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INTEGRATED METHOD OF OCCUPATIONAL RISK DEGREE ASSESSMENT AT THE ENTERPRISE

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The authors have developed an integrated method for occupational risk assessment at the enterprise, taking into account statistical data from 2008 to 2017. The analysis of occupational accidents has shown that occupational risk assessment should consider competence of workers, working conditions, accidents at production, not connected with the human factor. Matrix of harm and the severity of that harm is calculated for each accident factor. The essence of the method is that for each situation the specialist determines the rank of probability of its occurrence and the potential damage corresponding to this situation. According to this practice, risk can have three meanings: "unacceptable", "high" and "acceptable". The value of risk is determined as the intersection of the categories of employee competence, working conditions, accidents at work, not related to the human factor. Thus, an occupational risks assessment and management system is developed aimed at preserving life and health of employees, taking into account statistical data on accidents from 2008 to 2017. The results of the study allow us to conclude that the high level of competence of the employee in the field of labor protection can significantly reduce occupational injuries, despite the harmful working conditions and the high risk of an accident at work, which is not associated with the human factor.

Keywords: the complex method of assessment, professional risk, working environment.

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КОМПЛЕКСНЫЙ МЕТОД ОЦЕНКИ СТЕПЕНИ ПРОФЕССИОНАЛЬНЫХ РИСКОВ НА ПРЕДПРИЯТИИ

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Разработан комплексный метод оценки профессиональных рисков на предприятии с учетом статистических данных за период с 2008 по 2017 г. Анализ производственного травматизма показал, что при оценке профессиональных рисков следует учитывать компетентность работника, условия труда, аварийность на производстве, не связанную с человеческим фактором. Для каждой предпосылки к несчастному случаю рассчитаны матрицы ущерба и тяжести этого ущерба. Сущность метода заключается в том, что специалист для каждой ситуации определяет ранг вероятности ее наступления и соответствующий этой ситуации потенциальный ущерб. В соответствии с данной методикой риск может принимать три значения: «неприемлемый», «высокий» и «приемлемый». Значение риска определяется как пересечение категорий компетентности работника, условий труда, аварийности на производстве, не связанной с человеческим фактором. Таким образом, создана система оценки и управления профессиональными рисками, направленная на сохранение жизни и здоровья работников, с учетом статистических данных по несчастным случаям с 2008 по 2017 год. Результаты исследования позволяют сделать вывод о том, что высокий уровень компетентности работника в области охраны труда позволяет значительно снизить производственный травматизм, несмотря на вредные условия труда и высокий риск аварии на производстве, который не связан с человеческим фактором.

Ключевые слова: комплексный метод оценки, профессиональный риск, условия труда.

Introduction. In accordance with the regulatory and legal occupational safety documentation, since 2013 all enterprises of Russia have been assessing "occupational risk". "Occupational risk" is the probability of an accident (occupational disease) of an employee in the performance of duties under the employment contract. Risk is the probability of causing harm to health of an employee, the possibility of undesirable consequences, the measure of possible danger and the consequences of its realization (damage). The term "occupational risk" is used for the first time in the ILO recommendations "On health services in the enterprise" (1959).

According to GOST R 51898-02 risk is defined as the product of the probability of damage and the severity of the consequences of this damage:

$$R=P\cdot U. \quad (1)$$

In accordance with the occupational safety legal acts, the head of the enterprise is obliged to calculate the occupational risks for the staff.

Occupational risk is determined in order to establish the degree of danger of buildings, structures, equipment and technologies, to assess the state of occupational safety and to develop a system of preventive measures (organizational, technical) to reduce the level of occupational injuries. The author has developed a method for occupational risks assessment at the enterprise, taking into account statistical data from 2008 to 2017. The analysis of occupational injuries at enterprises from 2008 to 2017 showed that the most common types of accidents (A) are: impact of moving parts (29 %), deterioration of employee' health (21 %), accident (19 %), fall from a height (13 %).

Based on statistical data, the main reasons leading to the accidents were identified: non-compliance with occupational safety requirements — 57 %; deterioration of health of a worker (which is associated with harmful working conditions at the enterprise, with violations in the use of PPE and ignoring medical examinations) — 21 %; accidents at work (risk of injury taking into account products and structures used) — 22 %. According to statistics, workers between 18 and 25 years of age and over 45 years of age are the most likely to be injured. At the same time, 42% of accidents occurred in the period from 8 to 10 am. Taking into account the statistics of accidents from 2008 to 2017, it is possible to determine the main criteria for occupational risks assessment.

Main part. The analysis of occupational injuries showed that occupational risk assessment should take into account:

- competence of an employee;
- working conditions;
- accidents at work, not related to the human factor (violation of stability, breakage, unpredictable change in the internal state of potentially dangerous substances).

For a comprehensive assessment of occupational risks for each precondition for accidents or occupational disease (OD), we calculate the matrix of the occurrence probability of danger and severity of consequences.

The essence of the proposed method for determining the predicted occupational risks assessment using the materials of a special assessment of working conditions is that a labor protection service specialist for each situation determines the rank of the probability of occurrence of an accident or OD (low probability, medium probability, high probability) and the potential damage corresponding to this situation (small, medium, great).

To assess the degree of compliance of SAWC with the regulatory requirements and the degree of influence on the human body of harmful and dangerous factors of working conditions, we use a system of special points:

1 — optimal working conditions (class 1);

4 — permissible working conditions (class 2);

8 — not quite favourable working conditions (class 3.1);

12 — adverse working conditions (class 3.2));

15 — very poor working conditions (class 3.3);

20 — extreme, critical working conditions (class 3.4).

The higher the score, the greater the dangerous and harmful effects on the human body (non-compliance of working conditions with regulatory requirements). The results of a special assessment of working conditions are used to assess the negative impact of the working environment. The class of working conditions is determined in accordance with the Federal law No. 426 of December 28, 2013. The score corresponds to the degree value of the conditions status *R1*.

The work does not take into account manager competence, because the result of his organizational work directly affects personnel training.

According to GOST 12.0.230-2007, "competent person is a person with the necessary training and sufficient knowledge, skills and abilities to perform a specific job".

Table 1

Levels of probability of accident occurrence at different competence levels of an employee

Probability level	Probability	Number of accidents
1	Very low, 10^{-4}	0–2 for the whole period of research
2	Low, $5 \cdot 10^{-4}$	Once in 5 years
3	Medium, $2{,}7 \cdot 10^{-3}$	Once a year
4	High, $5{,}4 \cdot 10^{-3}$	Twice a year
5	Very high, $3 \cdot 10^{-2}$	Once a month

Table 2

Degree of consequences severity at different competence levels of an employee

Severity of consequences	Damage	Condition of the employee
1	Very low	pain without consequences for health
2	Low	deterioration of health with treatment in the emergency room (absence at work 3 days)
3	Medium	accident with mild health damage (absence at work less than 30 days)
4	High	accident with severe health damage (absence at work for more than 30 days)
5	Very high	fatal accident

The conditional value of risk is determined at the intersection of the corresponding column and row. In this case, the amount of risk can be represented in quantitative terms. Matrix values are chosen in accordance with statistical data on accidents in the workplace.

Table 3

Degree of risk R2 due to the incompetence of an employee

	Probability level					
Degree of harm	1	2	3	4	5	6
	2	1	2	3	4	5
	3	2	4	6	8	10
	4	3	6	9	12	15
	5	4	8	12	16	20
	6	5	10	15	20	25

Competence levels can be defined as follows:

- competent (risk level 1-5) - the employee is able to perform work independently in compliance with the occupational safety requirements;

- incompetent (risk 6-10) — the employee has some competencies, poor talent to perform his work in compliance with the occupational safety requirements. The employee requires control. Incompetent employees include employees who do not have practical experience with particularly dangerous works, regardless of the level of theoretical knowledge of the occupational safety requirements, as there is no skills of safe performance of works. These employees need training;

- incompetent (risk level 12-24) — the employee is not able to independently perform work in compliance with the occupational safety requirements; unconsciously violates the occupational safety requirements. The employee is not allowed to work. Additional training is required for the worker to comply with safety measures in the workplace. It is necessary to work out first aid practical actions of personnel, evacuation in case of an accident, methods of accident localization;

- dangerously incompetent — the employee is not able to independently identify, assess and manage risks in the performance of work; deliberately violates the occupational safety requirements, regulating work that is associated with high risk. Dangerously incompetent worker is not allowed to work.

In assessing competence safety engineer must take into account:

- possible risks of violations of the occupational safety requirements due to insufficient knowledge, skills, abilities;

- actual risks caused by: violations of the requirements of industrial and occupational safety; intentional violations of safety requirements, which are associated with negligence, irresponsibility of an employee and non-observance of labor discipline; work experience.

All the above-mentioned possible and actual risks (preconditions of emergency or accident) should be taken into account to assess the competence of an employee. This will give full information about the readiness of personnel to perform work in the workplace.

Calculation of accident rate at the production (stability violations, breakdowns, unpredictable changes in the internal state of potentially hazardous substances) is carried out taking into account the characteristics of structures, time and operating conditions.

Table 4

Levels of probability of an accident at work for reasons that do not depend on an employee

Probability level	Probability	Number of accidents
1	Very low, 10^{-4}	0–2 for the whole period of research
2	Low, $5 \cdot 10^{-4}$	Once in 5 years
3	Medium, $2{,}7 \cdot 10^{-3}$	Once a year
4	High, $5{,}4 \cdot 10^{-3}$	Twice a year
5	Very high, $3 \cdot 10^{-2}$	Once a month

Table 5

Severity of accident consequences in production for reasons that do not depend on an employee

Severity of consequences	Damage	Condition of the employee
1	Very low	pain without consequences for health
2	Low	deterioration of health with treatment in the emergency room (absence at work 3 days)
3	Medium	accident with mild health damage (absence at work less than 30 days)
4	High	accident with severe health damage (absence at work for more than 30 days)
5	Very high	fatal accident

Table 6

R3 risk level due to the production environment

	Probability level					
Degree of harm	1	2	3	4	5	6
	2	1	2	3	4	5
	3	2	4	6	8	10
	4	3	6	9	12	15
	5	4	8	12	16	20
	6	5	10	15	20	25

The values of the matrix are selected according to the statistical data of industrial accidents.

Risk assessment:

1. from 1 to 5 (low). The low degree of risks indicates the effective work of the company's management in the field of occupational safety;

2. from 6 to 10 (average). With the degree of risk from 6 to 10 a plan of measures should be developed to eliminate and minimize risks, indicating the timing of elimination of deficiencies and responsible persons;

3. from 12 to 25 — the degree of risk is high. With the degree of risks from 12 to 25, measures to reduce risks are taken slowly;

4. 25 — the risk is very high. With a degree of 25, an enterprise shutdown is required.

The author has developed the following matrix model of integrated assessment of occupational risk degree.

Table 7

Matrix of risk degree taking into account incompetent actions of personnel
and the fact of an accident at work (which is not related to the human factor)

	Риск некомпетентных действий персонала			
Risk of accident at work		Low risk	Medium risk	High risk
	Low risk			
	Medium risk			
	High risk			

Table 8

Matrix of risk degree taking into account incompetent actions of personnel and working conditions at the enterprise

	Risk of incompetent actions of personnel			
Risk, taking into account working conditions		Low risk	Medium risk	High risk
	optimal working conditions (class 1)			
	acceptable working conditions (class 2)			
	not quite favorable working conditions (class 3.1)			
	adverse working conditions (class 3.2)			
	very poor working conditions (class 3.3)			
	critical working conditions (class 3.4)			

Table 9

Matrix of risk degree taking into account working conditions and the fact of an accident at work (which is not related to the human factor)

	Risk of accident at work			
Risk, taking into account working conditions		Low risk	Medium risk	High risk
	optimal working conditions (class 1)			
	acceptable working conditions (class 2)			
	not quite favorable working conditions (class 3.1)			
	adverse working conditions (class 3.2)			
	very poor working conditions (class 3.3)			
	critical working conditions (class 3.4)			

A graphical representation of risk degree as a whole is shown in Fig. 1.

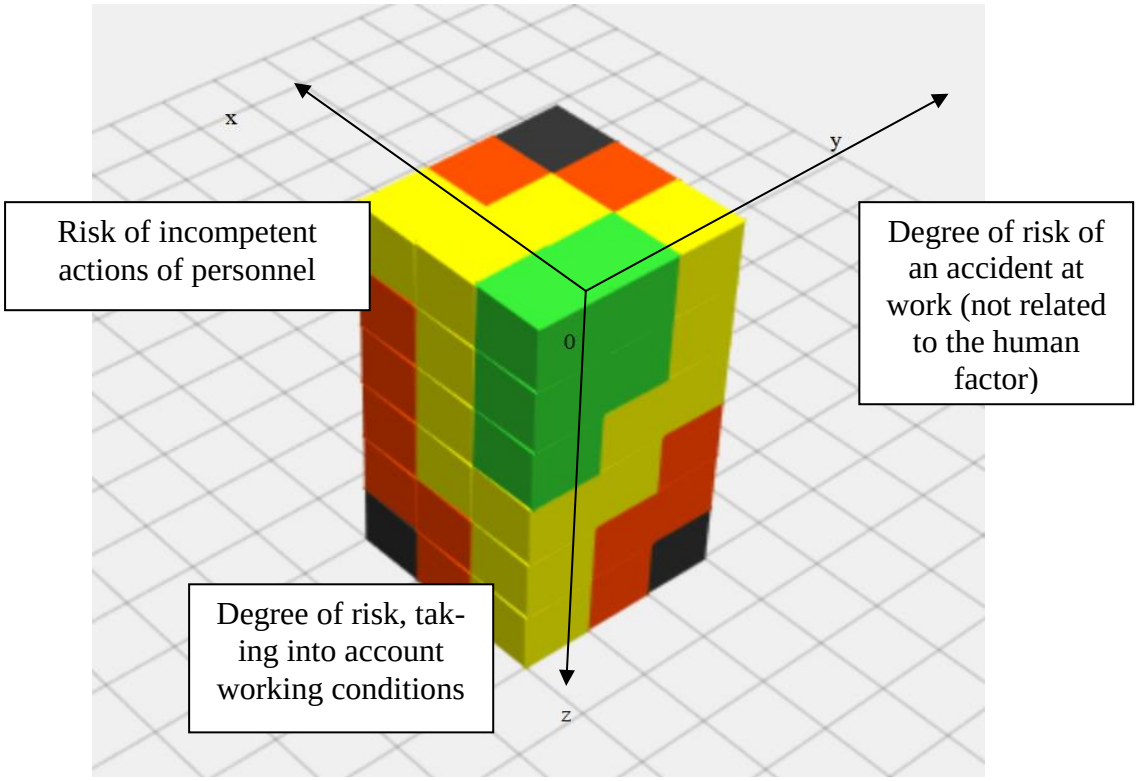

Fig. 1. Matrix model of integrated assessment of occupational risks

In accordance with the methodology, an integrated risk assessment can take the following values: "acceptable", "medium", "high" and "dangerous".

The value of risk degree is determined as the intersection of the categories of competence of an employee, working conditions, accidents at work (not related to the human factor).

The intersection point determines the degree of risk:

- green zone, the degree of risk is "acceptable", the work can be started with compliance with the existing safety requirements;
- orange zone, the risk level is "medium", the work can be started after the written approval of the manager;
- red zone, the degree of risk is "high", urgent organizational and technical measures in the field of occupational safety are required. The work cannot be started due to the high probability of occurrence of emergencies or accidents;
- black zone, the degree of risk is "dangerous". Production must be suspended.

The engineer finds the values from the matrices shown in tables 7-9. Further, based on the values found, a decision is taken on the admission of workers to production and measures are taken to reduce accident risks.

The author has formulated an integrated assessment of risk degree caused by occupational risk taking into account working conditions, competence of the worker and accident rate at production. Further there is a statistical model of the degree of risk.

Main causes that lead to emergencies and accidents from 2008 to 2017 were identified: failure to comply with the occupational safety requirements, incompetence of staff — 57 %; deterioration of health of an employee (due to hazardous working conditions at the company, with violations in the use of PPE and disregard to medical examinations) — 21 %; accidents at work (risk of injury taking into account the applied products and structures) — 22 %.

$$Rриск=Кут \cdot R1 + Кнд \cdot R2 + Кпс \cdot R3, \quad (2)$$

where $Кут=0.2$ — risk coefficient of working conditions;

$Кнд=0.6$ — risk coefficient of incompetent actions;

$Кпс=0.2$ — risk coefficient of accident at work;

$R1$ — occupational risk taking into account working conditions;

$R2$ — occupational risk taking into account an employee competence;

$R3$ — risk of an accident at work (disturbance of stability, breakage, unpredictable change in the internal state of potentially hazardous substances).

On the assessment scale of significance of risks the significance of risk is assessed (Table. 10), according to GOST R 12.0.010–2009. "Occupational safety standards system (SSBT). Occupational health and safety management systems".

Table 10

Risk values

Risk value interval	$0 < R \leq 5$	$5 < R \leq 10$	$10 < R \leq 15$
Risk importance	Low	Moderate	High

Hazard identification and risk assessment is carried out according to the *R*risk value.

Conclusion. An integrated method of occupational risk degree assessment is characterized by the simplicity of use, allows the safety engineer in the shortest possible time taking into account statistical data to make occupational risk assessment, thereby to reveal the most vulnerable links of production process. The disadvantage of this method is its absolute subjectivity.

In particular, statistics on industrial accidents is needed. To predict accidents at work associated with the violation of stability, breakdowns, unpredictable changes in the internal state of potentially hazardous substances, the safety engineer should take into account the operating conditions, the warranty period of work (MTBF), assess the state of technical devices of buildings and structures (taking into account their design features), restoration work. Next, it is necessary to identify accidents preconditions and consequences, make proposals to the head of the company on the creation of a system of protection from the accident and its localization.

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