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DEVELOPMENT OF BASICS OF HAZARDOUS AND CRITICALLY IMPORTANT OBJECTS CLASSIFICATION CONSIDERING THE THREAT OF AN ANTHROPOGENIC EMERGENCIES

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Abstract

In the article, such notions as "potentially hazardous object", "high threat object" and "potentially hazardous and critically important object" are articulated and categorized. Forms are given, with which the anthropogenic risks are shown for normal operational use of potentially hazardous objects and high threat objects, as well as during hazardous anthropogenic phenomena. The class division of main potentially hazardous and critically important objects is provided, including the threat of anthropogenic emergencies with the short characteristics for every class. An out line classification of potentially hazardous and critically important objects is given for first two stages, including the numeric serial encoding of every group category. Such notions as "explosion hazardous" and "explosion-proof" are analyzed. The analysis of the parameters of anthropogenic effects on potentially hazardous and critically important object potentially hazardous and critically important object is often multifactorial and is associated with the solution of uncertainties. This requires a systematic approach and the involvement of a suitable mathematical apparatus. It should be noted that due to the incompleteness of the knowledge base and the database available today, which are included in the calculations, the quantitative results of the potentially hazardous and critically important object analysis can have considerable uncertainty.

The practical implementation of the given classification of critically important objects, gives opportunity for controlling, forecasting and managing of anthropogenic risk level. The terms of fuzziness of critically important objects ranging were analyzed with using of geometrical convolution criteria method. A classification which takes into account and partly reduces the fuzziness of ranging is offered.

The method of analysis of various types of potentially hazardous and critically important object can be used to evaluate possible emergencies with subsequent analysis of damage caused by man-made accidents and natural disasters.

Key words: classification, threats, potentially hazardous object, high threat object, critically important object, risks, emergencies.

1. Problem statement.

According to the statistical data, there is a tendency towards expansion of quantity of natural disasters as well as anthropogenic and social emergencies. Such phenomenon is usual for Ukraine as well and in case of targeted influence on them by sabotage groups and illegal formations, the large accumulation of objects, connected to nuclear and chemical industries, as well as hydrotechnical constructions, vital infrastructure and utility systems can trigger appearance of critical circumstances, paralyse vital activity and force thousands of population masses to move.

Potentially hazardous objects (PHO) [1] or even high threat objects (HTO) [2] (transport, mining, metallurgical, chemical, communication systems and other) play important role in provision of high (and even average) living standards. In recent years, the share of resources that provide safety for PHO/HTO has increased to such an extent that the question on the reasonability and feasibility of the absolute safety concept in the process of PHO/HTO operation was raised. Global and regional emergencies and natural disasters, national and international terrorism, war conflicts, as well as world economic meltdown together with other shocks of the beginning of 21st century show that offered forecasting and managing strategies for further development, without direct quantitative accounting of growing number of threats, can become insufficient and even hazardous. Therefore, the alternative to the not paid off concept of absolute safety (accident-free operation), can be the concept of acceptable technical risk. The fact-based framework for this concept is that there is always a danger of incomplete implementation of the decision because of the impossibility to take into account all external and internal threats influencing PHO/HTO.

2. Analysis of the recent researches and publications.

There was always a concern in our country about the task of efficient technical condition management of the PHO/HTO. Nowadays, it becomes more relevant due to the presence of a large number of PHO/HTOs with long service life in various sectors of the economy. Since the resource of such objects is almost depleted, their operation is carried out in high-risk conditions. Most typically, PHO/HTO conceals the potential hazard, for example, objects of nuclear power, chemical industry, aircraft technology, fuel and energy complex, and other. Long after-warranty exploitation of the mentioned PHO/HTO is risky and poses threat to the population and the environment. The analysis of the PHO/HTOs development, created over the past half century, suggests that, despite the rapid development of theoretical areas such as system theory and cybernetics, including the theory of automatic control, reliability theory and security theory is clearly not enough for PHO/HTO security assessment.

Enhancing the safety of PHCIO requires regular assessment of technogenic safety levels. However, the lack of reliable data for the classification of PHCIO complicates their safety level assessment, without which the development of a set of measures to improve their functioning is impossible. The issues of developing approaches for the classification of existing PHCIO have been addressed in scientific papers [3,4], but this problem has not been fully resolved. The work is directed on improvement of methodology of classification of existent PHCIO for further practical introduction of complex of events for provision of their safe functioning.

3. Statement of the problem and its solution.

Today, according to the type of threat there are five groups of PHO/HTO are defined, on which hazardous substances are stored, produced, created, used, transported and destroyed. Depending on the kind of hazardous substances, the objects are divided into such subgroups as explosive, flammable, combustible, oxidized, toxic and highly toxic substances, which constitute a danger to the environment. By origin of the main hazardous factors arising from possible accidents, the following groups of PHO/HTO are defined: chemical, biological, fire-explosive, nuclear and radiation, as well as hydrodynamic hazardous objects. In Ukraine, there are nine thousands of potentially hazardous PHO/HTO [5-8] and the possibility of accidents on them is increasing with fixed assets wear factor growing older. It is important to mention that PHO/HTO are divided into safe and hazardous [9] according to the threat they potentially carry. Hazardous objects are subject to registration in the state register, require compulsory insurance and declaration of safety rate, are taken responsibility for in terms of damage to the third parties and fall under other procedures of state regulation in the field of anthropogenic safety [10]. The limit values for hazardous substances in the PHO/HTO, serving the reason for development of a mandatory industrial safety declaration is given below [11]. It is the following: ammonium nitrate – 2500 tons; ammonia – 500 tons (it is highly toxic, but because of a strong smell it is possible to take the necessary safety measures in time); phosgene gas– 0,75 tons; cyanide hydrogen – 20 tons; sulfur dioxide – 250 tons; combustible liquids, stored in a warehouse – 50000 tons; flammable gases – 200 tons; substances posing a danger to the environment– 200 tons; explosives– 50 tons; oxidizing substances – 200 tons; highly toxic substances – 20 tons. As on 2015, the number of PHO/HTO registered in 739 operating organizations in Ukraine was 2523 [12]. Organization of works on the population and territories securing in any region of the country, first, requires the detection of all the PHO/HTO posing threat of emergence situation (AS) occurrence. Placement of PHO/HTO on a territory is the cause of the anthropogenic hazard to it. The threat to the population is characterized by the types of potentially hazardous objects on the territory, as well as their number, accident rate, volume of pollutants emission, accumulated potential hazard, their allocation in relation to places of residence, operation duration. Adverse factors action zone in case of hazardous anthropogenic occurrence, considering daily average (annual and monthly average) wind distribution, direction and velocity, as well as other important factors also play their role in threat level definition. According to the mechanism of causing harm to human health, anthropogenic hazards are divided into two groups: hazardous anthropogenic processes and phenomena and anthropogenic pollution of the environment.

Upon condition of normal PHO/HTO operation and during hazardous anthropogenic situations, anthropogenic hazards can occur in the following forms [13]:

- dangerous uncontrolled or controlled release of energy (explosive, light, kinetic, thermal, electromagnetic, electric) accumulated in a object;
- dangerous uncontrolled or controlled release of substances (hazards of biological, chemical substances and radiation);
- the disruption of the necessary information streams or the appearance of dangerous streams of information (in announcing, controlling and managing systems of the objects).

However, now the classification of PHO or HTO is out of date and a new classification for potentially hazardous and critically important objects (PHCIO) should be developed [14]. This leads to the logical need for the development of a new classification of PHCIOs [15]. This work should be initiated by the PHCIO types classification analysis. Such a classification should be an integral part of regional security systems for anthropogenic emergencies informational support. On the basis of this classification, it is rational to develop the lists of certain PHCIO in regional offices of The State Emergency Service of Ukraine, ministries, departments, in cities and regions.

PHCIO [16] are physical or virtual objects and resources, providing functions and services, the violation of which will lead to the most serious negative consequences for the society life, socio-economic development, country defense possibility and national security ensuring. PHCIO defense is the set of measures executed by means of regulatory, legal, organizational and technological tools aimed at ensuring the security and stability of crucial infrastructure. In accordance with the lists, each enterprise or an organization having or creating the above-mentioned PHCIO, should create a catalog of such objects with indication of the objects hazard degree for each of the possible threats. Such catalog should also contain the information on possible causes of accidents, characteristics of hazardous premises, buildings, workshops, structures and other parts of the objects, list of emerging (as a result of dangerous events) damaging factors (radioactive substances, shock waves, dangerous factors of fires, hazardous chemical substances, etc.) and other hazardous characteristics.

Creating catalogues of the PHCIOs should be supplemented by the compilation of CIOs security passports with all the necessary characteristics of their hazard, vulnerability and protection against various types of anthropogenic threats. According to the types of anthropogenic threats, different systems and security services are created: fire, radiation, chemical, informational, anti-terrorist, ecological, security, access restriction, transportation emergency services, water, gas, heat and power supply systems, emergency medical services, etc. Departmental and local (objects) classifiers of technical and economic information are important part of the emergency information security systems. However, these classifiers are not sufficient in solving the problems of ensuring the population and territories safety from anthropogenic emergencies. The missing element of the information security systems, taking into account the above-mentioned tasks, should be considered a classifier of the PHCIOs posing threat of anthropogenic disasters. It is suggested to supplement the classifiers with the following classification. According to international and domestic practice, classification of technical and economic information, it is expedient to classify PHCIOs according to the hierarchical method by successive distribution of the objects into classification groups.

This article presents an extensive classification, carried out for the first two stages with the numerical sequential coding of each classification group (Fig.1) The first stage contains the classes encoded with 1-bit codes (1, 2, ..., 5), the second stage contains subclasses encoded with 2-bit codes (01, 11, 26, ...) in the corresponding classes. At the same time, the whole class and subclass codes will be 3-bit (100, 201, 236, ...). If necessary, the classification can be continued with the following stages: at the third stage the groups will be encoded with full 4-bit codes, on the fourth stage, the subgroups will be encoded with full 5-bit codes, on the fifth stage, that will be the types, encoded with full 6-bit codes.

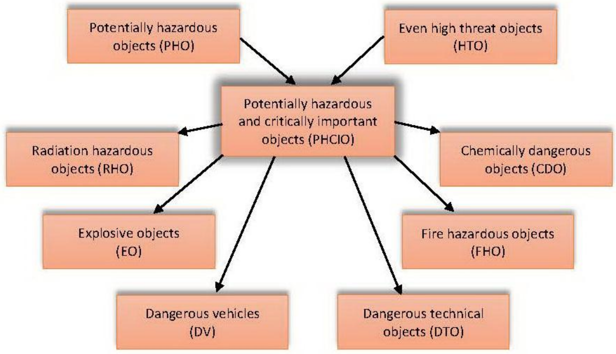

Fig.1. Classification of potentially dangerous CIOs

The nature of the classification on each stage depends on the selected feature of the objects distribution (type of hazard, the purpose of a object, etc.). In accordance with the adopted rules, the classification at each subsequent stage in different groups can be carried out according to various features. As a feature of the PHCIO distribution into classes, the main type of danger of a object (radiation, chemical, others) is used. The main PHCIOs, posing the threat of anthropogenic disaster, will be divided into the following classes (Table 1):

Table 1. List hazardous and critically important objects (PHCIO)

№	Title of PHCIO	Title of CIOs
100	Radiation hazardous objects (RHO)	101 NPPs with water under pressure and water-to-water reactors
		102 NPP with boiling water and graphite reactors
		103 Research nuclear reactors
		111 Nuclear waste reprocessing plants
		121 Uranium mines
		122 Containers of radioactive ore
		123 Radioactive waste storage facilities
		131 Other radiation hazard objects
200	Chemically dangerous objects	201 Oil refineries
		202 Petroleum organic synthesis plants
		203 Petrochemical plants
		204 Shale processing plants
		Manufacturing plants of:
		205 Artificial fibers and threads
		206 Synthetic rubber
		207 Plastic
		211 Paint and varnish materials
		212 Technical rubber products
		213 Fiberglass and fiberglass plastic
		214 Plexiglas
		215 Electrotechnical materials
		216 Cinema, photo and magnetic materials
		221 Chemical Reagents
		222 Chemical inputs
		223 Synthetic dyes

№	Title of PHCIO	Title of CIOs
		224 Film materials
		225 Polymers
		231 Mineral fertilizers
		232 Chemical agents for plants protection
		233 Soda
		241 Medicines
		242 Household chemical goods
		251 Hazardous chemical substances storage
		252 Railway vehicles with chemically hazardous substances
		253 Motor vehicles with chemically hazardous substances
		254 Naval vessels with chemically hazardous substances
		255 River vessels with chemically hazardous substances
		259 Other chemically hazardous objects
300	Fire and explosion hazard and fire hazard objects	301 Enterprises of the oil industry
		302 Gas industry enterprises
		303 Enterprises of the coal industry
		304 Shale industry enterprises
		305 Gas and oil wells
		306 Coal Mines
		307 Offshore oil platforms
		309 Other extractive industry enterprises
		311 Enterprises of the oil refining industry
		312 Petrochemical industry enterprises
		313 Enterprises of the gas processing industry
		314 Chemical industry enterprises
		315 Enterprises of the medical industry
		316 Enterprises of the metallurgical industry
		317 Mechanical engineering enterprises
		321 Nuclear Energy Facilities
		322 Thermal power stations and thermal power plants
		323 Energy facilities of the communal economy objects
		329 Other power objects
		331 Enterprises of the pulp and paper industry
		332 Enterprises of woodworking industry
		333 Wood dust making shops
		334 Coal dust making shops
		335 Sugar powder manufacturing shops
		336 Mills
		337 Elevators
		338 Enterprises producing ammunition, explosives, gunpowder and solid propellant rocket engines
		339 Other industrial enterprises
		341 Stocks of oil and liquid petroleum products
		342 Composition of fuel and lubricants
		343 Ground, underground and semi-underground reservoirs with FLS and CG
		344 Offshore platforms, semi-submerged and underwater oil storage facilities
		345 Railway overpasses for drainage and filling of FLS
		346 Open oil traps and sediment ponds with floating oil film
		347 Filling stations
		351 Composition of chemical inputs
		352 Composition of chemical plant protection agents
		353 Composition of the video film
		357 Rocket systems
		358 Warehouses with ammunition, explosives and solid propellant rocket engines
		359 Other fire and explosive products stocks
		361 Railway tanks with FLS and CG
		362 Automobile tanks with FLS and CG
		363 Naval vessels with oil and petroleum products

№	Title of PHCIO	Title of CIOs
		364 River vessels with oil and petroleum products
		365 Navy ships with liquefied gases
		366 Vehicles with ammunition, explosives and missile technology
		368 War ships
		369 Other vehicles with FLS and CG
		371 Oil Pipelines
		372 Gas pipelines
		373 Bases of liquefied gas
		374 Other production pipelines
		379 Other fire and explosion hazardous objects
		381 Fire hazardous objects with massive presence of people (large industrial, administrative, public and residential buildings, halls for spectators, etc.)
		382 Fire hazardous objects with large material values (museums, libraries, exhibition halls)
		383 Fire hazardous objects with a large number of pets and poultry
		384 Fire-fighting products warehouse
		385 Large forests
		386 Large peatlands
		387 Ripe crop on large areas
		389 Other dangerous objects
400	Dangerous vehicles	401 Passenger see ships
		402 Naval freight passenger ships
		403 Marine rail and road transport ferries
		404 Naval container vessels, trawlers, lighter vessels
		405 River passenger and freight passenger ships
		409 Naval and river vessels
		411 Passenger aircrafts
		412 Airplanes, cargo-and-passenger
		419 Other aviation equipment
		421 Rail passenger trains
		422 Train carying goods
		423 Metro trains
		424 Railway bridges
		425 Railway Tunnels
		426 Metro tunnels
		427 Metro escalators
		429 Other means of railway transport
		431 Buses
		432 Trolleybuses
		433 Road bridges
		441 Dangerous vehicles other
500	Dangerous technical objects	501 Hydroelectric power stations stank
		502 Rivers of artificial reservoirs stanks
		503 Waterproof dams
		504 Antimud slide protection facilities
		505 lavin protection structures
		506 Centralized water supply systems
		507 Centralized gas supply systems
		508 Centralized heating systems
		509 Centralized power supply systems
		511 Sewer systems
		512 Stadiums, ice palaces, swimming complexes and other large sports facilities
		513 Halls for spectators and dance halls, circuses and other entertainment and entertainment facilities with masses of people

Therefore, such types of CIO can be placed to one of any different classes. In the classification of CIO with several affecting factors, it is necessary to consider, first of all, the dominant factor.

The biggest group among the RHOs consists of nuclear reactors, which can be classified based on several features. According to the purpose, nuclear reactors will be classified as energy and research aimed, according to technical execution, they are divided into canistered and tubulated. Canistered reactors are created, mainly, with a water coolant under pressure and for tabulated ones, mainly with boiling water. They also are divided very differently according to the fuel type: according to the enrichment (natural and enriched uranium), the aggregate state of fuel (on ceramic fuel, metallic natural uranium or doped uranium). Of course, there are numerous construction types of reactors but practically, only few of their constructions are extensively used. The following ones are used as power reactors: canistered water-to-water thermal-neutron reactors with water under pressure (VVER-440, VVER-1000), graphite thermal-neutron reactors with boiling water as heat transfer agent (RVPK-1000). According to the energy spectrum of neutrons, the reactors are divided into thermal-neutron, fast nuclear and intermediate spectrum reactors. At the moment, the most familiar reactors are thermal-neutron ones. Intermediate spectrum reactors are used in research facilities. Depending on the type of moderator, thermal-neutron reactors are divided into light-water and graphite. Ordinary water has the best moderating ability and graphite – the worst. Because of their large capacities (440–1000 MWth), power reactors constitute the greatest radiation hazard in case of accidents. RHO also refer to facilities of extractive uranium industry, nuclear fuel industry, storage facilities and warehouses of radioactive materials as well as research nuclear reactors.

For example, the subclass 101 Rivne NPP, Zaporizhia NPP, South Ukraine NPP and Kmelnytsky NPP will be referred; Chernobyl NPP will be referred to the subclass 104 and so on.

The CDOs are also subject to classification, which is determined by those toxic substances that are produced, transported, stored or used on these objects. Concidering the inhalation danger and the size of the stocks that determine the extent of possible chemical contamination in case of accidents, experts analyzed more than 700 toxic substances that were most widespread in the national economy. On the basis of this analysis, several dozens of hazardous chemical substances (HCSs) were identified. The damage coused by them to the population in case of accidents would be the greatest. As a result of the spread of poured or discharged HCS in an area, the chemical damage zones (or chemical contamination) appear. The chemical damage zone includes the location of the spill and the area on which the HCS related substances are spreading with wind in impacted concentrations, penetrating into the buildings, premises and preserving damaging properties for a certain period of time. The boundaries of contamination zones depend on the permissible toxic doses of HCS, the amount of an HCS discharged or thrown into the atmosphere, the topography, the speed and direction of the wind, the vertical stability of the atmosphere ground layers: inversion (the lower layers are colder than the upper) and isotherm (the same temperature within 20–30 m from the earth's surface) contribute to the preservation of HCS high concentrations in the ground layer, convection (the lower layers warmer than the upper ones) causes the diffusion of contaminated air. The degree of danger of the CDO depends on the number of types and mass of HCS located on the site. The number of types of highly toxic substances, located within a single CDO varies from 1 to 16, and the mass of HCS is from several tons to 25 thousand tons.

Fire and explosion hazardous are objects with the presence of flammable liquids, combustible gases, dust. The criteria for their fire and explosion hazard are temperature of initial combustion, self-ignition and inflammability limits. Flammable substances (FLS) include liquids with a flash point not higher than 61 °C, capable of flaming up even from a short-term (no more than 30 seconds) contact with an ignition source with low energy (flame of a matche, spark, smoldering cigarette, etc.) and burn independently after removing the ignition source. Such substances are gasoline, kerosene, acetone, alcohol, ether, turpentine, diesel fuel, petroleum, benzene, toluene, pentane, hexane, etc. The flammable ones include gases that can form flammable and explosive mixtures with air at temperatures not more than 55 °C, which are ammonia, acetylene, hydrogen, butane, ethane, ethylene, methane, methyl chloride, propane, hydrogen sulfide, and others. It worth noting, that many substances that form an explosive mixture with air are also toxic, at the same time, which determines their double danger. Such substances are represented by ammonia, dichloroethane, methyl chloride, methylmercaptan, methyl trichlorosilane, carbon monoxide, ethylene oxide, hydrogen sulfide, carbon monoxide, toluene, ethylmercaptan, ethyl chloride and so on. Explosive dust (particles smaller than 850 microns) is considered to be the material, having inflammability limits not exceeding 65 g/m^3. These are such materials as flour, wood, cork; dusted coal, epoxy, sugar, starch, flour, sulfur, and others. Giving characteristics to FLS and combustible gases (CG) as the main sources of extensive fire explosions, it should be noted that they are more dangerous in handling than solid conventional detonating explosives (DE) used for military and industrial purposes, although the last-named are treated with caution as it is substances specially designed for explosions.

- FLS and CG easily (and often imperceptibly) leak and are emitted into the environment in a dangerous quantity, even with the least depressurization of containers and equipment and upon the violation of the discharge operations rules and careless handling in the process of use; unlike them, the DE are solid substances and do not experience such leakage;
- explosive vapor-air and air mixtures can easily explode from the smallest ignition sources (spark, flame of a match, etc.), and a TNT block can be thrown into the fire or can be shot with a fire arms and an explosion will not happen as it requires a special detonator capsule;
- DE are used by a narrow circle of specialists, and FLS and CG are used by a huge number of people;
- Safety during normal use of FLS and CG (as a fuel) generates negligence in dealing with them and violates safety rules that lead to leakage, evaporation

and numerous explosions and fires.

Classification of many fire and explosive objects is determined by the practically accepted categorization of premises. The category "A" includes premises containing flammable gases, FLS with a initial combustion of not more than 28 °C in an amount that it can form explosive mixtures of gas or steam with air, an indoor flare of which creates the estimated excessive pressure that exceeds 5 kPa. The category "B" includes premises in which there is combustible dust or fibers, FLS with a flash point of more than 28 °C, combustible liquids in such quantity that they can form explosive mixtures of dust or steam with air, an outbreak of which creates the estimated excessive pressure that exceeds 5 kPa. Depending on the category of premises included in the building, the categories of the buildings themselves are determined. The building is classified as "A", if the total area of the "A" category premises exceeds 5% of the total area or 200 m^2. The building is classified as "B" if it does not belong to the category "A" and the total area of the category "A" and "B" premises exceeds 5% of the total area of all premises or 200 m^2. The class of fire and explosion hazardous objects includes industrial objects in which there is at least one "A" building or two or more buildings of category "B". In addition to industrial objects with buildings, fire and explosion hazardous objects class includes immovable and mobile tanks and vessels for the transportation of FLS and liquefied CGs, marine oil storage facilities, FLS carrying tankers, oil pipelines, gas pipelines, offshore oil platforms, oil and gas wells together with coal mines and other objects.

In the proposed classification, fire and explosive objects also include explosive objects. Explosive objects are immovable and mobile ones with the presence of ordinary solid detonation explosives (TNT, hexogen, dynamite, etc.) for military and industrial purposes, such as factories for the production of munitions (shells, bombs, mines, missile and torpedo fighting units) and explosives as well as warehouses where they are stored, rocket systems, warships, airplanes, etc. Fire hazard objects include ones that have combustible and heavy-duty substances and materials in their composition that can burn independently after removing the ignition source. These are premises, buildings, structures, vehicles, forests, peatlands, crops of ripe grains and so on. Unlike fire and explosion hazardous objects containing sources of increased danger of fires and explosions, FLS, combustible gases and dust capable of forming explosive mixtures with air, fire hazard objects do not have such sources of increased danger of explosions and fires and are essentially fire-vulnerable and need protection from the fire, as it poses danger on such objects. This danger is, first of all, is posed for the objects themselves. And the term "fire hazard", traditionally used in the system of fire safety, is not correct enough, since, in this case, it does not quite logically use the very concept of "danger" and according to essence and common sense is used for identifying the objects from which the threat of fires comes (but not the objects to which this threat is directed). It should be noted that the notion of "danger" and "security" (from danger) are not used correctly, when, instead of the term "explosion-proof", the term "explosion-safe" is often used for the labels on electric motors and other electrical equipment in a special execution. Such labels usually mean that if this equipment does not spark, does not flare, does not explode and does not create the threat of explosions in the explosive environment (for example, in gas-air environment). Though, it is logical, that the equipment is inherently explosive, and the notion of "explosion-proof" in such case will be applicable to the premises and the building, having an explosive atmosphere, in which this electrical equipment is located (thus, of course, the electrical equipment will also be protected from explosion of a dangerous mixture, but this explosion protection is secondary, since the main purpose of its special execution is to ensure the safety of people around them, as well as, appliances, premises, and not the electrical equipment itself). However, incorrect use of the term "explosion safe" is reflected in a number of regulatory documents on electrical equipment and as a concecuence, in electrical engineering, the terms "explosion-proof" and "explosion protected" are most often used as synonyms in practice.

Classes from 1 to 3 of the PHCIO already include vehicles carrying radiative, chemical, fire and explosive and fire hazardous cargo. Therefore, Class 4 mainly includes those vehicles that carry large numbers of passengers or expensive safe goods, as well as hazardous transport facilities.

Protective structures, holding back vast amounts of water in high-rise reservoirs, and also throw off powerful mud and mud-stone flows (mudflows) and snow slide from the mountains are included in the 5th form of the CIO (potentially dangerous technical structures) with the threat of the disaster emergence; technical systems of communal services (water, gas, heat, electricity, sewage) as well as constructions with massive stay of people are also included here.

The classification of critical objects, it is proposed to use the target programming method for ranking, which can be used if there is information about the "ideal" object (strategies, statuses, alternatives, solutions). Then, as a ranking function, it is natural to use the distance between the current z and the "ideal" and objects in the form of a metric of multicriteria space [18]:

$$R_i(z)=\left(\sum_{k=1}^{n} w_k \left|f_k(z)-f_k(i)\right|^p\right)^{1/p} \quad \Rightarrow \quad \min,$$

where R_i – is the distance of the current alternative z to the "ideal" i; $0 \le f_k \le 1$ – k criterion in the normalized form, $k = 1,2,\ldots, n$; w_k is the weight coefficient of significance of the k-th criterion; p – is the parameter space of the criteria ($p = 1$ is a linear metric, $p = 2$ is a Euclidean metric, $p = +\infty$ is a Chebyshev metric).

An example of the practical use of the obtained advanced classification was given in [17].

4. Conclusions.

To conclude, the practical implementation of the described classification of CIOs will allow to control, predict and regulate the level of anthropogenic risk as well as to develop economic mechanisms for managing safety in order to reduce the consequences of possible accidents.

In order to take into account and partially overcome the uncertainty of ranking alternatives by geometric convolution of criteria, it is proposed to remove uncertainty about the ranking rule at the stage of qualitative analysis of the problem of ranking of critical objects, that is, according to the peculiarities of the emergency being worked out, justify the choice of either the "minimum distance to ideal" rules or "maximum distance to anti ideal" rules. When selecting representative statistical material to form a reference set of objects of each class and to further determine the decisive functions and distributive positions in the criterion space, take into account the weight coefficients of their level of uncertainty.

Thus, at least 3 groups of calculation methods with the necessary databases should be included in the tools for the analysis of the PHCIO:

1) methods for assessing processes and ways occurrence of adverse events (accidents, natural disasters and disasters);

2) methods describing the consequences of adverse events, such as the release, behavior and spread in the environment of dangerous substances and the mechanisms of damage to these substances of the human body;

3) methods for assessing economic loss and optimizing the use of funds to prevent or mitigate the effects of adverse events.

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РОЗРОБКА ЗАСАД КЛАСИФІКАЦІЇ НЕБЕЗПЕЧНИХ КРИТИЧНО ВАЖЛИВИХ ОБ'ЄКТІВ ІЗ ЗАГРОЗОЮ ВИНИКНЕННЯ ТЕХНОГЕННИХ НАДЗВИЧАЙНИХ СИТУАЦІЙ

В статті визначено поняття "потенційно небезпечний об'єкт", "об'єкт підвищеної небезпеки" і "потенційно небезпечний критично важливий об'єкт" відповідно до запропонованої системи їх класифікація. Наведено форми, за яких реалізуються техногенні небезпеки під час нормальної експлуатації потенційно небезпечних об'єктів і об'єктів підвищеної небезпеки та в небезпечних техногенних явищах. Надано розподіл на класи основних потенційно небезпечних критично важливих об'єктів із загрозою виникнення техногенних надзвичайних ситуацій з їх стислою характеристикою. Наведено розширену класифікацію потенційно небезпечних критично важливих об'єктів, яку створено на перших двох ступенях з цифровим порядковим кодуванням кожного класифікаційного угруповання. Визначено правильність використання термінів "вибухобезпечні" і "вибухозахищені". Проведено аналіз параметрів антропогенних впливів на потенційно небезпечні критично важливі об'єкті, який часто є багатофакторним і пов'язаний з розв'язкою невизначеностей. З урахуванням неповноти бази знань і бази даних, наявних на сьогоднішній день, запропоновано розрахунки, кількісні результати аналізу потенційної небезпеки критично важливого об'єкта в умовах невизначеності.

Практична реалізація наведеної класифікації критично важливих об'єктів призначена для контролю, прогнозу і надання пропозицій щодо регулювання рівня техногенного ризику. Проаналізовано умови невизначеності ранжування критично важливих об'єктів із застосуванням методу геометричної згортки критеріїв та запропоновано підхід, який враховує та частково знижує невизначеності ранжування, що підвищує адекватність результатів класифікації.

Метод аналізу різних видів потенційно небезпечних критично важливих об'єктів може використовуватися для оцінки можливих надзвичайних ситуацій з подальшим аналізом збитку, що наноситься в результаті техногенних аварій та природних катастроф.

Ключові слова: класифікація, загрози, потенційно небезпечний об'єкт, об'єкт підвищеної небезпеки, критично важливий об'єкт, ризики, надзвичайні ситуації.

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РАЗРАБОТКА ОСНОВ КЛАССИФИКАЦИИ ОПАСНЫХ КРИТИЧЕСКИ ВАЖНЫХ ОБЪЕКТОВ С УГРОЗОЙ ВОЗНИКНОВЕНИЯ ТЕХНОГЕННЫХ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ

В статье даны определения понятий "потенциально опасный объект", "объект повышенной опасности" и "потенциально опасный критически важный объект" в соответствии с предложенной системой их классификации. Приведены формы, при которых реализуются техногенные опасности при нормальной эксплуатации потенциально опасных объектов, объектов повышенной опасности и в опасных техногенных явлениях. Представлено деление на классы основных потенциально опасных критически важных объектов с угрозой возникновения техногенных чрезвычайных ситуаций с их краткой характеристикой. Приведена укрупненная классификация потенциально опасных критически важных объектов, которая осуществлена на первых двух ступенях цифровым порядковым кодированием каждой классификационной группировки. Определены правильность использования терминов "взрывобезопасные" и "взрывозащищенные". Проведен анализ параметров антропогенных воздействий на потенциально опасные критически важные объекты, который часто является многофакторным и связан с развязкой неопределенностей. В силу неполноты базы знаний и базы данных, имеющихся на сегодняшний день, предложены расчеты, количественные результаты анализа потенциальной опасности критически важного объекта в условиях неопределенности.

Практическая реализация приведенной классификации критически важных объектов предназначена для контроля, прогноза и подготовки предложений по регулированию уровня техногенного риска. Проанализированы условия неопределенности ранжирования критически важных объектов с применением метода геометрической свертки критериев и предложен подход, который учитывает и частично снижает неопределенности ранжирования, что повышает адекватность результатов классификации.

Метод анализа различных видов потенциально опасных критически важных объектов может использоваться для оценки возможных чрезвычайных ситуаций с последующим анализом ущерба, наносимого в результате техногенных аварий и природных катастроф.

Ключевые слова: классификация, угрозы, потенциально опасный объект, объект повышенной опасности, критически важный объект, риски, чрезвычайные ситуации.