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Management of Environmental Risk

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Abstract. **The article is devoted to research methods of diminishing risks for technogenic accidents, natural and ecological disasters, catastrophes and emergency situations. In this paper substantial attention has been paid to ecological aspects of technogenic accidents. During research a better introduction to the concept of "acceptable risk" has been made.**

Accident development scenarios are becoming increasingly sophisticated. Procedural framework for assessing operation of dangerous objects is still at the development stage, and, as the analysis shows, quite frequently the task is solved with the help of various methods in order to develop reliable scenarios and estimate the accident consequences.

Keywords: **Risk, environmental and technogenic accidents, hazardous effects, economy.**

I. INTRODUCTION

Existence of human beings relies on the use of ecosystem services. Correlation between humans, society and nature has caused many problems which are especially topical nowadays [1]. Attitudes to nature are completely revised [2]. Up until the second half of the 20th century, a limited understanding on the interaction of human beings and nature prevailed. Now people are aware that natural resources are not perpetual and any activity of a man influences nature both in the short and the long term. Environment management has become a theme of vital importance among entrepreneurs in Latvia [3].

For over than ten years the human civilization has been living in the 21st century. Humankind entered the new millennium equipped with an enormous number of tools and devices it had created and which could have a profound impact on the environment and prove to be as powerful as our planet's own natural forces. Today, it is not only the fact to be proud of but the circumstance that causes serious concerns about our future. These concerns look reasonable since the cost humankind pays for such power is coming as an increased number of explosions, fires and other sorts of emergency situations resulting in pollution of the environment and leading to adverse social and economic consequences. Nowadays, this aspect may be considered a global problem the whole of mankind is facing at the start of the next time [4].

Today humankind faces the threats of technogenic accidents, natural and ecological disasters, catastrophes and emergency situations [5].

Suffice to say that during the recent 20 years over a milliard people on the Earth have suffered from emergency situations including those 5 million, who lost their lives or were injured, whereas the estimated resulting damage amounts to trillions of dollars. Over the same time period, millions of people have been driven from their native lands due to ecology, thus becoming refugees. At a given moment, the number of ecological refugees worldwide exceeds 10 million people, whereas the number of traditional refugees (victims of regional wars and military conflicts) is above 13 million people [6].

Natural calamities also lead to serious consequences resulting in technogenic accidents. During the last 20 years the total of 800 million people suffered from natural disasters, which is more than 40 million people per year; approximately 140 thousand people perished. Annual material damage amounted to at least 100 milliard dollars. [7]

As regards technogenic accidents and catastrophes, the risk of nuclear power plant accidents (for Latvia, in the first instance, it is Ignalina Nuclear Power Plant in Lithuania, which is less that 30 km away from the Latvian border), chemical facilities, accidents happening during transportation of dangerous goods, failure of pipelines and dams are worth mentioning [8].

Thereby, the problems related to ensuring ecologically secure human existence in the environment are of primary importance in the new millennium, as well. Today, experts in various fields have begun studying these problems since they are of a complicated intersectoral nature. It has required a scientifically based approach to integration of various scientific skills [9].

Science and education today are putting great efforts in getting humankind out of ecological crisis and providing overall safety of life processes.

One of the most widespread threats in the world that maintains or causes other similar disasters is the risk of fire and explosion. Each fire and explosion generates slag, which has an adverse effect on ecology, i.e., environment. This article is primarily devoted to aforementioned problems, i.e., to the ways of combating such type of technogenic accidents.

While bringing benefit to people, fire has become increasingly uncontrollable, getting indomitable and turning into a vicious enemy that brings harm to people and environment. Even to this day, humankind has been unable to find the way how to fully subjugate and control fire [11].

The achievements of humanity that, on the one hand, make our world and environment an increasingly dangerous place from an ecological perspective, on the other hand, create more and more sophisticated ways, methods and tools to combat technogenic and ecological accidents and natural calamities including fire, explosions and emission of dangerous substances. It is important to achieve such correlation between the objective and natural development rate of the two processes that, if possible, the second would prevail or at least would not lag behind the first one. [12]

This is the strategic goal of all kinds of security arrangements of any system including fire security, ecological safety and others.

However, just now it should be admitted that organisation and level of technical systems for environmental and human protection are well below the standards, which under the present circumstances are established and declared by the UNO and other authoritarian international organisations.

It can be explained by the fact that at a given moment almost everywhere new substances and materials are being developed and implemented, whose potential ecological and other impact has not been studied well enough, yet, in fact, judging by all, including ecological parameters the level of threat may prove and indeed quite frequently is very high [13]. If the risk could be assessed on a timely and objective basis, if there were a scientifically grounded basis for security standards, if the level of education and knowledge in safety sphere increased, if the safety reasons became more important than any kind of profit, then it would be possible to avoid multiple accidents and catastrophes, which have already shocked the world with their severity, including fires – a most wide-spread type among technogenic accidents.

The world is registering a tendency of persistent growth rate for fires. If in the ’80s of the last century on the Earth an average 5 million fire outbreaks per year were registered, in the new millennium the number already increased and reached 7 million incidents. In many developed countries direct material damage caused by fire constitutes approximately 0.3% of GNP. It means that the economy of the countries works solely to cover the costs of fire one day per year. Such situation was very vividly described by a journalist V. Travinskis [10]: “When the number of fire victims is calculated in dozens of thousands and the resulting damage – in milliards, it comes out that the detriment may be compared to that caused by the so-called XX century “small wars”. However, small wars start and end once in a while but the detriment caused by fire occurs every year, which in fact becomes a never ending “small war” with fire. Alas, these “wars” continue in the XXI century as well”.

In Latvia, with its population of 2 million people, the problem of fire remains as much complicated and the following fire risk parameters can be singled out:

- It was calculated that on average 4.34 fires arise per one thousand Latvian inhabitants annually;
- 100 people per one million on average perish;
- Every year fires produce nearly 1000 tons of slag that is dangerous for the environment [14].

It should be noted that technogenic accidents become increasingly more complicated, which makes it more difficult to keep them within the acceptable risk boundaries. Efforts made to combat fires also become more sophisticated and costly.

Significant amounts of dangerous substances are now being concentrated on quite limited storage space. Several decades ago, oil products in the port of Ventspils were kept in reservoirs with the capacity of 20 thousand cubic meters; today, however, they are being stored in 50 thousand cubic meter tank capacities. Because of oil product transit at certain railway stations, many trains carrying dangerous oil products may be simultaneously held over lay-time. Unfortunately, the great majority of such stations are located within large city limits, thus creating potential risk for environment.

The risk associated with the processes happening during technogenic accidents that involve environmentally dangerous substances is multifold [5].

Experts and society are pretty well aware of the social and economic character and amount of the losses resulting from the accidents and such type of catastrophes. Still, notwithstanding the fact, experts know little about the impact of, for example, burning substances and materials on the water that is used for extinguishing fire as well as the impact on lithosphere. These issues are not either well enough covered in the fire-fighting technical and other literature, or related to the impact of fire-generated heat on environment [15].

Proper attention is not paid to ecological aspects of technogenic accidents in connection with breakdown of tanks containing dangerous substances during explosions and breakdown when dangerous cargo is hauled by water, railway or motorway. It, in turn, prevents from developing proper safety measures and systems that protect environment from the slag produced by the accident. A profound research in the sphere of ecological safety from technogenic accidents and catastrophes is required that would be based on fundamental and applied sciences; besides, integration of various sciences is needed [16].

It should be added that the science that would directly deal with technogenic accidents, and which it would be worth naming a comprehensive technogenic safety theory, is at its development stage yet and its concept apparatus has not been shaped yet. Therefore, many authors tend to treat the same concepts in different ways. The problem discussed in this article is complicated; moreover, the task of developing acceptable definitions and concepts is also complicated. Therefore, this research represents an attempt to develop definitions that do not come in contradiction with common sense and can be applied within the boundaries of the problem in question.

Many authors have stressed that there is necessary drastic reduction in environmental impact of economic activities to avoid collapse of civilization, and change should come from society by transforming dominant cultural patterns, changing attitudes and behaviour [17; 18; 19].

II. Types of Risks That Represent a Threat for Entities as Biosociotechnical Systems

If we look at an entity as a biosociotechnical system (BSTS), it might be said that such a system contains four risk varieties. These are natural, technogenic, human factor and social risks. [5]

Natural risks

The first type of risks is determined by such intrinsic properties of a BSTS component as nature. These risks are also named “inevitable” or natural disasters: earthquakes, floods, landslides or landslips, tsunami, avalanches, snowstorms, drought or extreme heat, forest and peatbog fires, outbreaks of infectious disease, etc. As a result of the impact of natural disasters, normal operation of the whole of BSTS or its separate elements may be disrupted or even totally destroyed (eliminated). These risks refer to the type that is not dependent upon human activity if only in cases when human activity causes such risks. [5].

People, however, can exert influence on the degree of severity of the effect produced by such risks by developing and introducing preventive measures, creating technosphere entities and organising the social environment with the due account for possible natural cataclysms, quickly launching rescue and recovery activities in the risk realisation zone.

All of this becomes possible thanks to the fact that the risk is being realised within a limited space and time. [6]

Technogenic risks

The first type of technogenic risks is defined by the intrinsic properties of technosphere entities that in the course of time grow obsolete and fail to function. Each entity in technogenic sphere has its own, quite precisely defined operational lifespan. Those technosphere entities are especially dangerous, which hold large internal power reserves or those with a high degree of power concentration, and those containing special substances (radioactive, toxic, inflammable or explosive substances). In other words, one of the sources of technogenic risks is the ability of technosphere entities to alter in the course of time their features (parameters) that ensure their normal functioning [5].

If not for natural ageing, failure and disruption of operation of technosphere entities may be caused by acquisition of the new, unexpected qualities, their interaction with other technical systems. For example, electromagnetic fields of high precision devices may cause failure or interfere with the functioning of navigation and radio technical equipment or interfere with the operation of computer systems, which in turn may trigger off failure of larger technical systems.

Human factor risks

One of the first determinative elements for the human factor risks is, on the one hand, man's ability to experience periodic fatigue and stress, to become ill, grow old, which brings about permanent changes in a person's psycho-physiological condition upon which a person's successful (safe) life activity is conditioned. Interaction among people (interpersonal relationships) is the second human factor risk determinant.

Key relations (interaction) in natural life, including between people, are represented by competition where one individual (a person, people) is striving to secure the best conditions for survival at the expense of the other (another) individual (people) or by driving away other biological species [6].

In wide sense, competition also means such interaction where one organism spends the resource available for another organism and could be consumed by the latter. Representatives both of the same and of different species are capable of taking away each other's potential resources. Everything that becomes useful for ensuring human life activity may be regarded as a potential resource.

Competition for potential resources among people may take various and quite weird forms – from "lawful" to barbarous (physical liquidation of a person with the purpose to obtain his resources) [6].

People who lose the battle for potential resources and who lack own conditions for necessary normal life activity are likely to land in the so-called "risk zone".

The „risk zone" implies poverty, rancour, lack of education and upbringing, absence of moral goals, which become the source of crime, terrorism, trigger social explosion, etc. People from the "risk zone" threaten the BSTS in general, its separate elements in particular, and are dangerous for the secure course of life.

By comparing the risks that determine the intrinsic properties of BSTS elements, it might be stated this type of risks can be regarded as most dangerous and least studied.

Social risks

To ensure successful survival, people create not only technogenic but also diverse social "structures" with various hierarchies. Elementary social "organisms" (team, organisation) and large formations like countries and country alliances can be distinguished. Social entities like any other BSTS element, spring up, develop and die, i.e. they also have their own life cycles. Quite often it is not visible because the lifespan of a social organism is much longer than human life, especially with reference to some social "structure" with tall hierarchy. Typical sizes of social entities that ensure their successful operation tend to change in the course of time. It is exactly the thing that determines one side of the nature of social risks. The second side of social risks relates to interaction (correlation) among various social structures.

Analysis of various options of social structure formation shows that today there is not a single **form** that may be recognised as ideal or at least satisfactory from the risk management perspective. This **area** requires an especially thorough research and should be presented as a scientific problem rather than an ideological, religious or political issue.

Local interactions

In practice, there is a complex interaction of BSTS elements, which is determined by the global exchange of matter and energy within the system. However, it is useful to examine the issue on the level of its components both for educational purpose and for solving a number of specific tasks [5].

Man – technosphere (a traditional model "man – machine").

In its generalised form, the local interaction problem (risk source) can be reduced to the mutual disparity of the parameters of the elements of the given system.

On the one hand, for technosphere entities it is typical that their common functioning with a man is possible only under certain limitations "of the human freedom", namely, to achieve safety in their interaction with technical systems people should observe certain rules of behaviour [16].

On the other hand, for numerous reasons, during interaction with a technosphere entity a man is capable of dangerous behaviour – deliberate or unintentional – a man may deliberately or unknowingly or for some mistake break down (ruin, damage...) the technosphere entity.

Man – nature (a man – environment).

Natural environment factors are critical for creation of the necessary and satisfactory circumstances of the normal human life activity (favourable climate, territory sufficient for human population and sufficient area of fertile soil, presence of sufficient quantity of high quality drinking water sources, etc.). By drawing on the required natural resources, a man, in his turn, transforms and changes the natural environment in the way that is both favourable and unfavourable for him. On the level of such local interaction, the risk sources come in the form of discrepancy between the natural environment factors that are required for normal human life activity and the ones that exist in reality and that have developed both in the natural way and as a result of human activity [5].

Man – social environment

On the basis of the risk that manifests itself on this level of local interaction, there is the contradiction between personal interests of separate people and the interests of the people united into various social institutions (structures): a team, company, city, religion, state, etc.

Technosphere – nature

On this level of local interaction, the source of the problems is the ability of the elements of the given system to influence each other. Technosphere entities are able to alter the parameters of the surrounding nature. The question is not only about the favourable or unfavourable changes but also about the positive changes that improve the quality of the environment both for technosphere entities and for people. The natural factors, in their turn, may seriously affect the lifespan of technosphere entities.

Social environment – technosphere

The principle of social organisation adopted in this or that BSTS can seriously influence the operation and development opportunities of technosphere. The functioning of technosphere and selection of the right direction of development depend on the stability of social environment.

Social environment – nature

On this level of local interaction, the source of the problem is in the principal mutual interdependence of the elements of the system and the ability of these elements to influence each other. Social environment can exist solely by making use of and transforming the potential resources provided by the environment. Nature may be preserved only if the social environment is organised in the way to ensure rational and efficient utilisation of natural resources on the provision that nature is preserved as the basis for BSTS functioning. Competition among various forms of organisation of the social environment will be won by the most viable one, which will prove capable of solving the task exactly in the manner mentioned above.

Acceptable risk level

For assessment of the risk level in the systems where risk is an inherent element with the ever-present possibility for realisation it is necessary to introduce the concept of "acceptable risk". In literature, acceptable risk is often defined as a certain trade-off between desirable minimum level of danger and technical and economic possibilities of its realisation. However, in reality it is a much more complicated matter [22].

Acceptable (permissible) risk represents a non-linear function of the following elements: the result that can be achieved by technical means; organisational possibilities of the resources and economic opportunities for its realisation, which are determined by the specific character of the structure of the given social organism; knowledge of threat; perception of the acceptable risk level that has been shaped on the common and social levels; the degree of distortion of the adequate risk perception in comparison with the real level of danger due to lack of information or resulting from excessive information pressure.

The reciprocal influence of the above mentioned components is extremely complicated. The first two may be referred to the category of provisionally objective parameters. To a certain extent, they reflect the condition and possibilities of such BSTS elements as nature and technosphere. The rest in the list may be referred to the category of provisionally subjective parameters.

They reflect the condition and possibilities of such BSTS constituent elements as a man and social environment.

In such a manner, the acceptable level of risk is a complicated function of multiple subjective and objective factors.

Possibly, the most paradoxical fact is that the defining role in determining the acceptable risk level is played by subjective factors (what we think, what we may do, how we see it) rather than by objective ones (what can be done).

Each BSTS (for example, a state, international alliance, countries of the same region, city) legally corroborates its perception of the acceptable risk level in the system of legal, organisational, regulatory and engineering and technical documents [5].

Analysis of various BSTS hierarchy resources, as well as their economic and technical potential shows that legally corroborated risk level rather reflects the idea of acceptable (permissible) risk level that has been shaped in the given BSTS and fails to correspond (usually it is much lower) to the technical, resource and economic potential required to attain it.

Modern system of concepts about acceptable risk levels does not provide a full description of all risks, thus creating the situation where many essential risks fall beyond the scope of risk level monitoring and management system, which prevents the development of effective and efficient set of measures for risk mitigation.

Today, the most crucially important sphere of activity is the one dedicated to creation of the system of parameters that would allow developing such perception of acceptable risk that would stay close to real circumstances.

III. Technogenic Emergency Situations and Their Effect on Economy and Ecology

Modern developed society more and more frequently faces the problems of ensuring security and protection of inhabitants, economic entities, environment against adverse effect of the factors detrimental for technogenic environment and ecology. Technogenic emergency situation (ES) can be defined as interference with the normal operation of an entity, or specific territory or the course of people's life resulting from a technogenic accident or catastrophe, which has caused or is likely to cause the loss of people's lives or valuables, as well as is hazardous for the environment.

As seen from the ES definition, it covers social, ecological and economic, as well as technical economic aspects.

Social and ecological aspects are associated with human losses (fatalities) and significant impact on reproductive ability of natural resources.

Economic aspect is determined by significant economic loss both in monetary and physical terms: damage and destruction of engineering communications, buildings and structures, disablement, need for substantial investment in recovery and compensation costs, costs of insurance and setting up other special foundations, as well as ample resources and various equipment involved in the remedy and rectification of the adverse consequences.

The emergency situation concept is closely related to the "danger" and "risk" concepts.

Danger, with reference to technogenic emergency situation, means appearance of the phenomena and processes in technogenic sphere, capable of killing people, causing physical losses and producing destructive effect on the environment.

Risk is the quantitative estimate of the danger concept. "Risk" concept does not fit into one single indicator, for example, the expected annual number of fatalities, the probability that an individual becomes victim of this or that technology in a year's time, likelihood of adverse consequences for a particular group of persons (factory employees, inhabitants, children, etc.), probability of an accident with a simultaneous large number of casualties.

The basic document of the Republic of Latvia that requires assessment of risk is the Regulations of the Cabinet of Ministers No.532 dated 19 July 2005 "Regulations on the Procedure for Elimination of Consequences of Industrial Accidents and Risk Mitigation Measures". These regulations refer to more than 40 republic entities, whose operation is connected with oil products, natural gas and liquefied gas, chlorine, ammonia and other hazardous substances. Depending on the amount of hazardous substances found at an entity, its administration must develop a programme for prevention of industrial accidents or Security Reports that should specify civil protection and rescue measures. If over 500 tons of liquefied gas are kept at the site, a security protocol must be developed, if the stored amount is 50 tons of gas, a security programme is required. In cases when the amount of gas in storage does not exceed 50 tons, the security document is not required. An explosion in the liquefied gas balloon storage facilities in 2003 at Riga Central Market that took people's lives happened at the entity falling exactly under this category when it was not required to develop the security documents specified in the Regulations of the Cabinet of Ministers.

Analysis of the entities, to which the Regulations of the Cabinet of Ministers apply, shows that an absolute majority of these entities can be included in the list of hazardous chemical substance containing facilities of high importance for the national economy.

The main purpose of developing a security document is to assess the entity operation risk and select the methods and ways to reduce such a risk to the minimum. In simple terms, such a security system should be created at a dangerous facility, which would be proportionate to the degree of threat it represents.

The main target function of such a system is to create the necessary and sufficient conditions for stable and safe operation of the system in general, including the entity itself.

Taking into account all above said, danger can be defined in a broader sense: any phenomena or processes happening in the security system of a technogenic entity that could result in all system or some system component deviation from a stable operation or even from fulfilment of target functions, or destruction of separate system elements may be regarded as danger or an adequate concept of "risk".

Risk level or degree that shows the extent of deviation from normal operation of an entity may vary from insignificant, which can be compensated by the security system, to substantial one.

In the security system, transformation of risks from potential into the real ones happens according to a particular pattern (Figure 1).

Catastrophe or non-catastrophe provoking situations, which differ among themselves by destructive factors, consequences and detriment, may cause risk.

If an emergency situation develops according to the catastrophe scenario, it may be manifested in the form of:

- catastrophe;
- cataclysm;
- chaos.

In the narrower sense, a catastrophe is a large-scale accident, and according to the classification adopted by the Western countries, the emergency situations accompanied by at least 100 casualties and at least 400 injured, with at least 35 thousand people evacuated and at least 70 thousand left without drinking water sources are regarded as catastrophes.

A catastrophe is a dynamic, rapidly developing process, which causes sharp qualitative changes of the system (technological, biological, social, etc.) status, as well as triggers off appearance of destructive factors that are highly detrimental for the system.

Repeated catastrophes cause changes in the key system structures that further fall into sub-structures. Further destruction of sub-systems is called cataclysm.

Finally, the catastrophe scenario may cause chaos. Chaos is confusion and disarrangement of the elements, processes and phenomena, total uncertainty, lack of any system, extreme confusion, and total collapse. Evolvement of an emergency situation into a catastrophe is shown in Figure 1.

As shown in Figure 2, an extraordinary factor plays a significant role in the development of an emergency situation into a catastrophe. An extraordinary factor is an event of technogenic or some other origin, which manifests itself through such influence when the current processes or existing phenomena sharply deviate from the norm and have a negative impact on the people's vital capacity, economy operation, social sphere and environment. In the narrowest sense, an accident may refer to extraordinary factors. While designing technogenic security measures for the entity, the extraordinary situation development dynamics should be taken into consideration.

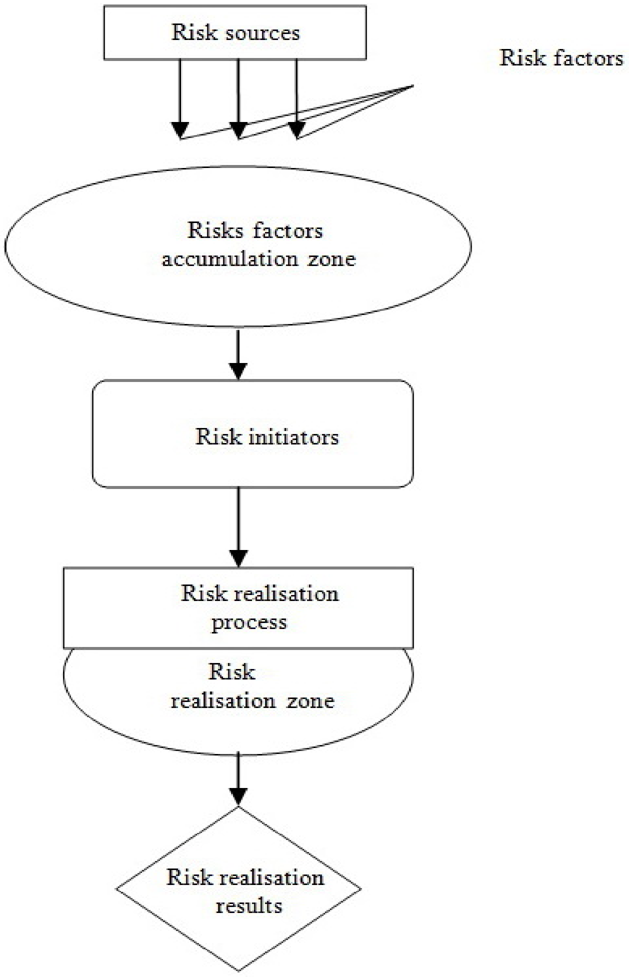


Fig. 1. Risk realisation scheme [5]

The process of development of an emergency situation is split into multiple stages:

1. origination of adverse circumstances, deviation from the system or normal state of the process;
2. appearance of an emergency situation;
3. extraordinary factor escalation stage;
4. an extraordinary incident process takes place, during which influence is exerted on people, entities and environment;
5. in the evolving emergency conditions the effect of the lasting destructive factors remains;
6. making managerial decisions in respect of people rescue and liquidation of the consequences of an emergency situation;
7. transportation of people, equipment and other freights;
8. direct liquidation of the consequences of an emergency situation, relief measures.

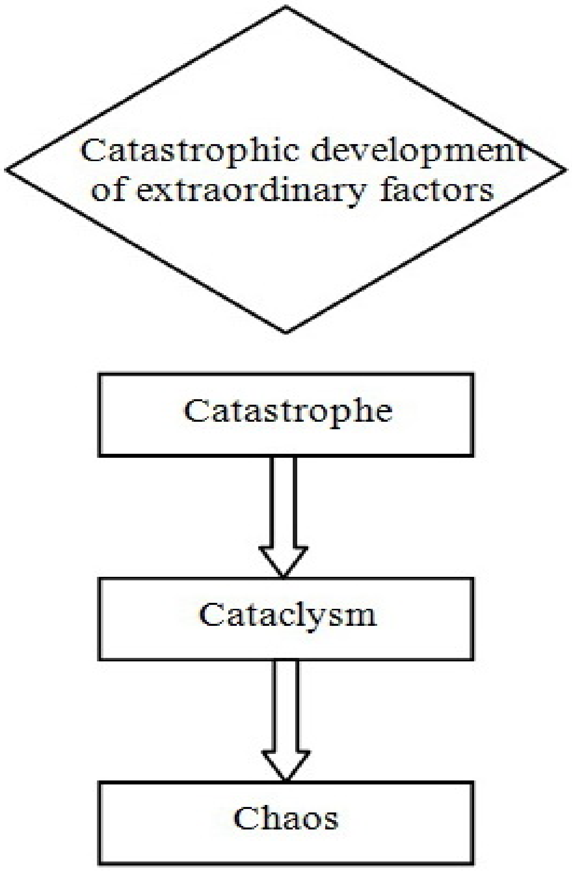


Fig.2. Catastrophic development of emergency situation [5].

Certain territories may be fully destroyed as a result of emergency situation; some may suffer from partial destruction, some may be only slightly affected, whereas some may remain absolutely intact. Accordingly, demolition, devastation, destruction and diseases resulting from occurrence of extraordinary incidents may vary within a considerably wide spatial range.

Keeping in mind the fact that, in the narrow sense, accidents (explosion, emission of hazardous substances, fire, etc.) can also be reckoned among extraordinary factors, the main task in ensuring entity safety is accident prevention. For this purpose, it is necessary to provide scientific substantiation and develop a set of measures aimed at prevention of technogenic accidents, protection of the staff and population, national economic assets and the territory, as well as safeguarding the life and health of the people, lessening the potential harm to environment and material values.

While designing the measures aimed at mitigation of risk of accident at the entity, each specialist participating in this process should proceed from the potential technogenic and ecological danger presumption. Such presumption provides for the assumption that it is recognised as true unless the contrary is proved.

In connection with the presumption, any activity *apriori* is viewed as dangerous until certain research (examination) has been done and preventive steps have been taken and such conditions have been created, which are considered absolutely non-hazardous for the people, economic entity and the environment.

Absolutely non-hazardous conditions are such operating conditions, when danger can be ruled out with a certain probability. However, presence of some definite risk is assumed.

Risk inherent in dangerous entities forms an integral part of these entities, and there is always a probability that it will be implemented. In this connection, it is necessary to introduce the concept of permissible (acceptable) risk.

Acceptable risk is the minimum probability of danger that can be ensured given available technical and economic resources. In the Latvian legislation, the minimum risk is not specified. In other countries including the EU member states, acceptable risk is provided by legislation. The acceptable risk of fatality is normally set at 10^{-6} cases. The risk of fatality at 10^{-8} cases per year is considered negligible.

At a given moment, complex technogenic security problems can be solved on the basis of system analysis results.

Security system analysis provides for disclosure of all factors and circumstances that influence origination of adverse phenomena and incidents (accidents, explosions, fires, catastrophes, etc.) and development of provisional measures of protection in order to reduce the likelihood of occurrence of such phenomena or incidents; a package of methods used for preparation and substantiation of decisions related to complicated security issues.

System-based approach provides for consideration of the phenomena from the viewpoint of their mutual interrelation as a unified whole or complex. The goal or result achieved by the system is called the system backbone. Systems possess the features, which the elements they are built of are lacking. These extremely important system features, which are called *emergency,* lie at the basis of technogenic security system analysis.

Methodology status of technogenic security system analysis has its own specific features. It contains elements of theory and practice that are closely interlaced together, where strict formalised methods are found side by side with intuition and personal experience. Prevention of or protection from danger is based on the perception of causes. There is the link between causes and effects. Causes and dangers form hierarchical, chain structures or systems, i.e. they form the "cause and effect tree". Creation of such "tree" is a remarkably efficient process for discovering the causes of accidents, fires, car accidents, traumas, etc. A simple "tree" of the fire-related accident is shown in Figure 3.

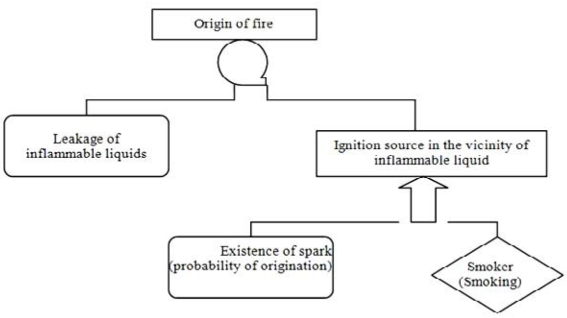
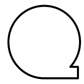
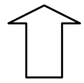


Fig. 3. Accident "tree" (origination of fire) [5]

Symbol  means that the final incident is implemented if one (but not both) of the initial incidents takes place

Symbol  means that the incident is implemented if one of the initial incidents takes place (initial cause).

The correctness of "tree" creation should be verified by a qualified expert, which would allow avoiding the developer's subjective mistakes and ensuring precise description of the entity and the actions.

Setting system boundaries in the security analysis is a problem. If the system is too narrow, provisional measures may turn out to be incomplete, unsystematized, that is, many dangerous situations may fall outside the focus of attention. On the contrary, if the system under consideration is too broad, the analysis results may prove to be too general and non-specific.

New incentives loaded with environmental risk management

To avoid the situation when the future energy becomes a heavy burden for development of the national economy, "Latvia Green Energy Strategy 2050" has been developed and it comprises both short-term and long-term goals for sustainable development of the energy sector focusing mainly on reduction of energy consumption and independence from fossil fuel. Three parallel directions have been developed in the energy strategy: modification of consumption of energy resources by initiating energy management policy on the national level; introduction of new technological solutions in the national energy sector; and expansion of the tasks of applicable scientific research starting from simulation of the national energy policy up to creation of innovative energy technologies.

The large-scale new incentives in the Energy Strategy 2050 will help Latvia to develop economically and achieve that innovative energy technologies will contribute to the Green Growth of the country over the next 10 to 40 years. Priorities for the next 10 years will be as follows:

1) regular analysis of the energy sector development and policy instruments using the system dynamics modelling method, which will allow controlling and monitoring the ongoing activities in the country and energy sector and drafting proposals for adjustment;

2) reduction of energy consumption in all power system elements due to increase in energy efficiency on the part of energy producers and energy end-users and reduction in energy loss in power transmission systems, which will allow reducing the volume of primary energy resources on the national level;

3) wider and more efficient use of biomass for energy purposes, starting from individual heating in a private house and ending with a 100 to 140 MWe CHP plant in Riga due to development of wood and forest residues, fast-growing shrubs and other cultivated crops, improvement of technological solutions for biomass use and increase in energy efficiency;

4) energy efficient use of biogas is associated with establishment of two types of biogas systems: installation of biogas purification facilities allows biogas to enter the pipelines for natural gas and energy efficient use of biogas in CHP plants, while producing heat and electricity;
5) use of wind energy in the Baltic Sea and on land is associated with the problem of efficient consumption of a high volume of produced electricity due to non-uniformity of wind speed, therefore the simultaneous construction of a wind farm and large accumulator plants (such as compressor plants) will provide the possibility of creating an energy efficient system;
6) use of solar power for heat and electricity production is associated with the purchase of relatively expensive technologies, however the fact that solar energy costs will always be zero is the leading aspect for the future prospects of solar stations;
7) expansion of smart power grids throughout Latvia will provide an opportunity to regularly inform the end users of the efficiency of energy consumption and options to reduce energy consumption [25].

"Latvia Green Energy Strategy 2050" has been developed by scientists of the Faculty of Power and Electrical Engineering of Riga Technical University, who have been actively calling upon the society during last five years to participate in the development processes of the energy sector and upon the government to coordinate the national energy policy.

IV. Conclusions

Nowadays, in economically developed countries technogenic accidents and catastrophes surpass such traditional causes of devastation as natural disasters in terms of the number of victims and the magnitude of destruction. According to specialists' estimation, the main causes of technogenic accidents are:

- system technical element failure due to technological defects or mistakes made at the design stage;
- human error during operation of complex mechanic systems run by people (up to 60% of cases).

In other countries security issues are solved by increasing the degree of safety of the system technical components. In Japan, for example, over the recent years the share of accidents resulting from failure of technical components has decreased from 72 to 42 per cent. At the same time, the "human factor" share has increased from 28 to 58 per cent.

Study of technical progress shows that machines are being constantly improved and control over their operation parameters becomes increasingly difficult and may go beyond the boundary of human ability to react to the changes in the system status. Therefore, simultaneously with the improvement of process parameter control systems and security of technical systems it is necessary to develop scientific and methodological basis for managing human activity, i.e., design human actions required for operation of mechanical systems run by men.

Accident development scenarios are becoming increasingly sophisticated. Procedural framework for assessing operation of dangerous objects is still at the development stage, and, as analysis shows, quite frequently the task is being solved with the help of various methods in order to develop reliable scenarios and estimate the accident consequences. Therefore, to ensure development of the entity security programmes and protocols it is necessary to continue research, to develop economic concept for risk analysis. Within the framework of this concept, risk analysis should be regarded as one of the components of cost/benefit study. Risk is an expected loss of usefulness caused by certain incidents or action.

The ultimate goal is to distribute resources in the way that would allow for their maximum usefulness for the society.

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Atstāja Dzintra, Jānis Bartušauskis, Jānis Ieviņš, Anatolijs Jemeļjanovs. Vides risku pārvaldība
Rakstā apskatītas metodes riska samazināšanai tehnogēno avāriju, vides un ekoloģisko kataklizmu, kā arī katastrofu un ārkārtas situāciju radīto risku noteikšanai un samazināšanai. Pētījuma ietvaros plaši apskatīti tehnogēno risku ekoloģiskie aspekti, kā arī sīkāk izpētīts „pieļaujamā riska" koncepts.
Šodien cilvēcei draud tehnogēnās, dabas un ekoloģiska rakstura avārijas, katastrofas un ārkārtas situācijas.
Lai minam, ka pēdējo 20 gadu laikā ārkārtas situācijās uz Zemes cieta vairāk kā viens miljards cilvēku, tai skaitā vairāk kā 5 miljoni gāja bojā vai tika ievainoti, bet radītie zaudējumi tiek lēsti triljonos dolāru.
Ļoti smagas ir arī dabas katastrofu sekas, kas arī noved pie tehnogēnām avārijām. Pēdējo 20 gadu laikā dabas katastrofās cieta kopumā 800 miljonu cilvēku, t.i., vairāk kā 40 miljoni cilvēku ik gadu, aptuveni 140 tūkstoši cilvēku gāja bojā. Materiālie zaudējumi ik gadu sastādīja ne mazāk kā 100 miljardus dolāru [2].
Tādējādi arī XXI gadsimtā problēmas, kas saistītas ar cilvēka ekoloģiski drošas eksistences nodrošināšanu visās apdzīvojamās vidēs, joprojām ir ļoti aktuālas. Mūsdienās šīs problēmas sākuši pētīt dažādu profilu speciālisti, jo tām ir skaidri izteikts komplekss starpnozaru raksturs. Tāpēc ir nepieciešama zinātniski pamatota pieeja dažādu zinātņu prasmju integrācijai.
Avāriju attīstības scenāriji kļūst arvien sarežģītāki. Metodiskā bāze bīstamu objektu darbības novērtēšanai vēl joprojām ir izstrādes procesā, un, kā liecina analīze, uzdevumus bieži vien nākas risināt ar dažādiem paņēmieniem, lai izstrādātu drošus secinājumus, paredzot avāriju radītās sekas. Tādēļ, lai izstrādātu objektu drošības programmas un protokolus, nepieciešams turpināt pētījumus, izstrādāt ekonomisko koncepciju risku analīzei. Riska analīzi jāskata kā sastāvdaļu vispārējā izdevumu un ienesīguma pētījumā. Risks ir gaidāmais lietderīguma zudums, kuru izraisa kādi notikumi vai kāda rīcība. Galamērķis ir sadalīt resursus tādā veidā, lai tie būtu maksimāli noderīgi sabiedrībai.

Дзинтра Атстая, Янис Бартушаускис, Янис Иевиньш, Анатолий Емельянов. Управление экологическими рисками
Статья посвящена исследованию методов снижения рисков техногенных аварий, стихийных и экологических бедствий, катастроф и чрезвычайных ситуаций. В работе значительное внимание было уделено экологическим аспектам техногенных катастроф.
Сегодня человечеству могут угрожать техногенные, природные и экологическиыех аварий, стихийных бедствий и чрезвычайных ситуаций. Достаточно отметить, что за последние 20 лет на Земле от чрезвычайных ситуаций пострадали более одного миллиарда человек, в том числе более 5 миллионов были убиты или ранены, полученные убытки исчисляется в триллионах долларов. Очень серьезны последствия стихийных бедствий, что также приводит к техногенним авариям. За последние 20 лет от стихийных бедствий пострадали в общей сложности 800 миллионов человек, т.е. более 40 миллионов человек каждый год, около 140 тысяч человек погибли. Материальный ущерб ежегодно составляет не менее 100 млрд долларов [2]. Таким образом, в новом веке, проблемы, связанные с экологически безопасной обитаемой средой для человеческого существования по-прежнему очень важны. Сегодня эти проблемы стали изучать различные специалисты различных профилей, потому что эти проблемы имеют явную сложную межотраслевую связь. Потребовался научно-обоснованный подход к интеграции различных навыков наук.
Сценарии развития аварий становятся все более изощренными. Методологические основы оценки эксплуатации опасных объектов до сих пор в процессе развития, и, как показал анализ, часто задача решается с помощью различных методов, чтобы разработать обоснованные выводы и надежные сценарии и оценки последствий аварии. Поэтому, чтобы в предприятиях разработать программы и протоколы безопасности, необходимо продолжать исследования, для разработки концепции экономического анализа рисков. В рамках этой концепции анализа рисков следует рассматривать как один из компонентов затрат / выгод. Риск - ожидаемая потеря целесообразности, вызваная событиями или действиями.
Конечная цель заключается в распределении ресурсов таким образом, чтобы ресурсы были бы наиболее полезными для общества.