibrations*
01.1.2.2.1	Contact method
01.1.2.2.2	Air method
01.1.2.3	*By type of ultrasonic vibration sources*
01.1.2.3.1	Manual sources
01.1.2.3.2	Stationary sources
01.1.2.4	*According to the mode of generating ultrasonic vibrations*
01.1.2.4.1	Permanent ultrasound
01.1.2.4.2	Pulsed ultrasound

Factor Code	Name of Factors
01.1.2.5	*According to the method of radiation of ultrasonic vibrations*
01.1.2.5.1	Ultrasound sources with a magnetostrictive generator
01.1.2.5.2	Ultrasound sources with piezoelectric generator
01.1.3	***Infrasound***
01.1.3.1	*By the nature of the spectrum*
01.1.3.1.1	Broadband infrasound, with a continuous spectrum with a width of more than one octave
01.1.3.1.2	Tonal infrasound, in the spectrum of which there are audible discrete components
01.1.3.2	*By time characteristics*
01.1.3.2.1	Constant infrasound
01.1.3.2.2	Unstable infrasound
01.1.4	***Vibration***
01.1.4.1	*By transmission method*
01.1.4.1.1	Vibration is general
01.1.4.1.2	Local vibration
01.1.4.2	*By direction*
01.1.4.1.1	Vertical vibration
01.1.4.1.1	Vibration is horizontal
01.1.4.3	*By exposure period*
01.1.4.3.1	The vibration is temporary
01.1.4.3.2	The vibration is constant
01.1.4.4	*By frequency*
01.1.4.4.1	Low–frequency (up to 4 Hz - general, 8-16 Hz -local) vibration
01.1.4.4.2	Medium frequency (8-16 Hz – general, 31-63 Hz – local) vibration
01.1.4.4.3	High–frequency (31-63 Hz - general, 125-1000 Hz – local) vibration
01.1.4.5	*By the nature of the spectrum*
01.1.4.5.1	Narrow-band vibration
01.1.4.5.2	Broadband vibration
01.2	**Radiation**
01.2.1	***Optical (non-ionizing radiation)***
01.2.1.1	Extremely Low-Frequency Radiation (ELF)
01.2.1.2	Radio frequency and microwave radiation
01.2.1.3	Infrared radiation
01.2.1.4	Visible light emission
01.2.1.5	Ultraviolet radiation (UV)
01.2.1.6	Laser radiation
01.2.2	***Ionizing radiation***
01.2.2.1	Alpha radiation
01.2.2.2	Beta radiation
01.2.2.3	Gamma radiation (exposure)
01.2.2.4	X-ray radiation
01.2.2.5	Electrically charged air particles – versions
01.3	**Electromagnetic fields (EMF)**
01.3.1	Geomagnetic field (attenuation)
01.3.2	Electrostatic field
01.3.3	Permanent magnetic field (including hypogeomagnetic)
01.3.4	Electric fields of industrial frequency (50 Hz)
01.3.5	Magnetic fields of industrial frequency (50 Hz)
01.3.6	Electromagnetic fields at the workplace of a PC user
01.3.7	Electromagnetic radiation of the radio frequency range
01.3.8	Broadband electromagnetic pulse
01.4	**Lighting**
01.4.1	***Natural light***
01.4.1.1	Natural light ratio
01.4.2	***Artificial lighting***
01.4.2.1	Illumination of the working surface for visual work categories
01.4.2.2	Direct brilliance (control is carried out visually)
01.4.2.3	Light ripple coefficient
01.5	**The effect of electric current**
01.5.1	***Electrical accidents***
01.5.1.1	Electric shock
01.5.1.2	Electric burns
01.5.1.3	Electrical fires
01.5.2	***The effect of an electric arc***
01.5.2.1	*Thermal risks of an electric arc when working with electrical equipment*
01.5.2.2	*Impact of welding arcs*
01.5.2.2.1	Exposure to smoke and gases
01.5.2.2.2	Fires and explosions
01.5.2.2.3	Electric shock
01.5.2.2.4	Noise hazards
01.5.2.4.1	Exposure to UV and IR radiation

Factor Code	Name of Factors
01.5.2.2.5	Burns
01.6	**The threat of fire or explosion**
01.6.1	Ignition of combustible substances
01.6.2	Static electricity
01.6.3	Working with pressure vessels
01.6.4	Exposure to smoke
01.7	**Climate/microclimate**
0.1.7.1	***Air temperature***
01.7.1.1	*Air temperature in the open area*
01.7.1.1.1	Increased air temperature in the open area
01.7.1.1.2	Low air temperature in the open area
01.7.1.2	*Indoor air temperature*
01.7.1.2.1	Increased air temperature in the production room
01.7.1.2.2	Reduced air temperature in the production room
01.7.2	***Increased air velocity***
01.7.2.1	Increased air velocity in an open area
01.7.2.2	Increased air velocity in the production room
01.7.3	***Increased humidity***
01.7.2.1	Increased humidity in the open area
01.7.2.2	Increased humidity in the room
01.7.4	***Increased thermal radiation***
01.7.5	***Increased atmospheric pressure***
01.8	**Aerosol composition of air**
01.8.1	Highly and moderately fibrogenic aerosols
01.8.2	Weakly fibrogenic aerosols
02	**PRODUCTION FACTORS OF CHEMICAL NATURE**
02.1	**Toxic substances**
02.1.1.	Solid toxic substances
02.1.2	Liquid toxic substances
02.1.3	Gaseous toxic substances (hazard classes 1-4)
02.2	**On the effects on the human body**
02.2.1	Substances of sharply directed action
02.2.2	Substances that cause suffocation (e.g. carbon monoxide)
02.2.3	Intoxicants (for example, organic solvents and their nitro- and amino derivatives
02.2.4	Irritating substances (e.g. chlorine, ammonia, acetone)
02.2.5	Carcinogenic substances (cause cancer - for example, nickel, chromium compounds, amines, asbestos, resin)
02.2.6	Mutagenic substances (gene mutations, chromosome damage – for example, mercury, styrene, magnesium, benzene
02.2.7	Allergenic substances (sensitizers – for example, isocyanate)
02.2.8	Teratogens (cause birth defects – for example, oxalic acid, thalidomide)
02.2.9	Narcotic analgesics
02.2.3	Intoxicants (for example, organic solvents and their nitro- and amino derivatives
02.2.4	Irritating substances (e.g. chlorine, ammonia, acetone)
02.2.5	Carcinogenic substances (cause cancer - for example, nickel, chromium compounds, amines, asbestos, resin)
02.2.6	Mutagenic substances (gene mutations, chromosome damage – for example, mercury, styrene, magnesium, benzene
02.2.7	Allergenic substances (sensitizers – for example, isocyanate)
02.2.8	Teratogens (cause birth defects – for example, oxalic acid, thalidomide)
02.2.9	Narcotic analgesics
02.3	**On the way of penetration of harmful substances into the human body**
02.3.1	Through the respiratory organs
02.3.2	Through the gastrointestinal tract
02.3.3	Through the skin and mucous membranes
02.4	**By physical action**
02.4.1	Flammable substances
02.4.2	Explosive substances
03	**PRODUCTION FACTORS OF BIOLOGICAL NATURE**
03.1	**Microorganisms**
03.1.1	Producing microorganisms
03.1.2	Preparations containing live cells and spores of microorganisms
03.1.3	Pathogenic microorganisms (viruses, bacteria, fungi, protozoa)
03.2	**Plants**
03.2 1	Allergens and toxins produced by plants
03.2.2	Carcinogens (wood dust, mold fungi)
03.3	**Animals**
03.3.1.	Animals – pathogens of zoonotic diseases (livestock)
03.3.2	Attacks of poisonous arthropods, snakes, invertebrates, and insect bites (agricultural workers)
03.3.3	Animal attacks – bites, scratches (veterinary workers)
03.4	**Soil and agricultural dust**
03.4.1	Soil dust
03.4.2	Agricultural dust
04	**PRODUCTION FACTORS OF MECHANICAL NATURE**

Factor Code	Name of Factors
04.1	**Falling into the work area**
04.1.1	***The Fall of a Man in the work area***
04.1.1.1	Falling from a height
04.1.1.2	The fall of an employee on the surface of one level (as a result of slipping, tripping, etc.)
04.1.2	***Fall, collapse in the work area***
04.1.2.1	Falling, collapse, collapse of objects
04.1.2.2	Falling, destruction of buildings, structures, and their elements
04.2	**Transport accidents**
04.2.1	***Road traffic accidents***
04.2.1.1	Conflict
04.2.1.2	Hitting an employee
04.2.2	***Falls on transport***
04.2.2.1	A drop of the transported cargo
04.2.2.2	The fall of an employee from a moving vehicle
04.3	**Impact of production equipment**
04.3.1	***Danger when working with production equipment***
04.3.1.1	Moving and rotating parts of equipment, mechanisms, machines, and tools (blows, grips, squeezes)
04.3.1.2	Immobile cutting parts of production equipment, mechanisms, machines, tools (cuts, scratches)
04.3.2	***The surface temperature of production equipment***
04.3.2.1	Exposure to the high surface temperature of equipment, mechanisms, machines, tools, liquids, gases, vapors
04.3.2.2	The impact on the employee of the low surface temperature of equipment, mechanisms, machines, tools
05	**PRODUCTION FACTORS OF PSYCHOPHYSIOLOGICAL NATURE**
05.1	**The severity of labor**
05.1.1	***The nature of the load on the human body***
05.1.1.1	Intensive load on the heart, blood vessels
05.1.1.2	Load on the musculoskeletal system
05.1.1.3	The load on the respiratory organs
05.1.2	***Quantitative characteristics of the load***
05.1.2.1	Static load size
05.1.2.2	Number of uniform movements
05.1.2.3	The volume of cargo to be lifted
05.2	**Labor intensity**
05.2.1	Long-term mental work
05.2.2	Monotony of processes
05.2.3	Stress in the emotional sphere
06	**GENERAL INDUSTRIAL POLLUTION**
0.6.1	Polluted water
06.2	Solutions of non-toxic substances (coloring, gluing, oily, etc. substances)
06.3	Non-toxic dust (small chips, small fragments, coarse dust)

4. CONCLUSIONS

Currently, the Republic of Kazakhstan applies a strictly regulated approach to the issuance of PPE on the basis of established norms [71]. The current regulatory procedure is associated with various difficulties and barriers, is not flexible and does not allow the employer to adjust the volume of issuance or the timing of wearing PPE.

The obtained scientific results form the basis of a new mechanism for ensuring PPE from the effects of harmful and hazardous production factors within the framework of an individual approach to each employee, depending on the established degree of occupational risk.

This mechanism ensures the transition from a list-based approach of providing PPE to a risk-oriented one. Based on the developed classification of production factors for the assessment of occupational risk, a "List of PPE depending on harmful production factors and the degree of their impact" has been prepared for testing, which will be included in subordinate regulatory legal acts in the form of a list of relevant (correlated) PPE is used in automating the process of providing PPE, integrating information systems of various organizations and government agencies.

The results of the study are of great practical importance not only within one state, but also on an international scale. The developed classification can be applied to identify and assess occupational risk in any enterprise or production.

ACKNOWLEDGMENT

This work is supported by the scientific and technical program on a topic: "Risk-oriented organizational-economic mechanisms for ensuring safe work in the conditions of modern Kazakhstan" (IRN OR11865833) under the program of funding research of the Republican Research Institute of Occupational Safety and Health under the MLSPP of the Republic of Kazakhstan.

REFERENCES

[1] https://adilet.zan.kz/eng/docs/K1500000414, accessed on Nov. 23, 2015.

[2] https://adilet.zan.kz/rus/docs/U1400000732, accessed on Jan. 17, 2014.

[3] https://www.gov.kz/memleket/entities/enbek/documents/details/285862?lang=ru, accessed on Jan. 20, 2022.

[4] https://adilet.zan.kz/rus/docs/Z1400000243, accessed on Oct. 20, 2014.

[5] Donagi, A., Aladjem, A. (1998). Systematization of occupational hazards by occupation. Encyclopaedia of Occupational Health and Safety, Fourth Edition, Published by the International Labour Organization. Geneve: International Labour Organization.

[6] Brandt, A.D. (1947). Industrial Health Engineering. Published / Collections: Public Library of India, Bharat Ek Khoj.
[7] Tillmann, W.A. (1966). Accident research: Methods and approaches. Psychosomatic Medicine, 28(2): 194. https://doi.org/10.1097/00006842-196603000-00011
[8] Stellman, J.M., Daum, S.M. (1973). Work is dangerous to your health: A handbook of health hazards in the workplace and what you can do about them. New York: Vintage Books, 448 p.
[9] Key, M.M., Ede, L. (1977) Occupational Diseases: A Guide to Their Recognition. US Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health.
[10] Abikenova, S., Daumova, G., Kurmanbayeva, A., Yesbenbetova, Z., Kazbekova, D. (2022). Relationship between occupational risk and personal protective equipment on the example of ferroalloy production. International Journal of Safety and Security Engineering, 12(5): 609-614. https://doi.org/10.18280/ijsse.120509
[11] https://online.zakon.kz/Document/?doc_id=34182412, accessed on Dec. 10, 2015.
[12] https://online.zakon.kz/Document/?doc_id=35193093, accessed on Dec. 31, 2020.
[13] https://copyright.kazpatent.kz/?!.iD=wQEy, accessed on Sep. 6, 2022.
[14] Systematization of Occupational Hazards by Occupation https://www.iloencyclopaedia.org/part-xviii-10978/guide-to-occupations/item/996-systematization-of-occupational-hazards-by-occupation.
[15] https://adilet.zan.kz/rus/docs/H11T0000878, accessed on May 28, 2019.
[16] Murtonen, M. (2007). Risk assessment in the workplace: A practical guide. VTT - Technical Research Center of Finland, Ministry of Social Welfare and Health, Department of Occupational Safety, Tampere, Finland.
[17] https://docs.cntd.ru/document/728094911, accessed on Jan. 31, 2022.
[18] Eric Gislason. (2018). Types of Hazards. December 26. Newsletter. NASP Corporate office training office and member services. https://naspweb.com/blog/types-of-hazards/, accessed on March 7, 2023.
[19] Industrial noise and its effect on the human body. https://shumer.cap.ru/news/2017/08/16/proizvodstvennij-shum-i-vliyanie-ego-na-organizm-chel, accessed on March 7, 2023.
[20] Baker, D. (2015). Application of noise guidance to the assessment of industrial noise with character on residential dwellings in the UK. Applied Acoustics, 93: 88-96. https://doi.org/10.1016/j.apacoust.2015.01.018
[21] Nassiri, P., Monazzam, M.R., Asghari, M., Zakerian, S.A., Dehghan, S.F., Folladi, B., Azam, K. (2014). The interactive effect of industrial noise type, level, and frequency characteristics on occupational skills. Performance Enhancement & Health, 3(2): 61-65. https://doi.org/10.1016/j.peh.2015.01.001
[22] Bozkurt, T.S., Demirkale, S.Y. (2017). The field study and numerical simulation of industrial noise mapping. Journal of Building Engineering, 9: 60-75. https://doi.org/10.1016/j.jobe.2016.11.007
[23] Ramos, D., Schoenmann, L., Scott, D., Trent, J. (1996). The effects of vibration on workers. Work, 6(2): 127-132. https://doi.org/10.3233/WOR-1996-6207
[24] Semenov, I.P. (2018). Industrial Vibration: An Educational and Methodical Manual. Minsk: Belarusian State Medical University, 2018. - 52 p.
[25] Sanitary standards 2.2.4/2.1.8.583-96 "Infrasound in the workplace, in residential and public premises and on the territory of residential development". The State system of sanitary and Epidemiological rationing of the Russian Federation.
[26] Sanitary rules and regulations 2.2.4/2.1.8.582-96. Hygienic requirements when working with air and contact ultrasound sources for industrial, medical and household purposes (approved by the Resolution of the State Sanitary and Epidemiological Supervision of the Russian Federation dated 31.10.1996 N 51).
[27] Hnenna, H. (2016). Risk assessment of the complex harmful factors. Metallurgical and Mining Industry, (1): 187-190.
[28] Fokin, V.A. (2020). Assessment of the risk to the health of workers in the extractive industries when exposed to noise above 80 dBA. Occupational Medicine and Industrial Ecology, 60(11): 867-869. https://doi.org/10.31089/1026-9428-2020-60-11-867-869
[29] Chebotarev, A.G., Kuryerov, N.N. (2020). Hygienic assessment of noise and vibration affecting mining workers. Mining Industry, (1): 148-153. https://doi.org/10.30686/1609-9192-2020-1-148-153
[30] Kuryerov, N.N., Chebotarev, A.G. (2022). Risks to the health of mining machine operators caused by exposure to noise and vibration. Mining Industry, (1): 138-143. https://doi.org/10.30686/1609-9192-2022-1-138-143
[31] Non-Ionizing Radiation - Overview – OSHA. https://www.osha.gov/non-ionizing-radiation#:~:text=Non-ionizing%20radiation, accessed on March 15, 2023.
[32] Ionizing Radiation - Overview – OSHA. https://www.osha.gov/ionizing-radiation/background, accessed on March 16, 2023.
[33] Goodhead, D.T. (1989). The initial physical damage produced by ionizing radiations. International Journal of Radiation Biology, 56(5): 623-634. https://doi.org/10.1080/09553008914551841
[34] Meeren, A., Bertho, J.M., Vandamme, M., Gaugler, M.H. (1997). Ionizing radiation enhances IL-6 and IL-8 production by human endothelial cells. Mediators of inflammation, 6(3): 185-193. https://doi.org/10.1080/09629359791677
[35] Mukherjee, D., Coates, P.J., Lorimore, S.A., Wright, E.G. (2014). Responses to ionizing radiation mediated by inflammatory mechanisms. The Journal of Pathology, 232(3): 289-299. https://doi.org/10.1002/path.4299
[36] Sanitary rules and regulations 2.2.4.1294-03 2.2.4. Hygienic requirements for the aeroion composition of the air of industrial and public premises. The Ministry of Health of Russia, Moscow 2003. https://files.stroyinf.ru/Data1/39/39140/index.htm, accessed on March 17, 2023.
[37] Skyberg, K., Hansteen, I.L., Vistnes, A.I. (1993). Chromosome aberrations in lymphocytes of high-voltage laboratory cable splicers exposed to electromagnetic fields. Scandinavian Journal of Work, Environment & Health, 19(1): 29-34.
[38] Skyberg, K., Hansteen, I.L., Vistnes, A.I. (2001). Chromosomal aberrations in lymphocytes of employees

in transformer and generator production exposed to electromagnetic fields and mineral oil. Bioelectromagnetics, 22(3): 150-160. https://doi.org/10.1002/bem.33
[39] McNamee, D.A., Legros, A.G., Krewski, D.R., Wisenberg, G., Prato, F.S., Thomas, A.W. (2009). A literature review: The cardiovascular effects of exposure to extremely low frequency electromagnetic fields. International Archives of Occupational and Environmental Health, 82(8): 919-933. https://doi.org/10.1007/s00420-009-0404-y
[40] Workplace Safety & Hazards: Types, Examples and Prevention Tips. https://www.formpl.us/blog/workplace-safety-hazard, accessed on March 21, 2023.
[41] Floyd, H.L., Doan, D.R. (2007). Electric arc hazard understanding assessment and mitigation. Professional Safety, 52(1): 18-23.
[42] Kowalski-Trakofler, K., Barrett, E. (2007). Reducing non-contact electric arc injuries: An investigation of behavioral and organizational issues. Journal of Safety Research, 38(5): 597-608. https://doi.org/10.1016/j.jsr.2007.06.004
[43] Lamikiz, A., Ukar, E., Tabernero, I., Martinez, S. (2011). 5 - Thermal advanced machining processes. Modern Machining Technology, 335-372. https://doi.org/10.1533/9780857094940.335
[44] Welding arc: its properties, types, principle of operation. https://vt-metall.ru/articles/746-cvarochnaya-duga/, accessed on April 3, 2023.
[45] Welding Hazards in the Workplace: Safety Tips & Precautions. Katie Martinelli March 21, 2018. https://www.highspeedtraining.co.uk/hub/welding-hazards-in-the-workplace, accessed on April 5, 2023.
[46] About dangerous substances. Health and Safety Executive (HSE). https://www.hse.gov.uk/fireandexplosion/about.htm, accessed on April 7, 2023.
[47] Chorieva, M.M., Nigmatova, F.U., Mansurov, M.A. (2022). Harmful and dangerous factors in oil and gas production facilities. Economy and Society, 10-1(101): 45-50.
[48] Smoke inhalation. MSD Reference. https://www.msdmanuals.com/ru, accessed on April 11, 2023.
[49] Sanitary rules and regulations 2.2.4.3359-16 Sanitary and epidemiological requirements for physical factors in the workplace. https://fcgie.ru/515-mikroklimat-na-rabochem-meste-v-holodnyj-period.html, accessed on April 11, 2023.
[50] Mushnikov, V.S., Lichtenstein, V.I., Vyukhin, V.V. (2018). The influence of thermal radiation on the working conditions of workers. Environmental safety management system: Proceedings of the XII Correspondence International Scientific and Practical Conference (Yekaterinburg, May 30-31, 2018). Yekaterinburg: UrFU, 2018. pp. 242-247. http://hdl.handle.net/10995/74211.
[51] Koradecka, D. (2010). Handbook of Occupational Safety and Health. Edited eBook. https://doi.org/10.1201/EBK1439806845
[52] State standard (GOST) P 54578-2011 Workplace air quality. Predominantly fibrogenic aerosols. General principles for hygienic regulation, monitoring and evaluation. https://files.stroyinf.ru/Data2/1/4293794/4293794009.pdf.
[53] Shaykhlislamova, E.R., Karimova, L.K., Beigul, N.A., Muldasheva, N.A., Fagamova, A.Z., Shapoval, I.V., Larionova, E.A. (2022). Occupational health risk for workers from basic occupational groups employed at copper and zinc ore mining enterprises: Assessment and management. Health, (2): 107-118. https://doi.org/10.21668/health.risk/2022.2.10.eng
[54] Gorlenko, N.V., Murzin, M.A. (2020). Comparative assessment of occupational risks at enterprises of oil production and coal industries in the Irkutsk region. IOP Conference Series: Earth and Environmental Science, 408(1): 012022. https://doi.org/10.1088/1755-1315/408/1/012022
[55] Pratt, I.S. (2002). Global harmonisation of classification and labelling of hazardous chemicals. Toxicology Letters, 128(1-3): 5-15. https://doi.org/10.1016/S0378-4274(01)00529-X
[56] Quintero, F.A., Patel, S.J., Munoz, F., Sam Mannan, M. (2012). Review of existing QSAR/QSPR models developed for properties used in hazardous chemicals classification system. Industrial & Engineering Chemistry Research, 51(49): 16101-16115. https://doi.org/10.1021/ie301079r
[57] Lansford, J.L., Barnes, B.C., Rice, B.M., Jensen, K.F. (2022). Building chemical property models for energetic materials from small datasets using a transfer learning approach. Journal of Chemical Information and Modeling, 62(22): 5397-5410. https://doi.org/10.1021/acs.jcim.2c00841
[58] Escobar-Hernandez, H.U., Pérez, L.M., Hu, P., Soto, F.A., Papadaki, M.I., Zhou, H., Wang, Q. (2022). Thermal stability of metal–Organic Frameworks (MOFs): Concept, determination, and model prediction using computational chemistry and machine learning. Industrial Engineering Chemistry Research, 61(17): 5853-5862. https://doi.org/10.1021/acs.iecr.2c00561
[59] Jiao, Z., Hu, P., Xu, H., Wang, Q. (2020). Machine learning and deep learning in chemical health and safety: A systematic review of techniques and applications. ACS Chemical Health & Safety, 27(6): 316-334. https://doi.org/10.1021/acs.chas.0c00075
[60] Vo, A.H., Van Vleet, T.R., Gupta, R.R., Liguori, M.J., Rao, M.S. (2020). An overview of machine learning and big data for drug toxicity evaluation. Chemical Research in Toxicology, 33(1): 20-37. https://doi.org/10.1021/acs.chemrestox.9b00227
[61] Fayet, G., Rotureau, P. (2019). New QSPR models to predict the flammability of binary liquid mixtures. Molecular Informatics, 38(8-9): 1800122. https://doi.org/10.1002/minf.201800122
[62] https://adilet.zan.kz/rus/docs/V040002692_, accessed on Jan. 21, 2004.
[63] https://www.global-regulation.com/translation/poland/2986155/regulation-of-the-minister-of-health-of-22-april-2005-on-the-harmful-biological-agents-for-the-health-in-the-work-environment-and-the-protection-of-th.html, accessed on date Apr. 22, 2005.
[64] Biological hazards when working in contact with soil, livestock or crops. Health and Safety News December 21, 2017 Sebastian Krichka General topics. https://www.portalbhp.pl/aktualnosci-bhp/zagrozenia-

biologiczne-przy-pracach-w-kontakcie-z-gleba-zwierzetami-hodowlanymi-badz-przy-uprawie-roslin-8018.html, accessed on April 21, 2023.
[65] Biological hazards in the working environment. Geneva: International Labor Office, 2022. https://ilo.org/wcmsp5/groups/public/-ed_norm/-relconf/documents/meetingdocument/wcms_863811.pdf, accessed on April 23, 2023.
[66] Tymczyna, L., Chmielowiec-Korzeniowska, A., Drabik, A. (2007). Removing bacteria, endotoxins, and dust from ventilation system exhaust from a chicken hatchery. Poultry Science, 86(10): 2095-2100. https://doi.org/10.1093/ps/86.10.2095
[67] Dutkiewicz, J., Śpiewak, R., Jablloński, L. (2002). Classification of Harmful Biological Factors. Occurrence in Environment of Work. Ad punctum, Lublin, Poland.
[68] Rim, K.T., Lim, C.H. (2014). Biologically hazardous agents at work and efforts to protect workers' health: A review of recent reports. Safety and Health at Work, 5(2): 43-52. https://doi.org/10.1016/j.shaw.2014.03.006
[69] Promotion of occupational safety. Course. Hungary. https://munkavedelem.unideb.hu/sport/ajanlott%20anyagok/munkavedelem,%20jegyzet.pdf, accessed on April 29, 2023.
[70] State standard (GOST) 12.4.280-2014 Occupational Safety Standards System (SSBT). Special clothing for protection from general industrial pollution and mechanical influences. https://docs.cntd.ru/document/1200116594/titles/65C0IR, accessed on April 21, 2023.
[71] Order of the Minister of Health and Social Development of the Republic of Kazakhstan dated December 8, 2015 No. 943. On approval of the norms for issuing special clothing and other personal protective equipment to employees of organizations of various types of economic activity. https://adilet.zan.kz/rus/docs/V1500012627.