Optimization of costs for labor protection of the enterprise

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Abstract All The authors propose a justification for the distribution of the budget of labor protection (LP) of the enterprise on organizational-technical measures aimed at improving working conditions and safety and on social activities related to staff training and prevention of workers health. The accumulation of professional risk is considered, and the efficiency of costs for LP is estimated by reducing the rate of its accumulation, the change in the distribution of which can serve as the basis for flexible management of labor protection of the enterprise in order to reduce the level of professional risk. The increase in the effect of the cost of LP, determined by the criterion of reducing the rate of accumulation of professional risk, is very relevant in the development of LP management in the enterprise.

Keywords: safety, labor protection, optimization of costs, enterprise, management.

1. Introduction
The budget LP the company is allocated for the implementation of various measures to improve working conditions and safety, as well as to preserve and prevent the health of workers. The distribution of costs is appropriate to relate to their effectiveness, assessed by reducing the rate of accumulation of professional risk [1, 6, 14].

2. Method
2.1 Accumulation of professional risk
The risk of occupational disease (occupational risk) is determined by the probability of loss of health of employees as a result of professional activity. The risk accumulates during the work experience:

\[ R_i = R_{i-1} + \Delta R_i, \]

where \( R_{i(i-1)} \) – is the occupational risk accumulated by an employee during \( i(i-1) \) years of employment in the conditions of harmful effects of the working environment;
\( \Delta R_{i(i-1)} \) – is the increment of professional risk in the m-th year of the employee's work experience.
\( \Delta R \) can be interpreted as the rate of accumulation of professional risk, which depends on the state of the environment and its changes [2,15].

The accumulation of occupational risk in a given working environment, which determines the impact on the employee of harmful and dangerous factors, can be determined:
\[ R = \sum_{i=1}^{N} \Delta R_i, \text{where } i \in [1, N] \] (2)

The period of accumulation of risk to acceptable values is considered a safe work experience.

2.2 Management of working conditions and safety

Let the reduction of the annual increment of risk with the improvement of working conditions at the expense of expenses be equal to:

\[ \Delta \tilde{R} = \Delta R (1 - \varepsilon), \] (3)

where \( \varepsilon = 1 - \frac{\Delta \tilde{R}}{\Delta R} \) - is the coefficient characterizing the decrease in the rate of accumulation of occupational risk due to the implementation of measures to improve working conditions and safety.

Let \( Z_{\text{techn}} \) be the costs of organizational-technical measures to improve working conditions, in particular, to improve collective and individual protection, modernization of production technologies, and increase electrical safety at workplaces.

\( Z_{\text{social}} \) are costs of prevention of health of workers, in particular, on social and resort treatment, medical examinations, etc [3, 9, 19].

We consider the budget LP the enterprise:

\[ B = Z_{\text{techn}} + Z_{\text{social}} \] (4)

Moreover, the coefficient of change in the rate of accumulation of professional risk is equal to:

\[ \varepsilon = \varepsilon_1 + \varepsilon_2, \] (5)

\[ \varepsilon_1 = R_{\text{techn}} \cdot \frac{Z_{\text{techn}}}{Z}, \]

\[ \varepsilon_2 = R_{\text{social}} \cdot \frac{Z_{\text{social}}}{Z}, \]

\( K_{\text{techn/social}} \) - the weight coefficient determined empirically and characterizing the contribution of organizational-technical (social) measures in the system of integrated assessment of improvement of working conditions and safety;

\( Z \) - are hypothetical costs to achieve \( \Delta \tilde{R} = 0, \varepsilon = 1. \)

Using equations (3), (4), (5) get:

\[ \Delta \tilde{R} = \Delta R \left( 1 - \left( \frac{K_{\text{techn}} \cdot Z_{\text{techn}} + K_{\text{social}} \cdot Z_{\text{social}}}{Z} \right) \right) \] (6)

It seems appropriate to ensure the distribution of costs from the condition of the equal effect of reducing the rate of accumulation of professional risk in the implementation of organizational-technical and social activities: \( \varepsilon_1 = \varepsilon_2. \)

As a result, we obtain:

\[ Z_{\text{techn}} = \frac{B}{1 + \frac{K_{\text{social}}}{K_{\text{techn}}}} \] (7)

\[ Z_{\text{social}} = \frac{B}{1 + \frac{K_{\text{techn}}}{K_{\text{social}}}} \] (8)

Equation (7) and (8) determine the distribution of the budget LP the enterprise to perform technical and social measures to reduce professional risks, taking into account the equally significant effects of reducing the rate of accumulation of professional risk [4, 10, 16].
3. Results
The analytical substantiation of budget allocation to the enterprise on expenses on a performance of the organizational-technical actions directed on improvement of working conditions and safety, and the actions directed on prevention of health of the personnel is offered [7,18].
As a criterion for the effective allocation of costs is considered the rate of accumulation of occupational risk.

4. Discussion
Well-known economic approaches to the management present a tool to assess the cost in the monitoring system of expenses on the improvement of working conditions, where the criterion of effectiveness of the adopted solutions is to reduce direct and indirect losses of the enterprise [11,17].
The proposed approach to the allocation of funds on the within the adopted budget is based on estimates of annual increments of professional risk, allowing to manage the distribution of costs for measures to improve the conditions and safety of the enterprise.

Let $Z_m$ - is the cost of technical measures to improve working conditions and safety; $Z$ - is the cost to provide $\varepsilon = 1$.
Get from (3):
$$\Delta \tilde{R} = \Delta R \left(1 - \sum_{m=1}^{M} K_m \cdot \frac{Z_m}{Z}\right)$$

Equation (9) relates the change in the rate of risk accumulation ($\Delta R$) to the cost of implementing measures to improve working conditions and safety.
Equation (5) is a particular equation (9), where the activities of organizational-technical direction and social activities highlighted.
Equation (9) can be represented by:
$$\Delta \tilde{R} = \Delta R \left(1 - \sum_{m=1}^{M} \varepsilon_m\right)$$

where $\varepsilon_m$ determines the contribution of the implementation of the $m$-th event in the integrated assessment of the rate of accumulation of professional risk [13].
Thus, the efficiency of cost allocation for the implementation of measures to improve working conditions and safety is determined by a relative decrease in the rate of occupational risk:
$$\min \left\{\frac{\Delta \tilde{R}}{\Delta R}\right\} = \left(1 - \sum_{m=1}^{M} \varepsilon_m\right)$$

where $\varepsilon_m = \frac{K_m \cdot Z_m}{Z}$

The distribution of the budget to the enterprise is represented by equations (7) and (8), which can be interpolated for the $m$-th action to improve working conditions:
$$Z_{techn} = \frac{B}{1 + \sum_{j=1}^{M} \frac{K_j}{K_m}} \cdot j \in [1, \ldots m - 1, m + 1, \ldots M], j \neq 1$$

Let's consider an example of cost allocation for LP in the enterprise.
Let budget equal to 10% of $Z$ (equation (5)) a priori and distributed to the organizational-technical and social activities in the ratio of 1:3 provided $K_{social} = 10\%, K_{techn} = 30\%$. In this case, the reduction in the rate of accumulation of professional risk of personnel will be:
ε₁ = 0.3 \cdot \frac{0.25B}{Z} = 7.5\% \\
ε₂ = 0.1 \cdot \frac{0.75B}{Z} = 7.5\%

From equation (11), \( \frac{\Delta R'}{\Delta R} = 1\% \)

If the cost distribution changes according to equations (7) and (8), we obtain:

\( Z_{techn} = 0.75B; \ Z_{social} = 0.25B \)

Respectively

ε₁ = 2.25\% \\
ε₂ = 0.25\% \\
\( \frac{\Delta R'}{\Delta R} = 3\% \)

**Conclusion**

The distribution of costs within the budget LP the enterprise for the implementation of measures to improve the safety conditions is an important regulator in improving the occupational safety management system, where the rate of accumulation of professional risk can serve as an indicator of cost-effectiveness [10].

The development of the proposed approach involves the accumulation of statistics of accidents and occupational diseases, as well as decision-making in the database system, which forms a flexible financial policy for labor protection of the enterprise.

**References**

[1] Orniet S, Nowar S 2015 Procedia Economics and Finance Volume 27 pp. 144-152.
[2] Burlov V, Lepeshkin O 2017 Modeling the Process for Controlling a Road Traffic Safety System Based on Potentially Active Elements of Space and Time Transportation Research Procedia, 20 DOI: 10.1016/j.trpro.2017.01.02
[3] Korshunov G Polyakov S Shunmin L 2017 Assurance of reliability and safety in liquid hydrocarbons marine transportation and storing IOP Conference Series: Earth and Environmental Science, 87 (6) DOI: 10.1088/1755-1315/87/6/062009
[4] Seliverstov Y, Seliverstov S, Lukomskaya O, Nikitin K, Grigoriev V, Vydrina E 2017 The method of selecting a preferred route based on subjective criteria Proceedings of 2017 IEEE 2nd International Conference on Control in Technical Systems, CTS 2017 pp 126-130. DOI: 10.1109/CTSYS.2017.8109506
[5] Hopkins, Andrew 1955 Making Safety Work: Getting Management Commitment to Occupational Safety and Health. Sydney : Allen&Unwin
[6] Aldrich, Mark 1997 Safety First. Baltimore Johns Hopkins University Press
[7] Bernthal P, Wellins R 2000 Retaining Talent: DDL Development Dimensions International. DDI Leadership Development & Assessment. [in the Internet] http://www/ddiworld.com
[8] Congress, U.S. Office of Technology Assessment. Washington : DC: OTA-ENV-635
[9] Tchiehe D, Gauthier F. 2017 Classification of risk acceptability and risk tolerability factors in occupational health and safety Safety Science Volume 92 pp 138-147
[10]Burlow V, Grachev M, Shlygina S. 2017 Adoption of management decisions in the context of the uncertainty of the emergence of threats Proceedings of 2017 20th IEEE International Conference on Soft Computing and Measurements SCM 2017, pp. 107-108. DOI: 10.1109/SCM.2017.7970510
[11] Korshunov G, Polyakov S, Shunmin L 2017 Assurance of reliability and safety in liquid hydrocarbons marine transportation and storing IOP Conference Series: Earth and Environmental Science, 87 (6) DOI: 10.1088/1755-1315/87/6/062009
[12] Alekseev S, Tarasov A, Borovkov A, Aleshin M, Klyavin O 2017 Validation of euroncap frontal impact of frame off-road vehicle: Road traffic accident simulation Materials Physics and
[13] Burlov V, Popov N 2017 Management of the application of the space geoinformation system in the interests of ensuring the environmental safety of the region Advances in the Astronautical Sciences

[14] Byzov A P, Shershneva A I & Ens M A 2018 Assessment methodology for personal risk assessment in the field of waste storage. Paper presented at the Proceedings of the 2018 IEEE International Conference "Management of Municipal Waste as an Important Factor of Sustainable Urban Development", WASTE 2018, 49-51. doi:10.1109/WASTE.2018.8554146

[15] Chalovskaya E K, Klochihin I O & Kaverzneva T T 2018 Algorithm of assessing working conditions at waste processing plants. Paper presented at the Proceedings of the 2018 IEEE International Conference "Management of Municipal Waste as an Important Factor of Sustainable Urban Development", WASTE 2018, 3-6. doi:10.1109/WASTE.2018.8554133

[16] Idrisova J I, Myasnikov V N, Uljanov A. I & Belina N V 2018 Increasing the efficiency of labor protection in the enterprise. Paper presented at the International Conference on Information Networking, , 2018-January 586-588. doi:10.1109/ICOIN.2018.8343186

[17] Kireeva L, Kaverzneva T, Tarkhov D & Belina N 2018 Research of professional suitability in construction by the noise factor. Paper presented at the MATEC Web of Conferences, , 245 doi:10.1051/matecconf/201824503012

[18] Pykhtin K, Simankina T, Sharmanov V & Kopytova A 2017 Risk-based approach in valuation of workplace injury rate for transportation and construction industry. Paper presented at the IOP Conference Series: Earth and Environmental Science, , 90(1) doi:10.1088/1755-1315/90/1/012065

[19] Sokolitsyn A S, Kovalenko I I & Zvontsov A V 2017 Production risk economic assessment based on the fuzzy logic approaches. Paper presented at the Proceedings of 2017 20th IEEE International Conference on Soft Computing and Measurements, SCM 2017, 834-836. doi:10.1109/SCM.2017.7970738