The method of assessing occupational risk based on the materials of a special assessment of working conditions

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Abstract. Occupational risk assessment is one of the necessary procedures of the occupational health and safety management system. The purpose of the research is to develop a method for assessing occupational risk adapted to the procedure for assessing working conditions and the implementation of the proposed method in the management of occupational health and safety of the enterprise. The article proposes a method for assessing occupational risk, which includes compilation of a list of risk-forming factors influencing working conditions; determination of probability and damage weighting coefficients in accordance with the classes of working conditions; calculation of occupational risk in the workplace; distribution of assessment results by significance based on the risk ranking scale and development of appropriate measures to reduce the impact of risk in the workplace. The result of the research is to develop an accessible and practical-oriented method for determining occupational risk based on data from a special assessment of working conditions, which are mandatory reporting documents and characterise the actual state of working conditions at the enterprise. Keywords: occupational risk, special assessment of working conditions, weighting factors, risk-forming factor, occupational safety management system

1 Introduction

The procedure for assessing and managing occupational risks is one of the main elements of the occupational health and safety management system (OHSFS) at the enterprise, which is aimed at ensuring the safety and health of employees. The Standard Regulation on the Occupational Health and Safety Management System states that the methods of assessing occupational risks are determined by the employer independently.

An analysis of existing methods has shown that, despite all the diversity, a single approach to assessing occupational risks has not been established and they are not always applicable in practice [1-4].

In this regard, the issue of finding new methods of assessing occupational risks in the organisation of labour protection remains relevant. The purpose of the research is to develop a method for assessing occupational risk adapted to the procedure for assessing working conditions. The main objective of this study is to establish the relationship of

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occupational risk with working conditions, the introduction of the proposed method in the management of occupational health and safety of enterprises.

The article proposes a method for assessing occupational risk based on the materials of a special assessment of working conditions (SAWC), which includes [1, 5-6]:
- determination of the weighting coefficients of probability and damage of risk-forming factors using Fishburne formulas, ranking them on a five-level scale;
- compilation of a list of risk-forming factors of the influence of working conditions based on the materials of the SAWC;
- calculation of occupational risk in the workplace in accordance with the classes of working conditions;
- distribution of the results of the assessment of occupational risk by significance based on the ranking scale.

2 Materials and Methods

The main sources of information for the implementation of the procedure for assessing occupational risks in the workplace according to the proposed method are the materials and results of the SAWC, which are available in almost every organisation of any form of ownership [7].

Within the framework of this study, the calculation of occupational risk is carried out using a five-level scale, where each of the five levels is assigned an appropriate weighting factor. This evaluation system establishes a progressive increase in weight values depending on the level of possible negative consequences and the degree of probability of a dangerous event. Accordingly, the higher the value of the weighting factor, the greater the damage and the more likely the rate of occurrence of a dangerous event.

In the considered method of occupational risk assessment, it is proposed to use Fishburne formulas [1], which form a decreasing arithmetic progression and allow determining the weighting coefficients.

The weighting coefficients of the probability of occurrence of the risk-forming factor are determined by the first Fishburne formula (1)

$$B_{nm} = \frac{2(n-i+1)}{n(n+1)} \cdot \frac{1}{\bar{n}}, \text{ } i=1, n$$

For five levels (n = 1, 2, 3, 4, 5) estimates of the probability of occurrence of the risk-forming factor, the following values are obtained:

$$B_{1m} = \frac{2(5-1+1)}{5*6} = \frac{1}{3} = 0.33;$$
$$B_{2m} = \frac{2(5-2+1)}{5*6} = \frac{4}{15} = 0.27;$$
$$B_{3m} = \frac{2(5-3+1)}{5*6} = \frac{1}{5} = 0.2;$$
$$B_{4m} = \frac{2(5-4+1)}{5*6} = \frac{2}{15} = 0.13;$$
$$B_{5m} = \frac{2(5-5+1)}{5*6} = \frac{1}{15} = 0.07.$$
The weighting coefficients of damage from the risk-forming factor are determined by the second Fishburne formula (2)

\[ C_{im} = \frac{2^{m-k}}{2^{k}-1}, k=1, n \]  

For five levels \((i = 1, 2, 3, 4, 5)\) estimates of damage from the risk-forming factor, we obtain the following values:

\[ C_{1m} = \frac{2^{5-1}}{2^{5}-1} = \frac{16}{31} = 0.52; \]

\[ C_{2m} = \frac{2^{5-2}}{2^{5}-1} = \frac{8}{31} = 0.26; \]

\[ C_{3m} = \frac{2^{5-3}}{2^{5}-1} = \frac{4}{31} = 0.13; \]

\[ C_{4m} = \frac{2^{5-4}}{2^{5}-1} = \frac{2}{31} = 0.06; \]

\[ C_{5m} = \frac{2^{5-5}}{2^{5}-1} = \frac{1}{31} = 0.03. \]

The assessment of occupational risk based on the materials of the SAWC consists of the following stages [1, 8-9]:

1) Drawing up a list of risk-forming factors based on the materials of the SAWC, which represents harmful and dangerous factors of the production environment and the labour process (Table 1), each of which is assigned a letter code identifier with the prefix AWC (assessment of working conditions).

2) Determination of the \(P_{nm}\) value - the probability of occurrence of the n-th risk-forming factor, for each of the identified factors according to the proposed method (m), is performed according to the formula (3)

\[ P_{nm} = B_{nm} / \sum_{n=1}^{n} B_{nm} \]  

where \(B_{nm}\) is the weighting coefficient of the probability of occurrence of the risk-forming factor on a five-level scale, which is set according to Table 2.

3) Calculation of the occupational risk value for each of the identified risk-forming factors \(R_{nm}\), is determined by the formula (4)

\[ R_{nm} = P_{nm} * C_{im} \]  

where \(C_{im}\) is the weighting coefficient of damage from the risk-forming factor on a five-level scale, which is set according to Table 3.

4) Determination of the final value of the level of occupational risk based on the materials of the SAWC is carried out according to the formula (5)

\[ R_{SAWC} = \sum_{k=1}^{k=n} R_{nm} \]
Table 1. List of risk-forming factors based on the materials of the SAWC.

<table>
<thead>
<tr>
<th>Indicator of a risk-forming factor</th>
<th>Name and description of a risk-forming factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem-AWC</td>
<td>Chemical</td>
</tr>
<tr>
<td>B-AWC</td>
<td>Biological</td>
</tr>
<tr>
<td>APFC-AWC</td>
<td>Aerosols of predominantly fibrogenic action</td>
</tr>
<tr>
<td>N-AWC</td>
<td>Noise</td>
</tr>
<tr>
<td>INFRA-WC</td>
<td>Infrasound</td>
</tr>
<tr>
<td>ULTR-AWC</td>
<td>Air ultrasound</td>
</tr>
<tr>
<td>CV-AWC</td>
<td>Common vibration</td>
</tr>
<tr>
<td>LV-AWC</td>
<td>Local vibration</td>
</tr>
<tr>
<td>NOION-AWC</td>
<td>Non-ionising radiation</td>
</tr>
<tr>
<td>ION-AWC</td>
<td>Ionising radiation</td>
</tr>
<tr>
<td>MC-AWC</td>
<td>Microclimate parameters</td>
</tr>
<tr>
<td>LE-AWC</td>
<td>Parameters of light environment</td>
</tr>
<tr>
<td>SEV-AWC</td>
<td>Severity of labour process</td>
</tr>
<tr>
<td>INT-AWC</td>
<td>Intensity of labour process</td>
</tr>
</tbody>
</table>

Table 2. Weighting coefficients of the probability of occurrence of the risk-forming factor on a five-level scale.

<table>
<thead>
<tr>
<th>The probability of occurrence of a risk-forming factor</th>
<th>Weighting coefficient (Bnn)</th>
<th>Description of the probability of occurrence of the risk-forming factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low (VL)</td>
<td>0.07</td>
<td>Working conditions under which the altered functional state of the employee’s organism is restored during a regulated rest or by the beginning of the next working day (shift)</td>
</tr>
<tr>
<td>Low (L)</td>
<td>0.13</td>
<td>Working conditions under which the altered functional state of the employee’s organism is restored, as a rule, with a longer cessation of exposure to these factors than before the start of the next working day (shift), and the risk of health damage increases</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>0.2</td>
<td>Working conditions under which persistent functional changes occur in the employee's organism that occur after prolonged exposure (fifteen or more years)</td>
</tr>
<tr>
<td>High (H)</td>
<td>0.27</td>
<td>Working conditions under which persistent functional changes occur in the employee’s organism, leading to the appearance and development of occupational diseases of mild and moderate severity during the period of employment</td>
</tr>
<tr>
<td>Very high (VH)</td>
<td>0.33</td>
<td>Working conditions under which severe forms of occupational diseases appear and develop during the period of work</td>
</tr>
</tbody>
</table>

Table 3. Weighting coefficients of damage from the risk-forming factor on a five-level scale.

<table>
<thead>
<tr>
<th>Class of working conditions</th>
<th>Weighting coefficient (Cim)</th>
<th>Description of the damage from the risk-forming factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal and acceptable (1-2 class) (OA)</td>
<td>0.03</td>
<td>Exposure levels do not exceed the levels of hygienic standards (HS), a high level of efficiency is maintained, the organism recovers during rest or by the beginning of the next working day</td>
</tr>
</tbody>
</table>
Harmful, subclass 3.1 (B1) 0.06 Exposure levels exceed the levels of hygienic standards, the human organism requires a longer recovery and the risk of health damage increases

Harmful, subclass 3.2 (B2) 0.13 Exposure levels exceed the levels of hygienic standards, the development of initial forms of occupational diseases

Harmful, subclass 3.3 (B3) 0.26 The levels of exposure to harmful and hazardous production factors (HHPF) can cause persistent functional changes in the employee’s organism, the appearance and development of occupational diseases of mild and moderate severity

Harmful, subclass 3.4 (B4) 0.52 Levels of exposure to HHPF can lead to the appearance and development of severe forms of occupational diseases

The weighting coefficients of damage from the risk-forming factor presented in Table 3 are ranked on a five-level scale, adapted with the SAWC procedure and correlated with the classes of working conditions. The description of the damage from the risk-forming factor corresponds to the definition of classes of working conditions according to the Federal Law “On Special Assessment of Working Conditions” from December 28, 2013 No. 426-FZ [10-11].

The implementation of the proposed method makes it possible to determine the risks for each workplace, depending on the identified risk-forming factors and classes of working conditions.

3 Results

The final stage of the application of the method of assessing occupational risk based on the materials of the management system is the distribution of the results of the assessment of occupational risk by significance based on the ranking scale (Table 4) and the development of necessary measures to reduce the impact of risk. In accordance with the proposed ranking scale of occupational risk assessment results, the significance of the established occupational risk value for each of the identified hazards is determined, as well as in the workplace as a whole, taking into account the complex influence of risk-forming factors [12-13].

The assessment of occupational risk by the proposed method makes it possible to identify the most significant groups of risk-forming factors in terms of the impact of working conditions in the workplace. The obtained values are compared with the results ranking scale, the values of which correspond to the values of the five-level damage scale and range from very low to very high [2, 14]. Based on the calculations and assessments carried out, appropriate measures are being developed to reduce the impact of occupational risk in the workplace.

Table 4. Ranking scale of professional risk assessment results by significance and necessary measures to reduce the impact of risk.

<table>
<thead>
<tr>
<th>Range of risk values</th>
<th>0&lt;R≤0.03</th>
<th>0.03&lt;R≤0.06</th>
<th>0.06&lt;R≤0.13</th>
<th>0.13&lt;R≤0.26</th>
<th>0.26&lt;R≤0.52</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk significance</td>
<td>Insignificant</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Extreme</td>
</tr>
<tr>
<td>Measures to reduce the impact of risk</td>
<td>Representing a very small risk to human health and safety (no)</td>
<td>The overall risk and impact are low, but significant enough that</td>
<td>There is a significant risk and impact, meaning that measures must</td>
<td>The presence of potentially serious and dangerous risk-forming</td>
<td>Continuation of work in these conditions is unacceptable</td>
</tr>
</tbody>
</table>

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For clarity, color identifiers have been introduced on a five-level scale of risk significance:

- From 0 to 0.03 – light green;
- More than 0.03, but less than 0.06 – yellow;
- More than 0.06, but less than 0.13 – light orange;
- More than 0.13, but less than 0.26 – red;
- More than 0.26, but less than 0.52 – dark red.

Appropriate measures to reduce the impact of risk are proposed for each level of risk significance. In workplaces with a color identifier of red and dark red, it is necessary to carry out work to identify the most significant groups of hazards and develop a set of measures to reduce the level of occupational risk.

4 Discussion

The proposed method of occupational risk assessment allows establishing the numerical value of occupational risk at each workplace and identifying the most significant groups of risk-forming factors in terms of the impact of working conditions. The weighting coefficients of the probability of occurrence and damage from risk-forming factors are established according to the Fishburne formulas.

This approach to the assessment of occupational risk includes the compilation of a list of risk-forming factors based on the materials of the SAWC, with the assignment of a letter identifier. The weight coefficients of damage and probability are ranked according to a five-level scale, adapted with the SAWC procedure and correlated with the classes of working conditions. The description of the damage from the risk-forming factor corresponds to the definition of classes of working conditions according to the the Federal Law “On Special Assessment of Working Conditions” from December 28, 2013 No. 426-FZ. The developed scale of ranking the results of the assessment of occupational risk by significance allows comparing the values obtained and select appropriate measures to reduce the impact of occupational risk in the workplace.

5 Conclusions

The method of occupational risk assessment proposed in the article allows identifying the most significant groups of risk-forming factors influencing working conditions, to establish the numerical value of occupational risk at each workplace and, in accordance with the ranking scale of the results of occupational risk assessment, allows selecting appropriate measures to reduce the impact of working conditions at the workplace.

The practical significance of the proposed method of assessing occupational risks lies in its accessibility and the possibility of applying the results of a special assessment of working conditions, which are mandatory and characterise the actual state of working conditions at the enterprise [1-2, 7-8, 15].

This method is proposed for use in the procedure for assessing and managing professional risks at enterprises and organisations in various sectors of the economy.
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References

1. M. Kvitkina, S. Pushenko, E. Staseva, E3S Web of Conferences 363, 03031 (2022) DOI /10.1051/e3sconf/202236303031