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Methodological aspects of electric safety system analysis at underground enterprises

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Abstract
The basis for solving the electrical safety problem at underground enterprises is a system analysis, which is determined by the three-component system «man - electrical installation - environment». To solve the problem, the application of the system approach is proposed. It consists in the theoretical substantiation, scientific research and practical implementation of the methods of organizing the actions of the controlling (management) system in electrical safety.
The problems of power supply, reasons for the consequences of emergency conditions of electrical installations for reducing injuries, improvement of electrical safety in accordance with international and industry standards were considered and investigated.
The solution of the electrical safety problem at the enterprise is determined in the process of operation according to the criteria underlying the functioning of the controlling system in accordance with the current rules and standards of the ISO series.
The methodology of system analysis is used in the article for general principles of management and application. The modeling of the electrical safety problem has been carried out and the basic principles of the system approach of this problem at underground enterprises and its main aspects and ways of solution have been formed.
The simulation model for solving complex problems of reducing electroinjury stress in structural divisions was considered.
Key words: ELECTRICAL SAFETY, SYSTEM ANALYSIS, SYSTEM APPROACH, CONTROLLING IN ELECTRICAL SAFETY, LABOR PROTECTION, ASPECT, METHODOLOGY, GOST ISO 9000

Problem statement

According to long-term statistical data, electric shock in general industrial injuries is about 1%, and in the fatal, it is 15% or more. The analysis of industrial injury on rail transport of Ukraine for 1992-2016 years is presented in Fig. 1.

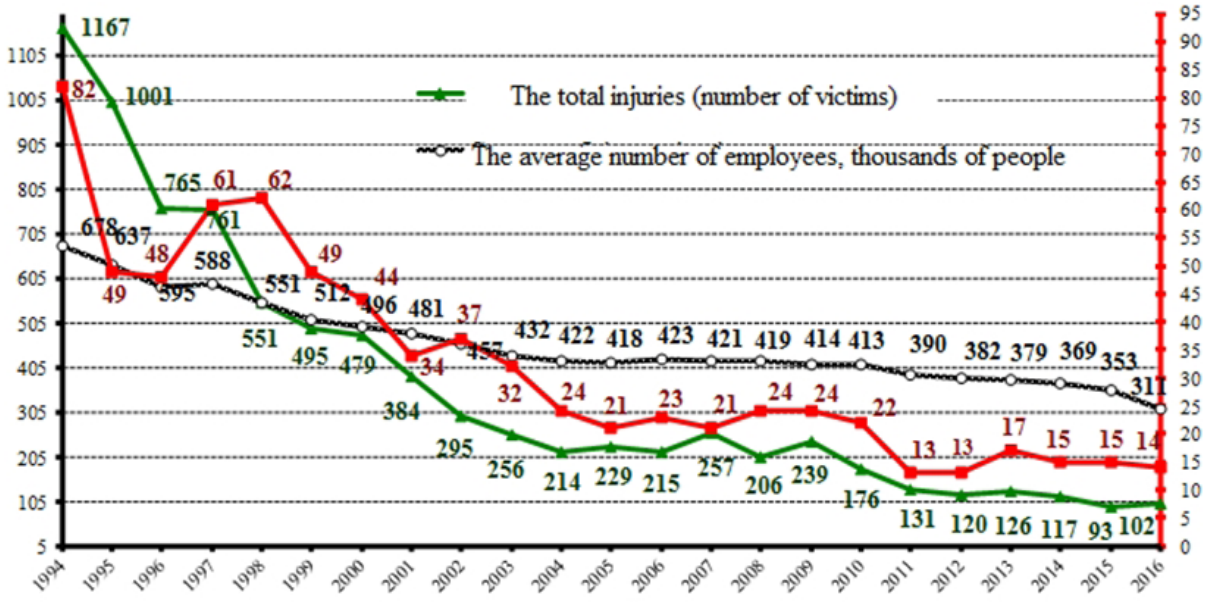

Figure 1. Schedule of injuries on rail transport in Ukraine

Achievement of positive changes in the dynamics of electro-injury requires the improvement of the regulatory framework for electrical safety, compliance with safety requirements for the development of electrical installations, their construction and operation, improving the level of training of electrical personnel in understanding the danger of electric shock, safe behavior when performing work in electrical installations and when their application. The study of electro-injury activity at underground enterprises, the

evaluation of the effectiveness of organizational and technical measures show that the basis for solving the problem of ensuring electrical safety is primarily the imperfection of system analysis monitoring. It is a sequence of actions to establish structural links between the elements of the system "man-electrical installation-environment" (MEE) and the system of controlling (management) in electrical safety (SCES) (Fig. 2).

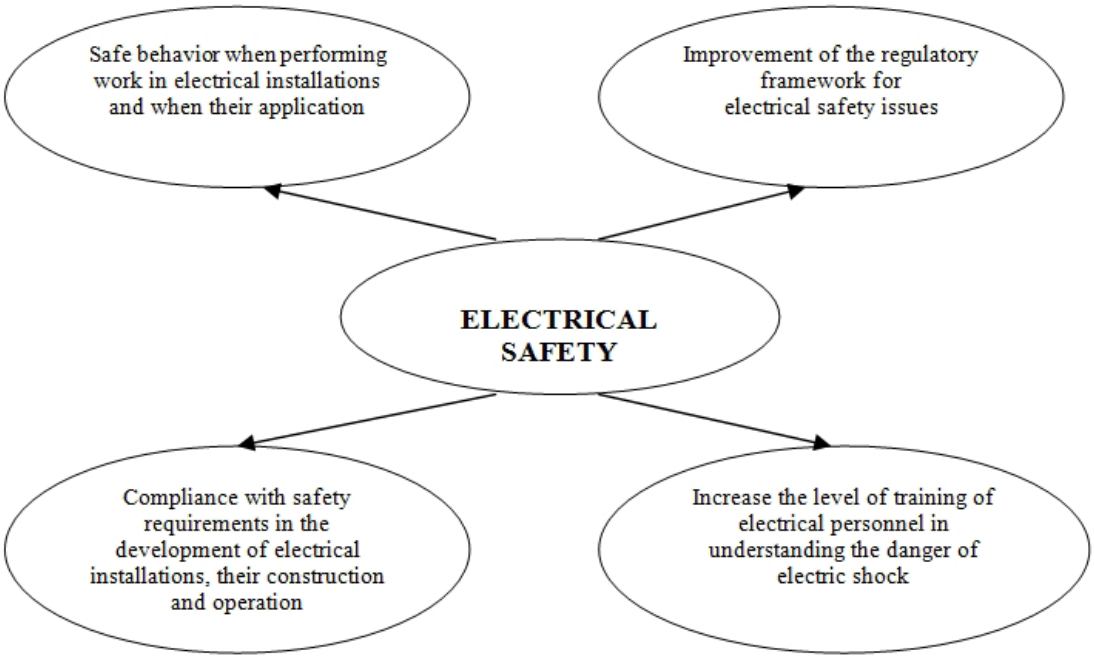

Figure 2. The scheme of the installation of structural connections between the elements of the system «man-electrical installation-environment» at the underground enterprises

Objectives of the study

The objective of system studies is to select a certain alternative to ensure the continuity of the technological production process, safe operation through the development and implementation of an information and analytical system (IAS-EB) in the structure of SCES using innovative technologies [1].

Presentation of the main material

One of the common causes of industrial injuries at underground enterprises is the carelessness of the employee. The actions of the employee can be considered as a negligence in the following cases: if he is inattentive in his work, he does not use means of individual protection, he refers to the requirements of the labor protection instruction light-mindedly.

Sometimes workers with long experience of more than 10-15 years ignore the implementation of labor safety rules and instructions on labor protection. The level of occupational injuries in Ukraine including fatalities exceeds those of the EU countries in two or more times. The loss of health and working capacity of the working population of Ukraine is a nation-wide problem. A comprehensive solution to this problem, the formation of a modern safe and healthy environment, and the minimization of the risks of occupational injuries are carried out at the state level through preventive measures in the framework of, as a rule, relevant national, sectoral and regional occupational safety programs [2].

Analysis of the theory and practice of the process of formation of preventive measures at the state level shows that for the sphere of labor protection a narrowly specialized approach to solving the following problems is typical:

- technology of choice of strategies and priorities of its development is not defined;
- no methodological basis for planning these activities and methods for assessing the effectiveness of achieving the goals taking into account changes in environmental factors, have not been developed.

At the same time, it should be recognized that the systematic approach and methods of applied system analysis in the field of occupational safety widely used in various fields of knowledge (philosophy, medicine, socionics, botany, etc.) are not used practically especially in strategic planning.

To solve any problem, it is necessary to use knowledge often profoundly professional and their set for each problem is specific and unique. However, if we pay attention not to the content specificity of a particular problem, but to the technology of working with it, then the probability of the success of its solution increases if we adhere to the corresponding

axioms regardless of the nature of the problem. Studies in this direction of such scientists as U. Ashby, N. Wiener, L. Von Bertalanffy, T. Saati, A. Chandler, A. Kolmogorov, V. Glushkov and many others led to the creation of a fundamentally new approach to problem solving. The system analysis and the system approach that arose on the wave of the origin and development of cybernetics, informatics and bionics allowed formulating a generally accepted technology for solving problems, to provide the necessary knowledge of specialists of various profiles including those engaged in managerial activities [3].

The accumulated arsenal of knowledge, methods and techniques of the theory of system analysis can be applied in planning preventive measures for labor protection for:

- ensuring labor safety;
- for detection, analysis and prevention of failures and other accidents at work.

The rail transport of Ukraine is characterized by technologically dangerous enterprises, chemically hazardous production, pollution of the production environment, where a systematic approach to the scientifically grounded strategy for predicting and neutralizing occupational safety hazards is important. Counteraction to these threats is ensured by the national system of labor protection, which is a complex multifunctional system that is influenced by factors of the internal and external environment.

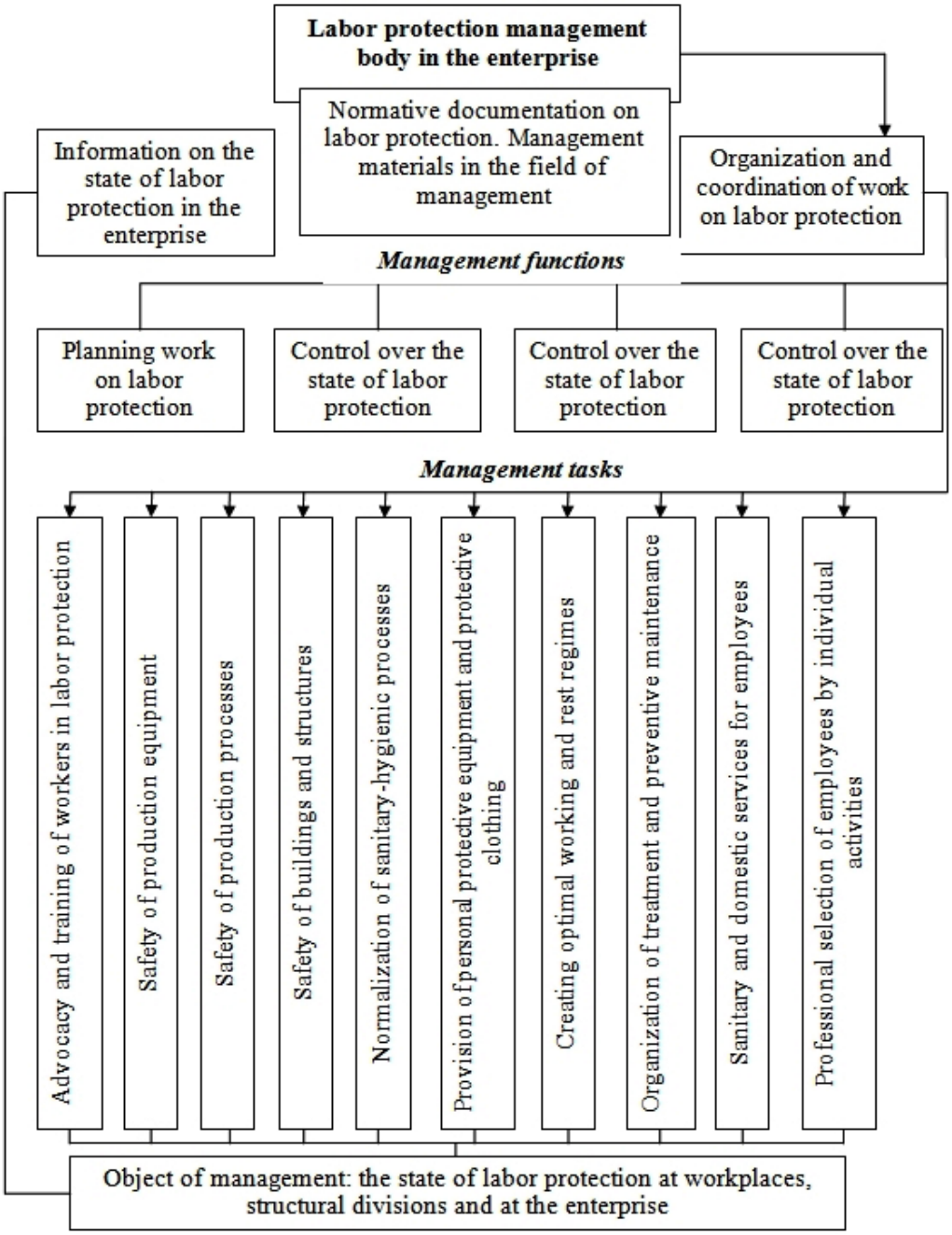

Figure 3. The scheme of management of a labor safety at the underground enterprises

Fig. 3 shows the overall scheme of labour safety management in the scale of one enterprise with functions and tasks in the field of labor protection and reduction of cases of electro-injury (4).

This system is focused on timely and guaranteed provision of occupational safety and health, prevention of accidents and occupational diseases at work, prevention of unforeseen external influences.

The essence of the system analysis of electrical safety in transport is that the consideration of its conformity to categories creates the basis for a logical and consistent approach to the problem of decision-making. The effectiveness of solving the problem of electrical safety through system analysis is determined by its structure of tasks.

Provision of electrical safety belongs to the class of poorly structured problems contains both qualitative elements and indefinite parties that have a random (probabilistic) character. Therefore, for a general solution of this problem, it is expedient to use the methodology of system analysis [5].

The problem of electrical safety at underground enterprises is the need to establish an optimal level of significance between the stringent requirements of existing standards, regulations, GOST ISO 9000, specific operating conditions and physical capabilities of a person to perform working functions. In the presence of objective functional limitations of the LES system, there are mutually exclusive situations or conditions under which the provision of the required level of electrical safety is impossible or difficult to achieve.

The operation of electrical equipment by personnel is always associated with the risk of electric shock, which significantly increases with the direct carrying out of repair, preventive and other works. Therefore, the ain of SCES is to reduce electro-injure damage during the operation of electrical equipment.

In the analysis of electrical safety methods to simulate non-stationary operating modes of electrical installations to determine the quantitative indicators are used characterizing the impact on human injurious factors, the modeling of potentially dangerous situations involving human beings, dynamic and predictive modeling of emergency regimes to determine the operational reliability of electrical equipment.

Optimization of the strategy of work in electrical installations taking into account the introduction of additional organizational and technical measures aimed at ensuring the required level of electrical safety is carried out in the maintenance and repair system (MRS).

The complex of organizational and technical measures taken to ensure electrical safety within the framework of SCES is of a preventive nature, it is an addition to the regulations for works in electrical installations and must not contradict the current regulatory and legal acts on labor protection. The operation of the SCES should be coordinated with the energy services involved in the operation, maintenance and repair of electrical installations.

The preparation of the decision on the use in the operational practice of the SCES is carried out by the power supply service (chief power engineer) of the enterprise, which studies the feasibility of the need for the introduction of technical controlling equipment, IAS-EB, training of qualified analysts and technical personnel for maintenance of relay protection and automation systems.

The effectiveness of solving the problem of electrical safety in the enterprise is determined in the process of operation according to the criteria underlying the functioning of the controlling system in accordance with the current regulations, the rules and standards of the ISO series [8].

The basis of system analysis is the use of a systematic approach to solving the problem of electrical safety consisting in the theoretical justification, scientific research and practical implementation of such methods of organizing activities that cover any kind of activity in the system (LES), find and establish patterns and relationships between its elements for the purpose of their effective use [6].

The hierarchy of the structure of the electrical safety system (ESS) includes many elements of different levels of significance and subordination and it is determined within the internal interrelations of the system, as well as in the implementation of external links with the subsystems of operation, maintenance, repair in the general management system.

The basic principles of the system approach to the problem of electrical safety can be formulated as follows:

- integrity. Electrical safety as a system of organizational and technical measures and means that protects people from harmful hazardous effects of electric current, electric arc, electromagnetic field and static electricity is the only system that is part of the overall system of enterprise management.

- structuring. Within the framework of a specific organizational structure of the ESS, it is possible to perform not only the analysis of the elements of the LES and SCES systems, but also to find the relationship between them. At the same time, the functioning of the ESS is equally conditioned by the properties of its individual elements and the properties of the management structure itself.

- multiplicity. Description of the elements of the LES system and their interrelations within the framework of the current ESS is carried out by a multitude of models: matrix, identical, imitative, mathematical, cybernetic, logical-possible, statistical and economic, and others.

- systematicity. Electrical safety in its structure, internal content and external relations has all the signs of a multi-level system. A systematic approach to the problem of electrical safety, including research and practical use of the following aspects:

- a system-element or system-complex aspect presupposes the identification of elements that constitute ESS taking into account the specifics, organization and management of technological processes under the conditions of underground enterprises.

- the system-structural aspect consists in establishing internal links and dependencies between the elements of the ESS allowing to get an idea of its internal organization (structure).

- the system-functional aspect presupposes the establishment of functions, for the implementation of which SCES is created and exists.

- the system-target aspect presupposes the need for a scientific definition of the goals and sub-goals of the ESS, SCES, LES system and the relationship between each of them.

- the system-resource aspect is the careful identification of the resources that are required for the functioning of the ESS, for solving its specific tasks arising in the operation of electrical installations at underground enterprises.

- the system-integration aspect is to determine the set of quality properties of the ESS, which ensures its integrity and feature in the specific conditions of underground enterprises.

- the system-communication aspect is the need to establish external relations of the controlling system with other management systems, which have a different hierarchical level in the general management system of underground enterprises.

- the system-historical aspect allows clarifying conditions in time of the investigated problem origin, the stages passed, the current state and also the possible prospects for the development of the ESS.

Simulation modeling is the most constructive direction in solving certain complex problems. To form the Simulation model of the problem solving process, it is possible to use the «target tree» method, which allows you to define, analyze and establish links between the main goal and the sub-goal of the problem, which is structured on a hierarchical basis. In the process of constructing a «tree of goals», expert methods are used to evaluate and rank the goals, to choose the final version of its decomposition. For successful implementation of the project, it is necessary to determine the criteria that can influence positively or negatively. The main requirement for them is a clear definition of their impact on the progress of the project. The use of the «target tree» method in the state planning of preventive measures for labor protection allows structuring problems in the field and ensuring the adoption of managerial decisions to achieve the goal with the least expenditure of funds. As shown by the conducted studies, this method is especially effective when forming state target programs on labor protection [7].

Conclusion

The introduction and use of the controlling system is an important aspect of the system approach to the development of new principles of system analysis of electrical safety at underground enterprises.

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