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Methodology of Risk-Oriented on the Basis of Safety Function Deployment

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Abstract*: The continuous improvement of the regulatory framework in the field of labor protection and global and environmental safety legislation, implementation of the Ukraine-EU Association Agreement are effective measures carried out by the state, aimed at creating a favorable legislative climate for employers in the area of their responsibility for establishing safe working conditions. Statistics on the occupational injuries level indicate a decrease in the total number of accidents and the number of lethally injured workers year after year. The study carried out by the author will allow for a well-grounded risk assessment of occurrence of industrial accidents and its subsequent implementation in emergencies. The proposed methodology for the safety function deployment and constructing a "house of safety" is one of the modern ways of expanding methodological approaches when using a risk-oriented approach in safety management systems and occupational hygiene.

***Index Terms*: Risk, safety and occupational hygiene, environmental safety, quality function, safety function, house of safety.**

I. INTRODUCTION

The total number of persons with occupational injuries (TNOI) has decreased significantly in Ukraine for the past 25 years. In study Yemelianova N. [1] cites statistical data, according to which the TNOI affected 124,971 persons in 1992 and decreased to 4,313 persons in 2017, that is, almost 29 times less. The figures with regard to the lethally injured (LI) are as follows – 2,619 people in 1992 and 366 – in 2017, respectively, that is, the decrease in LI occurred during that time only 7.15 times. It should also be noted that the number of employees in these years has decreased from 20.5 million to 7.63 million people, which is approximately 2.7 times less. The level of general and fatal injuries per 100,000 workers is shown in Figure 1 [2]. A significant role in the process of reducing the level of occupational injuries in Ukraine has been played by a decrease in the number of industrial sites in the coal mining industry, mechanical engineering and metallurgical complex, that is, in those areas of the economy that have always had high rates of injury. However, a lot of attention in Ukraine has been paid to modern changes in the safety and occupational hygiene legislation and a number of state-level regulatory documents in this area, drafted on the basis of the experience of other developed countries, have been put in place.

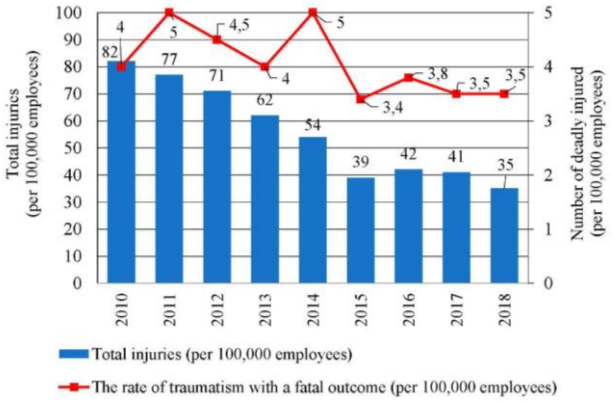

Fig. 1. The level of total and fatal injuries (per 100 thousand employees).

The main focus of the improvement of existing approaches to the systems of management of industrial and environmental safety and quality is the risk-oriented approach reflected in the (Recommendations on the establishment, implementation and improvement of the occupational safety management system, [3]; Concept of the Occupational Health and Safety Management System Reform in Ukraine, [4]; DSTU OHSAS 18001:2010 [5]; DSTU ISO 9001:2015 [6], as well as other regulatory documents adopted recently (DSTU OHSAS 18002:2015; DSTU IEC/ISO 31010:2013; DSTU ISO 14001:2015; DSTU ISO 14005:2015) [7-10].

II. METODOLOGY

The main definitions of the risk assessment methodology are provided in the regulatory documents on quality management, safety and occupational hygiene and environmental safety [6-14], according to which risk is: an uncertainty about the achievement of goals, for example in the field of health care, production environment safety, environmental aspect, financial stability [11]; a combination of the probability of occurrence of a injurious event or the impact and severity of an injury or deterioration of health that may be caused by such an event or influence thereof [6]; the effect of uncertainty,

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that is, a positive or negative deviation from the expected state with reference to possible events and possible consequences or their combination. The word "risk" is sometimes used when it comes to the possibility of only negative consequences [10]; effect of uncertainty on objectives [12]; risk identification is:

the process of identifying, recognizing and recording risks, which includes the definition of the causes and source of risk, events, situations or circumstances that may have a material impact on the achievement of objectives, as well as the identification of the nature of this impact [7]; the process of identification, recognizing and description of risks, structured according to four main elements – source of origin, events, causes, consequences [10]. Same approaches to the interpretation of the basic concepts of risk management create the foundation for establishing the concept of a single enterprise risk management system in order to achieve the maximum financial benefit and the level of product quality with minimal impact on the environment and life, health and efficiency of the participants in the production process and third persons. The mechanism for ensuring human safety, both in everyday life and under production processes, is based on the concept of sustainable development, acceptable and justified risk levels [14] and has the form of hierarchy of these concepts significance. According to the author of the article, the hierarchy of conceptual safety foundations may be presented as follows, taking into account the current regulatory framework in this area (Fig. 2).

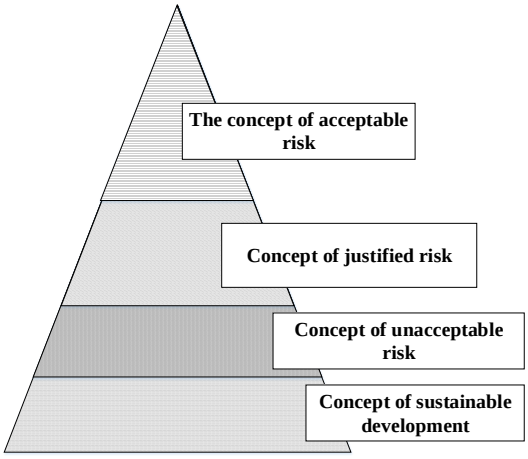

Fig. 2. The safety concepts hierarchy

The general strategy of the sustainable development concept is the need to balance the contemporary needs of humanity and the protection of the interests of future generations. Indeed, this goal requires the preservation of a safe and healthy environment as a guarantee of creating favorable conditions for the emergence and development of subsequent generations [15]. The implementation of the sustainable development strategy is also encouraged by the introduction of corporate social responsibility principles under the international standard SA 8000, and by the recently adopted ISO 45001 "Occupational health and safety", which gives a new impetus to the improvement of the system of professional safety and health management on the basis of risk-oriented approach.

III. RESULTS AND DISCUSSION

A. *Methodology of quality function deployment*

Combining the main systems of quality management, safety and occupational hygiene and environmental safety allows for wider use of risk assessment methods adopted in any of them, extending them to neighboring safety systems. One of the methods used in quality management systems is Quality Function Deployment (QFD), the idea of which was formulated at the end of the 1960s in Japan and was tested in the automotive industry of Japan and the USA [16]. The authors of the method S. Mizuno and Y. Akao tried to create a method of ensuring a high level of product quality that would meet customer requirements for goods before they were manufactured. Previous quality control methods were aimed primarily at identifying problems in the production process, or in post-production of goods. Thus, from 1960 to 1965, the statistical approach to goods quality management was transposed into comprehensive quality management, theoretical justification of which was developed taking into account the developments of Kaoru Ishikawa and A. Feigenbaum. All ideas covering this area were united under the same concept and defined as quality deployment; in fact, a methodology that transformed the requirements of the end user into certain quality characteristics was developed. This technique also used the Ishikawa causal diagrams [17], also called "fishbones" (Fig. 3). Their use is also possible in assessing the causes of the technical systems failure.

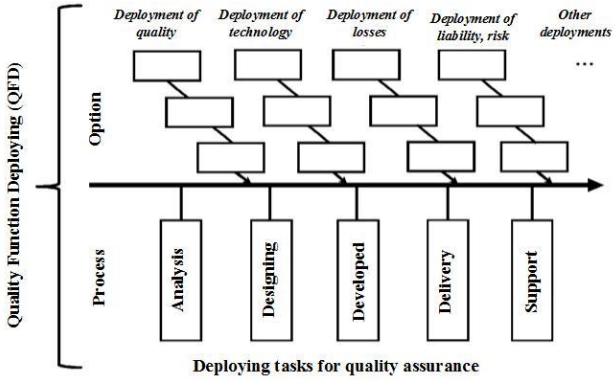

Fig. 3. Ishikawa diagram for quality function deployment (created according to Kuzmin, A.M, 2002)

This method allows you to consider possible costs associated with lowering the quality and financial implications thereof at all levels of hierarchy of processes and components of a product and identifying spots with the highest vulnerability by deterioration the quality of the final product. Such an approach to quality control in the author's opinion is very successful in assessing the safety of production, ranging from a separate area of production activity and deploying a safety function (SF) to a particular workplace, equipment or material. According to [18], QFD is a method for improving the project quality,

the purpose of which is to satisfy the consumer by transferring his or her requirements into the project objectives and in the main points of quality assurance for use at the production stage. This is a way to guarantee the quality of the project while the product is still at its design stage.

According to L. Sullivan [19], the main task of any production company is to offer (and promote) new products to the market before there will emerge competitive products with lower costs and improved quality. The mechanism ensuring that is called the Quality Function Deployment (QFD). Under QFD, all actions are based on "consumer opinion"; so the QFD represents the transition from manufacturing quality control to quality control of product development.

B. *From quality function to safety function*

Nowadays, the need to coordinate different management systems is becoming more and more relevant task for enterprises; they conduct their activities on the basis of sustainable development and corporate social responsibility. On the basis of common standards such as ISO 31000 (Risk management), ISO 26000:2010 (Guidance on social responsibility) and ISO 19011:2011 (Guidelines for auditing management systems), a fairly extensive arsenal of management system standards has been established [20]:

by type of loss: ISO 9001 (Quality), ISO 14001 (Environmental management), BS OHSAS 18001 and ISO 45001 (Occupational safety), ISO 27001 (Information security), ISO 28001 (Security management systems for the supply chain), ISO 50001 (Energy Management Systems), ISO 39001 (Road traffic safety); by industry: EA 91XX (Aviation), ISO 22000 (Food safety), ISO/TS 16946 (Automotive), IRIS (Railways), ISO 29001 (Petroleum, petrochemical and natural gas industries), ISO 13485 (Medical devices), ISO/IEC 20000 and TL 9001 (Information technology); by activity types: ISO 20252:2006 (Market, opinion and social research), EN 15838:2009-10 (Customer Contact Centers), EN 15038:2006 (Translation services).

To this end, it is a high time to rethink existing management systems and their combination in order to achieve the highest degree of product quality and the protection of the environment, the worker, the user and third parties from the negative impact of the broadened range of factors based on the synergistic effect of such approach. According to the author, acting in the direction of management systems integration, it would be expedient to use the developed experience of the quality function deployment to create a new methodological approach in assessing the risks to workers lives and health and the environmental impact of production activities, transposing an approach that has already proven itself well in deploying the safety function and building a "house of safety" (HoS). Other authors (Lombardi M., Bragliaa M., Kritsky D.N., Galimov F.M.) [21]-[24] also expressed interest in expanding the possibilities of QFD and described the procedures for using that method for other processes. But the concept of safety function deployment (SFD) and the construction of the "house of safety" (HoS) in the form presented is authored and published for the first time. An outdated attitude to the safety challenges of a production with a strategy of measures after an emergency occurred and caused losses, namely, the strategies of the POST-FACTORIAL response, shall be replaced by the strategy of identifying the germ of danger and the implementation of the necessary measures at the stage of development of the technological process, that is, to use the CONTRA-FACTORIAL strategy, based on the best practice security management for a particular production process.

Deploying a safety function creates this opportunity by using prognostic methods and analyzing various measures that may serve as safety barriers when developing the best practices in safety management in a particular industry or in a specific production.

The general view of using the "house of safety" method is shown in Figure 4.

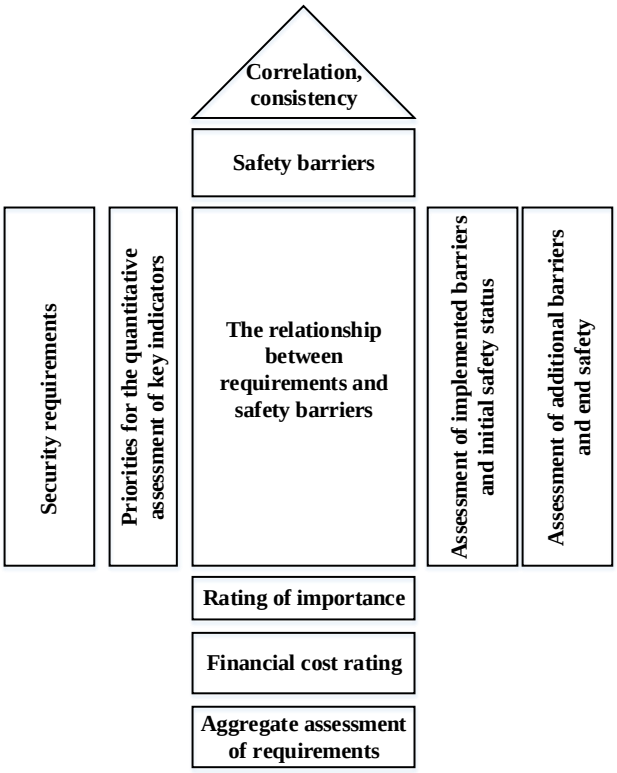

Fig. 4. Schematic representation of the method of safety function deployment with the "house of safety" construction

The given structure of the "house of safety" provides an opportunity not only to develop new safety barriers, but also using existing barriers to distinguish those, that do not significantly improve the situation but require some estimates for implementation and maintaining of their effectiveness. Orientation of the producers on the possibility of increasing their profit from economic activity may be supported by the introduction of the above methodology into the management system taking into account the specifics of a particular industry and relying on the possibility of financial support for measures aimed at supporting environmental and technology-related safety of production to allocate funds rationally and use the best practices from safety management in the future.In addition, the methodology presented is harmonized with the basis for management systems - Deming Cycle (P-D-C-A).

Its structure of the PLAN-DO-CHECK-ACT is clearly reflected in the safety function deployment and provides for control and continuous improvement.

IV. CONCLUSIONS

The carried-out study allows confirming the high level of occupational injuries in Ukraine despite the rapid decrease in the number of injuries registered by the official safety supervision bodies and those providing social guarantees to the insured under the system of compulsory state social insurance of the State Service of Ukraine on Labor and the Social Insurance Fund. Thus, indicators of injury frequency rate for both general and lethal injuries in Ukraine have decreased for the last eight years from 0.635 to 0.278 for RFGI, and from 0.035 to 0.024 for RFLI, but the analysis of the number of lethal injuries per 100 thousand employees although has decreased to 3.8 in 2017 and amounted to 4.0 in 2015 and 4.5 to 2016, it is still perhaps the highest indicator among the European Union Member States. According to the study data [25], the average working incident rate for lethal injuries per 100 thousand employees was 1.83 in 2015, with only Romania surpassing the figure, Ukraine manifested, that totaled 5.56. The development of safety management systems for production processes and the environmental component of production should be based on risk management under the standard ISO 31000 and the principles of social responsibility under the standard ISO 26000:2010, and also take into account the experience gained during the development of the quality management methodology under the standard ISO 9001. Following the analyzed approach to quality management by quality function deployment, the author has developed a methodology for the safety function deploying and constructing a “house of safety”, which provides more opportunities for the transition from the POST-FACTORIAL danger-response strategy to the CONTRA-FACTORIAL strategy for the detection of a germ of danger and implementation of the necessary measures at the stage of development of the technological process, based on the best practices of safety management for a particular production process. The author considers it expedient to conduct further study to improve the components of the “house of safety” and to identify correlations between danger sources and safety barriers.

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