UDC 331.45

O. Kruzhilko, V. Maystrenko, Ya. Storozh, Yu. Lyakh

Evaluating the effectiveness of measures to reduce the level of occupational injuries and occupational disease in the enterprise

Annotation: The article proposes a methodical approach to assessing the effectiveness of measures to reduce the level of industrial injuries and occupational morbidity in the enterprise, taking into account the causal relationships betweenthe implementation of measures and the economic indicators of the enterprise.A mathematical model for the prediction of indicators of industrial injuries and occupational morbidity has been adopted.

Key words: occupational injuries, occupational diseases, occupational health, harmful and dangerous working conditions, predictive model

Problem statement

The most important principle consolidated in the EU legal framework for occupational safety and health is its aim of encouraging improvements in the field of safety and health at work (EU Directive 89/391/EEC). That is, the main focus is not only the protection of workers and the prevention of accidents and occupational diseases, but also improving the state of safety and health. Accordingly, an assessment of the effectiveness of measures to reduce the level of occupational injuries and occupational disease at the enterprise is an important part of the modern system of management of occupational safety.

Analysis of recent research

Unfortunately, in Ukraine, the principle of the protection of workers who work at work with harmful and dangerous working conditions and at work with unfavorable weather conditions prevails. Moreover, in such cases, the main measures are the payment of compensations, allowances for work in hazardous and harmful working conditions, protection by time (reduction of working time), early retirement, free food, etc.

In this approach, workers who are not engaged in hazardous and hazardous working conditions are not entitled to the compensation given, although the risksof occupational disease or injury to the work are high enough or not appreciatedat all.

The existing legal framework is not focused on the implementation of the principle of prevention and improvement of working conditions. Analysis of the risk of occupational diseases and accidents, their impact on the economy of the enterprise is still not widely conducted. The main reasons are the lack of appropriate methodology for assessing the risk and the professional and psychological unpreparedness of specialists in this area.

Analysis of statistical data in recent years suggests that the main causes of occupational injury are:

 ISSN 1560-8956

- Organizational: insufficiency or lack of training on occupational safety issues; failure to comply with labor safety instructions; violation of technology; poor organization of work;

- technical: malfunction of production equipment; imperfection of technological processes; constructive disadvantages of workplaces;

- psychophysiological: false actions due to fatigue; monotony of labor; morbid condition of the worker; negligence; mismatch of psycho-physiological data of the worker to the work performed.

The main causes of occupational diseases: elevated levels of harmful substances in the air; insufficient or irrational lighting; increased levels of noise, vibration, infra and ultrasound radiation; unsatisfactory microclimate conditions and more.

It should be noted that today in Ukraine a significant number of injuries and occupational diseases are concealed, which has a significant impact on statistical reporting.

Formulation of the problem

On the basis of the foregoing, there is a need for such systems of labor protection management, which would be closely linked with the economic activity of the enterprise and allowed to form economically grounded measures to increase the safety of production.

The main criterion for assessing the effectiveness of safety management in such a system should be the actual magnitude of the risk exposed to workers in their workplaces, which should be constantly compared with the standard permissible level of risk.

The planning of events should be closely linked with the forecasting of the state of the labour protection at the enterprise, which allows: to assess the changes in the state of safety of production in the future; to identify the indicators and factors that have the most significant impact on the level of risk of production processes, to quantify the extent of this impact; to identify possible changes in its structure in the future and to predict the main directions of activity to improve the safety of production; to identify alternative actions to achieve the goal, as well as to formulate the goal itself; to substantiate managerial decisions on optimal distribution of available financial and material resources; to determine the priority of investing in preventive measures.

Presenting main material

The study of the dynamics of quantitative indicators of injury and occupational morbidity makes it possible to determine the patterns of their changes and, with this in view, predict the probable values of the level of indicators within the forecast error. Modeling methods are based on the construction of mathematical and statistical models that reflect the cause-effect mechanism of the process.

The initial data in the calculations are the performance indicators of the enterprise, on the basis of which the mathematical-statistical model for the previous pe-

riod is developed. Economic information on damage from injury and occupational disease should include cost data for the following articles:

- compensation for work in harmful working conditions;
- compensation for the consequences of injuries and occupational diseases;
- coverage of losses due to work in harmful working conditions;
- one-time and operational costs for improving the safety of production.

The methodical approach to assessing the effectiveness of measures to reduce the level of occupational injuries and occupational disease is as follows. The effectiveness of measures to reduce the level of occupational disease in an enterprise is determined by the sum of partial economic effects:

$$C = \sum_{i=1}^{l} c_i, \tag{1}$$

where c_i - economic evaluation i-th indicator of improvement of working conditions at work, l – number of indicators.

The economic effect caused by the reduction of losses due to occupational injuries and morbidity due to harmful working conditions is determined by the formula:

$$c_1 = \sum_{m=1}^{n_1} \Delta D_m \cdot N_m, \tag{2}$$

where ΔD_m - revenue from volume increase m-th type of products in the workplace by improving working conditions; Nm – number of workplaces m-th type, where measures to improve working conditions are implemented.

$$\Delta D_m = (D_1 - D_2) \cdot V_p, \tag{3}$$

where D_1, D_2 - total number of days lost due to illness associated with harmful working conditions before and after events conducted; V_p - average output per worker in the workplace m-th type.

Revenues at the expense of saving on training and retraining in connection with the replacement of workers who fell ill or left due to staff turnover due to hazardous and harmful working conditions, is calculated by the expression:

$$c_2 = \sum_{m=1}^{n_2} N_{m1} Q_m, \tag{4}$$

where N_{m1} - number of workers in the workplace m-th type, requiring retraining due to the replacement of workers who have become ill or have left due to staff turnover caused by dangerous and harmful working conditions; Q_m - the average industry expenditure on re-training one worker in the workplace m-th type.

The income caused by the decrease in the amount of compensation for work in harmful working conditions due to the improvement of its conditions, is determined by the formula:

$$c_3 = \sum_{m=1}^{n3} \Delta T_m Q_m, \tag{5}$$

 ISSN 1560-8956

where ΔT_m - Reducing the number of workers in the workplace *m*-th type that work in harmful working conditions; Q_m - the amount of compensation for work in harmful working conditions in the workplace *m*-th type.

Income due to a decrease in the value of compensation for the consequences of injuries and occupational diseases, is determined by the formula:

$$c_4 = \Delta Y_1 \cdot K_1 + \Delta Y_2 \cdot K_2 \quad (6)$$

where ΔY_1 – the predicted value of reducing the number injured due to the introduction of measures to improve the safety of production, K_1 – the average size of the compensation of the consequences of trauma; ΔY_2 – the predicted value of reducing the number of occupational diseases by introducing measures to improve the safety of production, K_2 – the average size of the reimbursement of the consequences of occupational diseases by industries.

Expenditures on the implementation of measures to improve the safety of production are determined by the formula:

$$c_5 = -\sum_{m=1}^{m_1} W_m \cdot N_m, \quad (7)$$

where W_m - average costs for implementation of safety improvement measures at the workplace *m*-th type; N_m – amount of workplaces *m*-th type, on which measures to improve the safety of production are implemented.

To predict the level of occupational morbidity and injury, data is collected on the number of victims per n previous years. Mathematical model for determining the increment of the number of the indicator y_j can be represented as a system of differential equations:

$$\begin{aligned} \frac{dy_j}{dt_1} &= \sum_{i=1}^{6} a_{1i} \cdot y_i + F_{1j}(t_1) + F_{2j}(t_2) \\ \frac{dy_j}{dt_2} &= \sum_{i=1}^{6} b_{1i} \cdot y_i + R_{1j}(t_1) + R_{2j}(t_2), \end{aligned} \quad (8)$$

where Y_j – modeling index; $F_{1j}(t_1)$, $R_{1j}(t_1)$ - the function of taking into account the monthly trendy; $F_{2j}(t_2)$, $R_{2j}(t_2)$ - the function of taking into account the annual trend, t_1 – serial number of the month and t_2 - ordinal number of the year in the model.

Having constructed differential equations for the indices, we obtain a system of linear homogeneous equations of the first order, which can be solved by numerical methods. The predicted value of the simulated indicator will look like:

$$y_{j\text{прогн}} = y_j + \frac{dy_j}{dt_1} \cdot \Delta t_1 + \frac{dy_j}{dt_2} \cdot \Delta t_2. \quad (9)$$

To construct the mathematical model of the indices, the conditions must be fulfilled - the quantity Y is normalized and its dispersion is constant. The normality of the distribution of indicators is provided by an unlimited set of factors through the use of the central boundary theorem.

When constructing a forecast model, the region of factors changes is determined which, in the general case, should correspond to the scale of those indicators, whose values are calculated as output data for predictive models. These requirements do not apply to the non-stationary part of the model, since in this case we are dealing with extrapolation over time (that is, we investigate the effect of the nonlinear time trend).

Conclusions

The proposed methodology allows to assess the effectiveness of the plan of measures to increase the safety of production, taking into account the causal relationships between the implementation of measures and economic indicators of the enterprise.

Estimates obtained using methods of forecasting and economic analysis of measures to reduce the level of injury and occupational disease, are only a basis for the adoption of a final decision on the management of occupational safety and health of the enterprise. In addition, additional criteria, including informal, may be taken into account. The proposed approach allows to proceed to the next stage - creation of an automated control system of labour protection in the enterprise, based on scientifically grounded methods for assessing the effectiveness of measures to reduce the level of occupational injuries and occupational disease.

REFERENCES

1. Національний профіль з безпеки та гігієни праці. Україна 2018. Міжнародна організація праці. URL : http//www.ilo.org/UkraineEUProject.

2. Кружилко О.Є., Майстренко В.В., Полукаров О.І., Демчук Г.В. Оцінка ефективності управлінських рішень у сфері охорони праці. *Проблеми охорони праці в Україні.* 2015. Вип. 29. С. 3–9.

3. Кружилко О.Є., Сторож Я.Б., Ткалич І.М., Полукаров О.І. Підвищення ефективності управління охороною праці на основі виявлення небезпек та оцінки ризиків виробничого травматизму. *Адаптивні системи автоматичного управління*. 2017. Вип. 2 (31). С. 38–45.

4. Оценка рисков на рабочем месте : практическое пособие : [перевод с финского] Мерви Муртонен; [науч. ред. : Г. З. Файнбург]; VTT-техн. исслед. центр Финляндии, М–во социал. обеспечения и здравоохранения Финляндии, Отд. охраны труда. – М.: Международная организация труда, 2011. 63 с.

5. МОТ. Окружающие факторы на рабочем месте. Инструкция МОТ. Женева, Бюро Международной Организации Труда, 2001 (ISBN 92-2-111628-X).

6. Парменова Д.Г. Систематизация факторов опасности для построения профиля риска судових работ. *Науковий вісник Херсонської державної морської академії.* 2014. № 1. С. 30–35.

7. Кружилко О.Є., Богданова О.В. Алгоритм вибору методів та визначення результативності оцінки ризику. *Вісник Кременчуцького національного університету імені Михайла Остроградського. Екологічна безпека.* 2016. Вип. 2 (97). С. 76–81.