IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388, p- ISSN: 2320-737x Volume 10, Issue 5 Ser. I (Sep. – Oct. 2020), PP 33-38
www.iosrjournals.org

Determination Of The Potential Danger In The Working Zone Of The Railway Workers On The Basis Of The Integral Index

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Abstract.*The article deals with the principles, methods and criteria for risk assessment to create controlled conditions that minimize the possible consequences of the impact of harmful and dangerous factors of the production environment and the labor process of railway workers. The unified approach to calculation of industrial risk on the basis of dependence on parameters of working environment and taking into account time of stay of workers in an area of influence of dangerous factors is offered.*

Keywords: *transport, occupational risk, industrial risk, hazardous factor, hazardous factor, occupational safety and health, occupational safety, hygiene standard.*

Date of Submission: 02-09-2020 Date of Acceptance: 18-09-2020

I. Introduction

The ILO's Global Fatal Accident Assessment shows that more than 300,000 people die in the workplace each year [1]. The World Congress on Occupational Safety and Health notes that annual mortality from "work-related diseases" in the world is 2.2 million people. In 15 EU countries they account for 120 000 deaths, which is 20 times more than the number of accidents at work [2]. Therefore, the term "work-related illnesses" is broader than "occupational illnesses" and includes all illnesses caused by work-related activities.

As a result of systematic influence of harmful production factors of different nature in the process of work the body is inflicted hidden damage, awareness of which comes when there are clear signs of disease, and when it is no longer possible to correct the situation by preventive measures. Therefore, the ILO's global strategy "Decent Work must be safe" made it possible to formulate a conceptual provision on occupational safety: "A productive activity in which an individual is exposed to excessive risks cannot be justified, even if it is beneficial to society as a whole" [3].

By declaring its intention to join the European Union, Ukraine has committed itself to bringing national legislation into line with EU legislation. In the process of integration into the world community, the development and implementation of the main provisions of harmonization of principles, methods and criteria of health risk assessment for workers in working conditions in accordance with international approaches is a necessary condition for ensuring socio-economic development of the state [4].

To form a new security concept in organizational and technical systems, the Weber-Fechner law can be chosen as a theoretical basis [5].

The purpose of the research is to develop methodological support to determine the level of danger of workers in the working zone under the condition of taking into account the joint action of harmful factors of different classes on the basis of the integral indicator - industrial risk.

II. Research Results

ДСТУ ISO 31000:2018 defines risk assessment as a process consisting of three stages: risk identification, risk analysis and risk assessment [6]. Risk identification is a process used to search, recognize and describe risks that may affect the achievement of objectives. Risk analysis is a process that is used to understand the nature, sources and causes of identified risks and to assess the level of risk. It is also used to study the impacts and their consequences, as well as to examine the currently existing controls [4]. It is known that the system "man - machine - environment" is an object of hazard analysis, which brings together people, technical objects, environment, interacting with each other. But imperfect regulatory, organizational and technical methods of risk management do not allow today to reach such levels of risks, which correspond to the level of economically developed states [7].

In statistics, variables are probabilities. The distribution of probabilities is considered to be the "true position" of the system that meets certain criteria of optimality and stands out from the multitude of possible ones. The form of theoretical risk expression is a statistical indicator, which is reduced to the probability of an undesirable event. The probability of such an event, some evaluation of the expected harm are combined into a single indicator, and therefore a set of probabilities of risk and harm or reward is combined.

In statistical theory of decision making, the risk function of evaluation *δ(x)* as a parameter *θ*, which is calculated at some observed parameters *x*, is defined as the mathematical expectation of the loss function $L(\theta, \delta(x))$:

$$R(\theta) = \int L(\theta, \delta(x)) \cdot f(x \mid \theta) dx, \quad (1)$$

where $L(\theta, \delta(x))$ – loss function from valuation parameter *θ* and evaluation value *δ(x)*;
$f(x \mid \theta)$ – the odds of an adverse event.

Estimates of risk in the working area under the influence of environmental factors are made with the assumption that the level of contamination is known [8]. This means that the pollution event has already occurred, *P = 1*.

In the case of air pollution in general, there is a certain fusion-national relationship between the level of pollution, perception and risk, in accordance with Weber-Fechner law:

$$r = 1/k \cdot \lg C/C_0 , \quad (3)$$

where *r* – the level of risk;
C – the concentration of airborne pollution, mg/m^3;
k – the factor of proportionality;
C_0– the lowest concentration, where the effect is felt.

Based on the normative indicators to be determined experimentally for each individual substance, it is realistic to establish two fixed points of dependence (3). If the replacement is made from *1/k* to *λ* for ease of change, then the equation will take the following form:
ГДК (permissible exposure limit)
ЛК (lethal concentration)

$$\begin{cases} 1 \cdot 10^{-6} = \lambda \cdot \lg \text{ГДК}_{\text{СД}} / \text{C}_0 \\ 0,5 = \lambda \cdot \lg \text{ЛК}_{50} / \text{C}_0 \\ \text{r} = \lambda \cdot \lg C/C_0 . \end{cases} \quad (4)$$

System of equation solution (4) to determine contaminant concentrations, exceeding ГДК$_{\text{сд}}$, as a result, it will have the following appearance:

$$r = (0{,}5 - 1 \cdot 10^{-6}) / [\lg(ЛК_{50} / ГДК_{СД})] \cdot \lg(\text{C}/\text{ГДК}_{\text{СД}}) + 1 \cdot 10^{-6}. \quad (5)$$

By analogy, we can determine the risk dependencies for noise levels, ionizing radiation and electromagnetic oscillations, and calculate the potential risk with the simultaneous action of heterogeneous factors (Table 1).

Table 1 –The calculation of the potential risk under the influence of heterogeneous factors
ГДК (permissible exposure limit)
ГДР (alarm level)
ЛК (lethal concentration)
ГДЕЕ (maximum permissible energy load)

quality environment parameters	*Units of measurement*	*Acceptable level standard*	*Harmful level*	*Formula to calculate the risk*
Chemical substances	mg/m^3	ГДК$_{\text{сд}}$, depends on the substance	ЛК$_{50}$	$r = 10^{-6} + b \cdot \lg \frac{C}{ГДК}$

Noise	dBA	ГДР	130 dBA	$r = 10^{-6} + 0{,}038 \cdot \lg \frac{I}{I_0}$
Ionizing radiation	m3 per year^{-1}	Dose limit ГДР=20	>50	$r = 10^{-6} + 0{,}358 \cdot \lg \frac{D_E}{ГДР}$
Electromagnetic fluctuation	W/m^2	ГДЕЕ, depends on frequency	>500	$r = 10^{-6} + k \cdot lg \frac{E}{ГДЕЕ}$

The main action in hazard assessment is transformation of information about any property of environment parameters into risk indicators. At this stage, there may be a difficulty associated with the fact that previous studies of the nature of exposure to harmful substances and other factors were conducted without regard to their mutual influence. Therefore, the decision on transformation of the "dose-effect" will be made on the basis of available experimental data (Table 1). Thus, the specified transformation can be carried out concerning each elementary property, and the next stage will be an erection of separate indicators to a single criterion of quality of the system as a whole.

The total risk calculation will be carried out in this sequence in the future. First of all, the values of the annual risk value for each factor $\boldsymbol{r_i}$ are calculated, and then the integral risk value is calculated:

$$R = 1 - \prod_{1=1}^{n} (1 - r_i), \tag{6}$$

The above shows that a unified approach to the calculation of parameters of the working zone has been obtained, which also does not require the introduction of multiple scales to characterize the quality of the environment. The resulting dependencies when used to certify jobs will greatly facilitate the assessment of factors in the production environment and the work process. Taking into account the mutual influence of factors, it is possible to determine the priority of labor protection measures, taking into account the level of production and occupational risks, to clarify recommendations for improving working conditions.

To take into account the probability of the worker being in the coverage area ***i*** the probability of a hazard can be determined ***i*** dangerous factor in the working area according to the following formula:

$$P_{v_i} = P_i^v \cdot P_i^p, \tag{7}$$

where P_i^v – the probability of action dangerous factor of ***i***;
P_i^p – the odds of an employee working in the area dangerous factor of ***i***.

Then we determine the probability of action dangerous factor of ***i*** and probability of finding the worker in the area of it`s action according to the formulas:

$$P_i^v = t_i^v / T_{CM} \;\text{ i }\; P_i^p = t_i^p / T_{CM}\,, \tag{8}$$

where t_i^v – the action time ***i*** dangerous factor;
t_i^p – the time of presence of the employee in the coverage area dangerous factor of ***i***;
T_{CM} – the stay period of the change.

The obtained expressions can be substituted by the formula (7), as a result, we have a probability of action ***i*** dangerous factor on the worker:

$$P_{v_i} = \frac{1}{T_{CM}^2} \left(t_i^v \cdot t_i^p \right). \tag{9}$$

In the case where there are simultaneously 2, 3, … ***n*** harmful factors, the probability of their action can be determined as follows:

$$P_v(2) = P_{v_2} + P_{v_1} - P_{v_2} \cdot P_{v_1}$$
$$P_v(3) = P_{v_3} + P_{v_2} - P_{v_3} \cdot P_{v_2} \quad . \tag{10}$$
$$P_v(n) = P_{v_n} + P_{v_{n-1}} - P_{v_n} \cdot P_{v_{n-1}}$$

If the probability of influence of harmful factors on the workers is known, the further determination of harmfulness of the production process as a whole will take place as follows:

$$P_{nn}^0 = \frac{N_1 P_0(1) + N_2 P_0(2) + \ldots + N_n P_0(n)}{N}, \tag{11}$$

where N_1, N_2, … N_n – the number of workers who are affected 1, 2, 3, … ***n*** harmful factors;
$P_0(1)$, $P_0(2)$, ... $P_0(n)$ – the employability 1, 2, 3, … ***n*** harmful factors;
N – the total employment.

The probability of action is then determined ***j*** dangerous factor by formula:

$$P_{b_j} = P_j^b \cdot P_j^p \cdot P_j^{nc}, \tag{12}$$

де P_j^b – the odds of being in the work area ***j*** hazardous factor (substance);
P_j^p– the odds of human presence in the area ***j*** hazardous factor (substance);
P_j^{nc}– the astonishing impact ***j*** hazardous factor (substance).

As noted above, the probability of having a working area ***j*** hazardous factor (or substance) and the probability of finding a person in the area of this factor is determined by the formula (8). And the astounding ability ***j*** hazardous factor (substance) is defined as:

$$P_j^{nc} = \frac{d_j}{D_j}, \tag{13}$$

d_j – the actual level (content) of the dangerous factor ***j*** (substance);
D_j – the limit level (content) of the dangerous factor ***j*** (substance).
As it is known, borderline level (content) *j* hazardous factor (substance) – is the level at which workers must be quickly evacuated from the danger zone.
If you put the formula (12) for P_j^b, P_j^p і P_j^{nc}, then the formula will have the following form:

$$P_{b_j} = \frac{t_j^b \cdot t_j^p \cdot d_j}{T_{CM}^2 \cdot D_j}. \tag{14}$$

Total probability of harmful impact ***m*** factors is determined by the formula:

$$P_b(m) = 1 - \prod_{j=1}^{m} \left(1 - P_{b_j}\right). \tag{15}$$

On the basis of the algorithm of transformation of the environmental parameters into an indicator of an industrial risk, the map analysis of working conditions was carried out according to the results of the certification of the jobs of the regional railway branch of the Southern Railway PJSC Ukrainian Railway. The data obtained is shown in Table 2.

ГДК (permissible exposure limit)
ГДР (alarm level)

Table 2 – The calculation of the evaluation of the working area parameters

No.	*Workplace, profession, workshop (section, department)*	*Class of working conditions*	*Factors of production environment and working process*	*Standard value (ГДК), (ГДР)*	*Actual value*	*Potential risk, r_i,*	*Integral risk, R*
1	2	3	4	5	6	7	8
1	Electric gas cooker, mechanical workshops (premises)	3.1	Hazardous chemicals, (Manganese)	0,2	0,31	0,02164	0,204081
			Dust of fibrogenic action (iron oxide)	6	6,5	0,004434	
			Infrared radiation, W/m^2	до 140	223	0,182853	
2	Electric gas cooker, mechanical workshops (out- of-doors)	3.1	Hazardous chemicals, manganese	0,2	0,33	0,024727	0,223607
			Dust of fibrogenic action (iron oxide)	6	6,3	0,002703	
			Infrared radiation, W/m^2	до 140	234	0,201765	
3	Machinist of fixed rail car 1A mechanical workshops	3.2	Noise, dBA	80	83	0,000609	0,000609
4	Blacksmith of manual forging, workshop of mechanical workshops, forge	3.3	Noise, dBA	75	92	0,003373	0,326984
			Infrared radiation, W/m^2	till 140	320	0,324706	
5	Tractor driver, mechanical workshops	3.2	Dust of fibrogenic action	4	4,3	0,003834	0,005402
			Noise, dBA	80	88	0,001574	
6	Machinist of the railway construction machine, mechanical workshops	3.2	Noise, dBA	80	85	0,001001	0,001001

The conducted assessment of working conditions shows that workplaces № 1, № 2, № 4 belong to 3.1 class according to [9], but the integral risk indicators according to [6] are excessive. Workplaces № 3, № 5, № 6 belong to 3.2 class, where the calculations of integral risk indicators are 10^{-4}, 10^{-3} і 10^{-3} respectively, that is, the maximum permissible and higher [6]. So, we have a proven subjectivity to evaluate the actual conditions and the nature of work according to [9]. Integral risk indicators testify to the contradiction of Ukrainian legislation with the world health and safety standards to create controlled conditions that minimize the potential consequences of harmful and hazardous factors in the production environment and the working process [4].

III. Conclusions

Methodological support, that has been proposed to determine the level of potential danger in the working zone of railway workers, takes into account the joint action of harmful factors of different classes on the basis of an integral index. This approach solves the issue of improving the medical and hygienic monitoring system. The introduction of the integrated harm indicator will allow for an objective assessment of the quantitative damage to human health caused by harmful and hazardous factors in the production environment.

References

[1]. Linn H.I., Amendola A.A. Occupational Safety Research: Overview. Encyclopedia of Occupational Safety and Health. International Labor Organization. Geneva, 2005. URL: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_116863.pdf (last access: 7.08.2020).

[2]. ILO Introductory Report: Decent Work - Safe Work. Geneva, International Labor Office, 2006. 56 p.

[3]. Статут (Конституція) Всесвітньої організації охорони здоров'я. [Чинний від 1946-07-22]. URL:https://zakon.rada.gov.ua/laws/show/995_599 (дата звернення 3.08.2020).

[4]. ISO 45001 Системи менеджменту охорони здоров'я і безпеки праці. Вимоги з застосування. URL: https://www.iso.org/standard/63787.html (дата звернення 3.08.2020).

[5]. Руденко, С.В., Гогунский В.Д. Оценка экологической безопасности в проектах: монографія. Одесса : Феникс, 2006. 144 с.

[6]. ДСТУ ISO 31000:2018 Менеджмент ризиків. Принципи та настанови (ISO 31000:2018, IDT) [Чинний від 2019-01-01] URL: http://online.budstandart.com/ua/catalog/doc-page.html?id_doc=80322 (дата звернення: 16.08.2020).)

[7]. Van Westen C.J. Methods for risk assessment. ACP-EU Natural Disaster Risk Reduction Program : веб-сайт. URL: http://www.charim.net/methodology/55 (last access: 16.08.2020).

[8]. ДСТУ ISO 14001:2006. Системи екологічного керування. Вимоги та настанови щодо застосування (ISO 14001:2004, IDT). [Чинний від 2016-07-01]. Київ, 2006. 17 с. (Держспоживстандарт України).

[9]. Про затвердження Державних санітарних норм та правил «Гігієнічна класифікація праці за показниками шкідливості та небезпечності факторів виробничого середовища, важкості та напруженості трудового процесу» / Наказ МОЗ України № 248 від 08 квіт. 2014 р. URL: https://zakon2.rada.gov.ua/laws/show/z0472-14 (дата звернення 03.08.2020).