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УДОСКОНАЛЕННЯ СИСТЕМИ УПРАВЛІННЯ БЕЗПЕКОЮ ПРАЦІ НА ПІДПРИЄМСТВАХ ХАРЧОВОЇ ПРОМИСЛОВОСТІ

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IMPROVING THE SYSTEM OF SAFETY MANAGEMENT IN THE FOOD INDUSTRY ENTERPRISES

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Abstract. *The methods of labor protection management, based on a combination of statistical analysis, expert estimation with ranking factors and combined forecasting the risks of occupational injuries with the implementation of algorithm formation of proposals about improving working conditions in the food industry enterprises, were improved. The results, which can be used in improving the management solutions' projects about providing safe working conditions of employees in the food industry enterprises as well as in the other industries of Ukraine, were received. Formulation of problem: the labor protection management in the enterprise is a part of the general enterprise management system, because only with a high level of labor protection it can be provided the effective implementation of the assigned tasks and the achievement of the best economical results. Therefore, the improving process of the functioning of the labor protection management system requires the rational organization and the effective cooperation between employees and managers of all structural departments, as well as the effective cooperation with the industry and appropriate public authorities [1].*

Key words: safety management system (SMS), occupational injuries, safety, risk forecasting, expert evaluation factors.

The important function of labor protection management is the analysis and forecasting the indicators of labor protection condition. The analysis in the labor protection management system is of principled meaning, due to becoming one of the main source of information, and allows to use the control actions promptly and correctly, what provides the effective functioning of the LPMS [2].

The scientific development of labor protection management system in Ukraine was founded in 1970s and has been developing [3-4]. The fundamental scheme of the LPMS of the enterprise, which was accepted in the USSR and now in Russia as well as in Ukraine [4], was progressive and effective for its time, but the changes in the social, economic and legal spheres makes it need the reorganization.

At present, this scheme of LPMS has significant shortcomings: there is no systematic record of humane, mechanical and environmental factors; there is no criteria for the analysis and synthesis of system, without which the conditions of work safety could not be scientifically and reasonably estimated; in modern terms, it is a socio-economically inefficient.

In the USSR, the LMPS of every industry fundamentally had no difference [5]. Studies have shown that the lack of scientific substantiation of construction and operation of the developed LMPS has become one of the main causes of its inefficiency [5-6].

The LPMS in the food industry is practically useless; labor protection services are reorganized, or they are headed by persons with no qualification; working conditions are not in compliance with applicable normative and legal acts of labor protection; employers do not create a healthy and safe working conditions, do not follow the provided technology of work; there is no analysis of injuries in the enterprises, including the accidents with death cases; the sources of occupational dangers are not being studied; the regularity of its formation is not being determined; there is no forecasting of occupational injuries and their consequences; the preventive

measures from of occupational injuries is not being developed; the work on perspective is not being planned and more.

Thus, was made a question - how to form the LPMS that would comprehensively dealt with the tasks of work safety in the food industry enterprises?

The aim of this work is - to improve the methods of labor protection management with the implementation of algorithm of proposals about improving working conditions in the food industry enterprises.

The object of this work is - the phenomenon of occupational injuries in the food enterprise.

Research methods. Studies were implemented by using the methods, such as statistical analysis, expert estimations and combined forecasting of the risk of occupational injuries. Work with results of expert estimations was carried out by the method of priori factors of ranking.

The presentation of the main material from research. The management, as a purposeful process, involves decision-making. The situation of the decision-making about reducing the level of occupational injuries is defined by a tuple:

$$\{X,Y,Q,R,Z,S,E,C,T\}, \quad (1)$$

where X – the set of information data used in the formation of management decisions;

Y – the set of indicators for estimation the number of industrial accidents;

Q – the set of managerial decisions permissible under the certain type of the problem;

R – the formalized selection rule of managerial decision from the set of possible;

Z – the set of constraints;

S – the set of possible states of the environment;

E – the set of expected results of implementation of alternative managerial decisions;

C – the cost of preventive measures from accidents;

T – time factor.

The increasing of safety level of production entails a significant investment in its upgrading, retraining staff, implementation of modern systems in production management. In this case, there is a contradiction, due to ,on the one hand, the need of increasing safety level (reducing Y), which inevitably leads to higher costs and increasing the cost C of production and, on the other hand, to reduction of production costs C, which can lead to the increase in occupational injuries (increasing Y).

The results of the managerial decision in the time period depends on the values of the set of indicators with which it estimates the conditions of labor protection in the previous time period and on accepted managerial decision:

$$Y^{t+\Delta t} = f\left(X^t(Z), Q, C\right). \tag{2}$$

The one of the promising research directions of solution of this contradiction and increasing the general level of work safety is the forecasting of the risks of occupational injuries which is directly related to the production process and creating conditions of avoidance from the injury based on these forecasts.

The labor protection management is aimed to minimize the indicators of estimation of labor protection conditions. The mathematical expression of selecting the best solution from the set of possible:

$$q_{onm} = q_j : y_j^{t+\Delta t} = \min_i\left(y_i^{t+\Delta t}\right),\ y_j^{t+\Delta t} \le y_\Gamma^{t+\Delta t},\ C_j \le C_\Gamma \tag{3}$$

where q_{onm} – the optimal managerial decision;

$y_j^{t+\Delta t}$, $y_\Gamma^{t+\Delta t}$ – the forecasted and limited (planned) value of the indicator of injuries in th moment of $t + \Delta t$;

C_j, C_Γ – the forecasted and limited (permissible) costs for the implementation of preventive measures from injuries.

The values $y_j^{t+\Delta t}$, $y_\Gamma^{t+\Delta t}$ will determine the level of the risk of occupational injuries in the enterprise.

The analysis of existing methods of forecasting the risks allows to conclude that the need of improving most of them, in order to adapt to the specifications of the food

industry enterprises and the comprehensive risk estimation of occupational injuries in the enterprise.

Official statistics consist mainly of much correlated between each other indicators, which, moreover, were measured with substantial errors. The correlation of output statistics leads to bad conditioning of the system of normal equations for the determination of the regression coefficients, and the presence of errors in the determination of output indicators causes the offset of estimates. To avoid this drawbacks with an aim of forecasting statistical indicators of occupational injuries it is proposed the following improvements of combined regression analysis method with principal components by using the method of expert estimation.

To clarify the main components and providing the reliability of the statistical estimation in the level of work safety in the food industry enterprises due to the incompletion statistical data by industry, it is necessary to use the method of expert estimations. The reliability of expert estimations is based on the assumption of cooperation between the experts with expert estimations' guaranteed reliability [7-8].

When using the expert estimations it is assumed that the opinion of the expert group is more reliable from the opinion of certain expert [7]. The method of collective expert estimations received a big widespread and is commonly used for sharing the experience of leading experts almost in all fields of knowledge and production [8].

The purpose of the expert survey are solution of the following tasks: an estimation of significance of knowledge about the main parts of labor protection for safe work operations in the food industry; synthesis of expert estimation and determining the consistency of expert opinions; estimation and identification of a combination of factors that affect on the risk of injury of employees on the workplaces in the food industry; determining ways of prevention the occupational injuries.

In order of solution the tasks and for estimation of the impact of various factors that influence on the number of industrial accidents in the food industry, it is necessary to engage a group of experts, where should be involved such specialists:

representatives of labor protection services, engineers and technical workers in the food industry; scientific and technical staff of higher education institutions and research institutes.

To exclude the corruption of data it is necessary to provide the anonymity of the survey, but based on the data considering that characterize the age, experience in the food industry, position, education.

It is necessary to make an expert survey in two rounds.

In the first round experts must assign each production indicator from the list an appropriate rank according to the degree of importance given, considering that the boundaries of ranks range from 1 to the maximum number of rank n. The 1 is must be assigned as the most positive estimation, and the number 1 + n - the minimum estimation. If the rank sequence of estimates submitted by j-th expert has the same estimations, then they must be assigned as the same rank of the numerical value.

In the second round the experts invited to estimate the importance of impact from certain factors or groups of factors on the level of injuries and give the quantitive estimation of its significance. When completing the questionnaire, the expert must determine the location of a factor in a range that is being ranked. At the same time it can include the additional factors or express an opinion about the change intervals ranked [7-9].

The method priori ranking factors is used in the processing of data obtained from interviews with experts or from studies that have been published in the literature. This experiment allows to design the object of study in a more appropriate way, to accept or reject some past hypotheses; give a comparative estimation of the impact of various factors on the optimization parameters and thus to select the common factors for the next experiment with deleting some of them in the future [7-10].

The feature of this method means that the factors which, according to the prior information, can have a significant impact, ranged due to reduction of their impact. The impact of each factor is estimated by the size of rank, which is given by an expert to this factor when ranking all factors with considering of their forecasted

impact on the optimization parameters. In the drawing up of expert opinions through their questioning, for each of them is proposed to complete the questionnaire with these factors stated and their dimension tolerances spacing variation.

The results of the expert survey (ranking) is calculated by the following procedure [10]:

1. The estimation results of these indicators are shown as a matrix of rank (tab. 1).

2. If j-th expert assign the same of importance rank, the matrix of rank is being transformed. This is due to the fact that the expert may not always accurately locate factors on certain feature.

Table 1

The matrix of results from expert eestimation indicators

Experts	Factors				
	X_1	X_2	..	..	X_i
1	a_{11}	a_{12}	..	..	a_{1i}
2	a_{21}	a_{22}	..	..	a_{2i}
j	a_{j1}	a_{j2}	..	..	a_{ji}

3. The sum of ranks by factor is being calculating $\left(\sum_1^m a_{ij}\right)$, where a_{ij} – the rank of every i-th factor of j-th expert; m – number of experts; n – number of factors.

4. Determinating the average sum of ranks: $\frac{\sum_1^n \sum_1^m a_{ij}}{n}$.

5. Calculating the deviation from average sum of ranks

$$\Delta i = \sum_1^m a_{ij} - \frac{\sum_1^n \sum_1^m a_{ij}}{n}. \quad (4)$$

6. Calculating the square of deviations from the average sum of ranks, which means the sum of squares of these deviations:

$$s = \sum_{1}^{m} (\Delta i)^2 \tag{5}$$

7. The level of matching opinions from the whole group of experts about the importance of selected factors is being estimated by the coefficient of concordance (agreement), ω [9]:

$$\omega = \frac{12s}{m^2(n^3 - n) - m\sum_{1}^{m} T_j}, \tag{6}$$

where $Tj = \Sigma(t_j^3 - t_j)$; t_j – the number of same ranks in j-th ranging.

8. The verification of conditions of matching experts' opinions: $\omega = 1$ – *estimations of all of the experts are same*; $\omega = 0$ – experts gave the different estimations, which means a lack of matching in experts' opinions.

9. The estimation of significance with coefficient of concordance (agreement) was holding beacause of criteria:

$\chi 2$- distribution of a number of levels of freedom $f=n-1$.

The value of $\chi 2$-criteria was founded by the formula:

$$\chi^2 = \frac{12s}{mn(n+1) - \frac{1}{n-1}\sum_{1}^{m} T_j}, \tag{7}$$

The hypothesis about the existence of matching of expert opinions may be accepted, if a given number of degrees of freedom tabular $\chi 2$ value less the estimated for the 5% significance level [9].

Thus, in the process of implementation expert estimation it need to be determined by the importance (significance) of every factor, and the matching of expert opinion also.

10. The total significance of factors is being determined by the estimation of all the experts.

Study results are processed by a priori ranking method, with the following making of diagrams of ranks.

The algorithm of formulating proposals to improve working conditions in the food industry enterprises on the basis of combined forecasting risks. During the developing measures of improving working conditions objectively appears the problem of finding a solution that would be the best (optimal) from all possible for the safe implementation of the technologial process in the food industry enterprises.

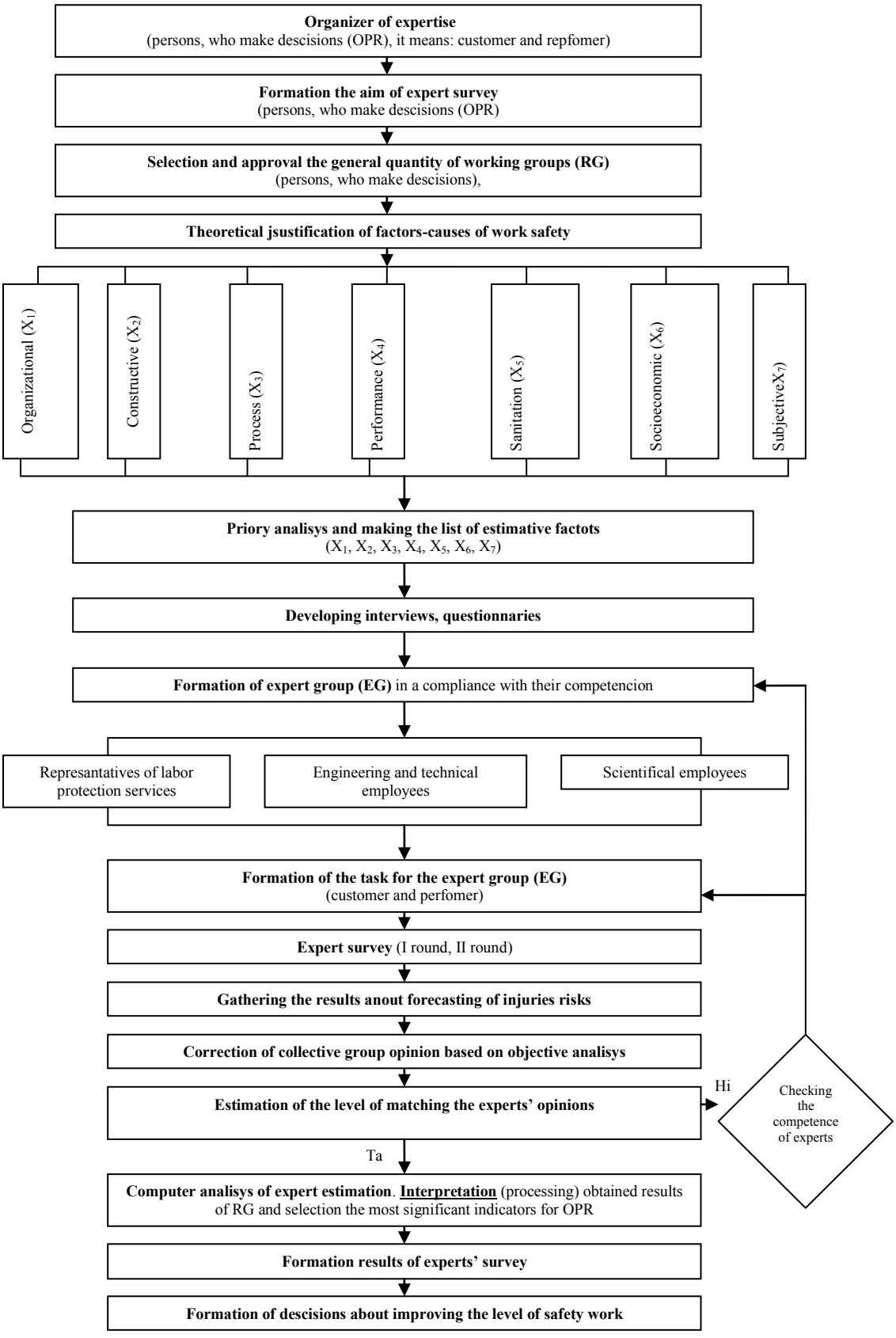

Fig. 1. The block-scheme of the algorithm of decision-making for the organization and providing safe working conditions on the basis of risk forecasting

The algorithm of implementation the expert estimation, shown in **Fig. 1**, which shows the main rounds of the process of decisions-making based on combined forecasting risks. The combination in this case is being implemented on the basis of specifying objective information on statistics of occupational injuries with making forecasts based on the method of principal components and refinement of such forecasts (or rather - the most influential factors) based on expert interviews.

The organizers of the expert survey (unit 1) are represented by persons, who makes decisions (DM), means the customer (our library). ATS set goals of expert survey (block 2) and performs the selection and approval of the Working Group (WG) (block 3), ie people who organize the process of expert estimation and pick up an expert group (EGWP justifies those indicators that are being proposed for experts (blocks 4, 5) and it's being developed interviews or questionnaires (Block 6). In the selection of experts (Block 7) - specialists, competent on this subject and which are able to solve this problem, DM and WG guided by own subjective point of view, making a selection on their own, or by objective data of experts (personal affairs) which is preferable. The composition includes representatives of the enterprise EG (because they know the main substance of enterprise production better than any other). Typically, they are representatives of labor protection services, as well as representatives of the labor collective (master, foreman, etc.).

After the formation of the expert group in front of them ATS and WP are putting tasks (Block 8), orally or in written form (in the previously prepared questionnaire form). To solve this problem, experts are being provided with questionnaires and regulations, and it's holding an expert survey (block 9).

The next stage in this algorithm is the analysis and processing of expert estimates that capture the experts' opinions, as well as the consistency of experts' thoughts (blocks 12-14), which method of determining them is above, and with the implementation of matching condition - the formation of the results of the expert survey (block 15) and of decision-making of improving the level of labor protection (block 16).

Checking the competence of EG can be done in two ways:

1) experts determine competence of each other by estimations;

2) to estimate the competence of experts drawn expert committee (or other competent expert group).

If the condition of competence doesn't implement with certain members of the EG, it is necessary to replace them with others, that means there is a return to the block 7 and solving the problem pepeats. As a threshold competency assessment of \experts it can be taken the sum of points gained by them in tests and answered questions during the testing (formation EG). Changing the rules of working is made of ATS and lies in reorganizing grading scales, clarification or revision of criteria with usage of which indicators are being estimated, the changing in formulation of solvable problem, then there is an operation unit 9, and the process of solving the problem repeats.

Thus, the proposed algorithm of a comprehensive expert estimation, based on objective forecasting of risks, allows to prepare some projects of managerial descisions about the providing of safe working conditions of emloyees in the food industry.

Conclusions: The one of the promising research directions of solution of and increasing the general level of work safety is the forecasting of the risks of occupational injuries which is directly related to the production process and creating conditions of avoidance from the injury based on these forecasts. The correlation of output statistics leads to bad conditioning of the system of normal equations for the determination of the regression coefficients, and the presence of errors in the determination of output indicators causes the offset of estimates. To avoid this drawbacks with an aim of forecasting statistical indicators of occupational injuries it is proposed the following improvements of combined regression analysis method with principal components by using the method of expert estimation.

Thus, the method of expert estimations should be used to clarify the principal components and provide the reliability of the statistical estimationof safety. The results can be used for improving project management decisions to provide safe

working conditions of employees of the food industry as well as companies in other industries in Ukraine.

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