TEKA. COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE – 2013, Vol. 13, No.4, 280-287

The ways of improving performance of industrial risk and working conditions

Dmytro Vyshnevskyy, Nikolay Kasyanov, Viktor Medianyk

Volodymyr Dahl East-Ukrainian National University,
Molodizhny bl., 20a, Lugansk, 91034, Ukraine, e-mail: ot_snu@ukr.net

Received September 20.2013: accepted October 14.2013

S u m m a r y .The article reviews the main features of the existing methods for assessing occupational risk and issues with their improvement.

K e y w o r d s . working conditions, injury, occupational diseases, indicators of industrial risk, harmful and dangerous production factors (HDPF).

INTRODUCTION

Academician-Secretary of Economical department in NAS of Ukraine V. Heyets in his report "Prediction of scientific, technological and innovational development: the state program of Ukraine and the world experience" (2006) at the XXI Kyiv International Symposium on Science and the scientific and technological forecasting, defining the picture of the day on the economy of our country in terms of technological level, said that the third and the fourth technological modes are now dominant in Ukraine, and the leader countries develop the fifth and the sixth ones, and stated that the facts are retarded by two technological modes [9]. Speaking of technological perspective in comparison with developed countries, the creation of one post in the field of high-tech economy is 100 thousand dollars currently. To accelerate the transition to the innovative economical background that will be competitive, we must multiply this amount by million potential workers, that results in a multibillion dollar amount Ukraine doesn't dispose of, so this is inappropriate. And to ensure the economical growth it is possible to use both: the actual domestic resources and the ones coming from abroad.

Concerning forging production (FP) the usage of obsolete and worn-out equipment should be considered as a necessity, but not to the detriment of security staff, accuracy, product quality and competitiveness. The results of studies carried out in developed countries show the relevance of the problems associated with impact on harmful and dangerous production factors (HDPF). And engineering production focuses on rolling, forging and pressing shops, including issues like the effects and preventive measures against the negative influence of noise [31,28,32,8,20], increased by smoking [24,18], dust [15,29,7,16] local high temperature thermal radiation directly and in combination with work intensity and stress [5,1,4]. To do this, the International Labour Organization in 1999 introduced in the Directive or the so-called "technical and hygienic management of hygienic monitoring employees» ILO OSH № 72 [12], which requirements must be performed in the study of the negative impact of poor conditions.

So nowadays the issues of creating safe working conditions for people with limited economic opportunities become topical. Therefore, the continuous improvement of safety management system (SMS), as required by European standards [21, 22], from the point of view of prevention occupational injuries and diseases can provide such decisions made that would already lead to significant social impact. This willl happen when the development of safety measures are based on the use of quantitative risk indicators of workers' health with the specifications such as technology, equipment, building and planning solutions to industrial districts and objective human capabilities etc. At present a qualitative transition minds of ordinary workers and employees to accept existing for more than 20 years thesis in developed countries, that absolute security does not exist [2,17,34], is required. Therefore, improvement of SMS based on social-hygienic monitoring and evaluating production risk in enterprises, will help not only to establish parameters HDPF in job evaluation, but also to make prediction and prevention measures based on health occupational diseases and injuries.

It is necessary to note the major contribution to improving the methodology of production risk by scholars, such as V.Vlasov, S.Belov, G.Hohitashvili, M. Izmyerov, V.Minko, G.Faynburg, G.Suvorov, K.Tkachuk, P.Pashkovskyi, O.Zaporozhets, V.Sevrikov, Y.Bulgakov, A.Belikov, V.Kuzin, V.Holinko, O.Izmailova, M.Dulyasova, O.Golyshev, A.Fomochkin, I.Panfyerova, O.Kruzhylko, O.Revuk, Y.Glebova, O.Levchenko and others.

OBJECTS AND PROBLEMS

The analysis indicates the need to improve existing methods for assessing working conditions and production risk, including and forging shops that have the worst HDPF in the engineering industry.

Materials and findings. Impact on people in a production environment HDPF always represents a risk. The current concept of production risk is a common belief system and theoretical propositions about the possible diversion of health as a consequence of it's influence. Despite the differences in the approaches and methods of evaluation, taking into account the specific features of traumatic risk occupations aimed at assessing human health due to the recommendations [20,22], it should be simultaneously in three areas (Fig. 1).

At that they are linked, and their joint implementation aloows to find a definition of risk hazard class conditions (2–valid, 3.1–3.4–bad, 4–dangerous) for their health "Public health standards microclimate production facilities" PHS 3.3.6.042-99 [26] and "safety classification of work in terms of environmental hazard and danger of environmental factors, severity and intensity of the work process" EH 3.3.5-8.6.6.1 -2002 [10], through an assessment of the working conditions and health workers. In the first area of risk assessment the data, obtained as a result of job evaluation as well as special studies of HDPF and conditions, is used.

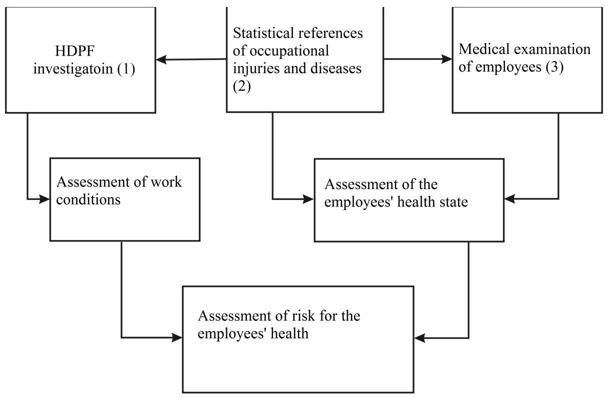

Fig. 1. Production risk assessment scheme

However, this method of assessing production risk loses its relevance due to the fact that the European standards [21,22] indicate its definition as a possible loss.

Over the past 15 years in Russia, compared to Ukraine, much more research has been done, that formed the basis of a number of regulations relating to various aspects of the production risk. And the approach mentioned in [13] allows a graphical method (Fig. 2) for determination of the occupational diseases risk depending on length of service of the employee, that is rediscovering probation areas risk. Using this method Cr (category of risk) for diagnosed cases of occupational diseases and Cs (category of severity) in April are determined via Table. 1 and 2.

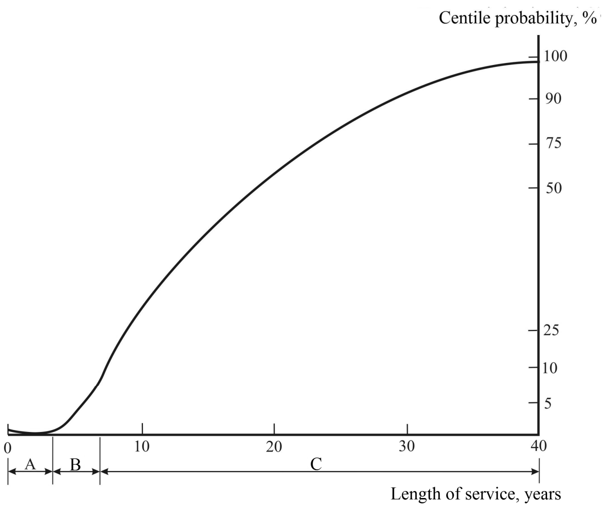

Fig. 2. Graphical interpretation of probation areas of occupational diseases (possible cases in %), where the zones: A – Safe, B – terminal, C – dangerous

Table 1. Category of risk for diagnosed cases of occupational diseases and their characteristic features

Category Cr	Probability, %	
	Diagnosed cases of occupational diseases	Diagnosed cases of early symptoms
1	>10	>30
2	1-10	3-30
3	<1	<3

Table 2. Category of severity for occupational diseases

Categor Cs	Category of severity based on medical prognosis and eventual forms of disability.
1	Disability that progresses even without further exposure and causes a change of profession
2	Permanent incapacity for work or need to change the profession
3	Constant moderate disability
4	Heavy temporary disability or sick leave for more than 3 weeks
5	Moderate disability or sick less than 3 weeks

Defined in the tables 1 and 2, the value of Cr and Cs allow you to deduce suggested in [13] the so-called single numerical indicator of risk:

$$i_{ir} = \frac{1}{Cr \cdot Cs}, \qquad (1)$$

which takes into account the probabilistic measure of risk along with the severity of occupational disease. And reciprocal value of the product $Cr \cdot Cs$ can qualitatively and quantitatively evaluate its features as an integrated parameter that varies for one disease ranging from 0 to 1, i.e. 0 < iir <1. Table 3 shows the interrelation between classes of working conditions in [11] with the same numerical measure of risk iir where "MTD level" stands for the level of morbidity with temporary disability and ΔT indicates a change in biological age relative to passport.

Table 3. Performance of occupational risk assessment

Hygienic assessment of working conditions according to D 2.2.755-99 (D 2.2.2006-05)	Medical and biological indicators		
	Indicator iir	MTD level	ΔT augmentation, years
Harmful (grades 3.1-3.2)	<0,3	More than average	Up to 3-5
Especially harmful (grades 3.3-3.4)	0,3-1	High	5-10
Dangerous (extreme) (Class 4)	>1	Very high	>10

In mentioned study [3] it is suggested to use the total risk summary, while the influence of several HDPF:

$$i_{ir}^{sum} = \sum_{i=1}^{n} i_{ir_i}, \qquad (2)$$

where: n – number of simultaneously active HDPF, i_{ir_i} – risk performance for the i-th factor.

But approaches to defining risk are outdated because they take into account the negative effect of HDPF on a person as effects that have occurred with sufficiently large intervals. Besides, they ignore the intensity of the process, equipment depreciation, resulting in increase of factor of severity – Fs, of the growing parameters of HDPF.

And what about the so-called "Delayed" negative effect of HDPF when it's manifestations occur late in time, but the effects are rapid and severe. That is, this method can not correctly determine the risk of professional morbidity.

There is another known method for assessing the risk of occupational diseases with regard to length of service for a particular region [30]. Its basis is a mathematical model based on Ferhyulst's equations for various occupational diseases that allows to approximat the empirical dependence, obtained in their analysis. In particular, the regression equation was obtained according to the accumulated probability P of vibration disease on length of service in years X for grinders, operating under the influence HDPF for metalworking enterprises in St. Petersburg:

$$P = \frac{98}{1 + 10^{(2{,}19 - 0{,}16x)}}, \quad (3)$$

where: 98, 2.19 and 0.16 – parameters of equations that determine the type of dependence.

This method allows to determine via the equation the 25% th and 50% of the risk and the average length of time before the official registration of occupational diseases that the exposure to the risk of these options will be equal at the experience of 10 years - 14 years for 25% th and risk 12 years for 50% of the first, respectively. But it ignores the tensions of work and intensity of exposure of HDPF, including vibration and synergy in their collective action. Thus, in [23] pointed out that the development of vibration disease must take into account the effect of concomitant risk factors (group and individual). If, for example, with the acceptable vibration and seniority of 10 years vibration disease probability is 1%, then the additional effect of noise at 100 dB (without MIP) should expect an increase of vibration disease in 1.5. With intensive cooling, especially with damp hands, there is an increased risk of 3-5. A heavy physical activity in the workplace (WP) with concomitant psychophysiological HDPF, such as smoking, increases the risk of vibration disease in approximately 2-fold.

Besides, there is a recent increase of occupational diseases cases on the background of other existing, and the conditions of its occurrence and impact of the negative effect the above approaches do not consider. In practical terms, these methods do not allow to define the consequent risk at the design stage or upgrading of production processes.

It should be noted that other methods for determining various indicators of risk for occupational diseases exist and new ones appear. In particular [14] determins Iod, the integral index of frequency and severity of occupational diseases in which the severity of the disease is estimated to 5 m categories based on his medical prognosis, and type of disability to which it leads (temporary, permanent, professional, general). This figure takes into account every case of its occurrence in a particular professional group:

$$i_{od} = \frac{\sum_{j=1}^{m} n_j \cdot K_j}{L \cdot \sum_{j=1}^{m} n_j}, \quad (4)$$

where: nj – number of occupational diseases of j category in the group, Kj – j category score of occupational diseases severity, $\sum_{j=1}^{m} n_j$ – number of occupational diseases in all categories of severity m, L – number of years of observation.

There are other developments, such as presented in [14,6,12] for determination the production risk. For example, in [12] is an approach to assess the occupational risk indicator as a temporary disability, which is the summary lost during the working time due to professional or professionally-caused disease. This method is more advanced because it determines whether total disability or death consequences, the study is equivalent to 6,000 man-days of disability. This allows to determine the number of days of disability due to known percentage of disability. Although these indicators are used in the famous methodology of assessment the levels of occupational risk in terms of health (Table 4) in the Russian Federation as a temporary standard [33], we can conclude that they are comprehensive, such as the above reasons in particular, "delayed" effect.

Table 4. Criteria of occupational risk in terms of health

№	Performance	Levels of occupational risk					
		Minimum	Low	Average	More than average	High	Very high
1	Classes of conditions due to the degree of hazard and risk	2	3.1	3.2	3.3	3.4	4
2	Integral performance of disability	<30	30-100	101-300	301-1000	301-3000	>3000
3	Integral performance of occupational diseases iir	<0,1	0,1-0,5	0,51-1,5	1,51-5,0	5,1-15	>15
4	Performance of occupational diseases iir	<0,05	0,05-0,1	0,11-0,25	0,26-0,5	0,51-1,0	>1,0
5	Occupational incidence (number of cases per 10,000 workers of the profession, production) for the year	≤1,5	1,6-5,0	5,1-15,0	15,1-50	>50	
6	The incidence of TD for all diseases (per 100 employees): - Cases of disability, - Days of disability	66,4-72,3 867-938	72,4-84,6 939-1081	84,7-90,7 1082-1153	90,8-96,8 1154-1225	96,9-102,9 1226-1281	>102,9 >1281

In table 4 TD stands for Temporary Disability

There are other methods of determining the production risk, including aimed at finding a correlation between the levels of dependency SHNVCH and frequency of disease, as shown in [25], when the latter is determined by the sum of the coefficients of regression dependence ai, showing an increase incidence of each HDPF multiplied by their actual value xi:

$$y = a_0 + a_1 x_1 + a_2 x_2 + ... + a_n x_n, \quad (5)$$

where: y – frequence of diseases.

But, according to the formula, for setting via coefficients a_i and Fisher's the exact specific contribution of each indicator HDPF in % to forming health indicators, it is necessary to have a basic value of the coefficient a_0, which depends on the production features.

All of the noted methods are aimed at determination of occupational risk, primarily related to the possibility of occurrence of occupational diseases. In contrast, in [27,35,36] showed that professional risk R is composed of the risk of damage to health due to:

– injuries of varying severity Rin,

– occupational diseases Rod,

– hazardous working conditions, severity and intensity of the work process that has taken the name "hidden" risk Rhid.

Dependence for the determination of risk has the form:

$$R = (N_{dth}/N) \cdot Y_{dth} + (N_{dis}/N) \cdot Y_{dis} + , \quad (6)$$
$$+ (N_{od}/N) \cdot Y_{od} + (N_{hid}/N) \cdot Y_{hid}$$

where: N – total number of employees at the station, N_{dth}/N, N_{dis}/N, N_{od}/N and N_{hid}/N - the frequency of damage to health from the deadly consequences, of the disability for one day or more, of the occurrence and frequency of occupational diseases and for working in hazard classes 3.1 ... 4 during the year, respectively, Ydth, Ydis, Yod and Yhid - damage to health in the such cases.

The mentioned hazard classes of work conditions correspond to the operating in Russia normative document [11], which provides a universal scale (Table 5) for assessment the damage injury conditions depending on the class of hazard.

Thus, the last of the method allows to determine the integral index of occupational risk R, which is a combination of actual and hidden risk of injury as a result of professional activities. And because the value of the loss of the last HDPF and conditions are determined by the reduction in days of life (24 hours), then the loss of fatal injury or disability for a day or more and occupational diseases can be expressed in the same units. And from the days of disability it's possible to transfer to the definition of occupational risk in monetary terms. This method represents a significant step forward, as it eases the adaptation of normative documents that are being adopted both in Russia and Ukraine, according to the requirements of the European standard [21,22]. It, unlike others, takes into account the risks of injury, occupational diseases and also a work injury.

Table 5. Scale of loss injury, depending on the class of hazard conditions

№	The degree of hazard conditions according to D 2.2.013-94	Term reduction of life, days per year	
		Range	Average
1	3.1	2,5-5,0	3,75
2	3.2	5,0-12,5	8,75
3	3.3	12,6-25,0	18,75
4	3.4	25,1-75,0	50,0
5	4	>75,0	

CONCLUSIONS

1. This research determines that all of the methods of assessment determine the performance of production risk by the impact of HDPF on the human body. At the design stage of various stations, shops and when they upgrade, retooled they can not give the correct answer to what would be a professional risk at a particular workplace or even at the station. They do not consider how the range and degree of deterioration of equipment and physiological feature of the employees affect.

2. During the intensification of production with new technologies with simultaneous operation of morally and physically obsolete equipment, it is necessary to improve existing methods and approaches for the determination of production risk, thereby, instead of ever increasing damage compensation for injuries and occupational diseases, to direct funds sprecifically for technical upgrading and improvement of cultural production and the creation of healthy and safe working conditions.

REFERENCES

1. **Atan L., C. Andreoni C, V.Ortiz, Silva E et al. 2005.:** May, High kidney stone risk in men working in steel industry at hot temperatures // Urology. – 65(5): 61-858.
2. **Belov S V. Brinza, B. Vekshin etc., 1985**. Industrial Process Safety: A Guide. – M.: Mechanical Engineering, – 448. (in Russian).
3. **Boiko.T., Naumov A., Gerasimov I. and others 1999.:** Assessment of risk of occupational diseases and ways to reduce the basis of length of service in terms of exposure to harmful factors of produc-tion: Guidelines - St. Petersburg. – 44. (in Russian).
4. **Chen.M.L, Chen.C.J, Yeh.W.Y, Huang.J.W, Mao.I.F2003 May-Jun1999.:** Heat stress evaluation and worker fatigue in a steel plant // AIHA-J-(Fairfax,-Va)., 64(3): 9-352. (in China).
5. **Dures-Dobos F.N**. **1981.:** Hazards of heat exposure Seand.G. work environm – Vol.7.№2.73-78.
6. **Egorova A., Yegorov A.M, 2009.:** System approach to management of production risk to workers of metallurgical production: Author. dis. uch on competition the degree of Dr. med. Science: special. 14.00.50 "Occupational Medicine" / FSIS "Federal Research Center of Hygiene". – Mytishchi. – 48.
7. **Fine J.M., Gordon T., Chen L.C., Kinney P, Falcone G., Sparer J., Beckett W.S. 2000.:** Characterization of clinical tolerance to inhaled zinc oxide in naive subjects and sheet metal workers // J-Occup-Environ-Med. Nov, 42(11): 91-1085.
8. **Giordano C., Conticello S., Beatrice F., Montemagno A., Boggero R. 2001 Oct.** Non-auditoiy effects of environmental noise: a study of metallurgical and mechanical workers // Acta-Otorhinolaryngol-Ital., 21(5): 6-281. (in Italy)
9. **Heyets V., 1-3 June 2006.:** Prospects for Ukraine's economy and the possible impact on his innovative factors / XXI int. Kyiv Symposium on Science of Science and the scientific and technological forecasting "Prediction of scientific, technological and innovation development: State Program Ukraine and world experience" (Kyiv). - [Electronic resource]. Mode of access: www.ief.org.ua / text / Dopovid.pdf.
10. Hygienic classification of work in terms of hazard and danger of environment factors, severity and intensity of the work process: SK 3.3.5-8.6.6.1-2002, approved. Order of the Ministry of Health of Ukraine № 528 from 27.12.2001 year - Mode of access: http://document.ua/gigienichna-klasifikacija-

praci-za-pokaznikami-shkidlivosti-nor4882.html.

11. Hygienic criteria of assessment of working conditions in terms of harmful values and hazards in the work environment, the severity and intensity of the labor process: a guide. P 2.2. 99-753. - Moscow: Fed. MU Center for Sanitary Inspection Russia, 1999. – 192. (in Russian).
12. ILO. Technical and ethical guidelines for workers' health surveillance. - OSH No 72. Geneva: International Labour Office, 1998. – 41. (MOT. Technical and ethical guidelines for medical monitoring of workers).
13. **Izmerov N., Denisov E., 2003.:** Occupational hazard for health workers: a guide / ed. – Moscow: Trovant. – 447. (in Russian).
14. **Izmailova O., 2006.:** Systematic approach to managing occupational hazard when exposed to a complex physical environment factors: Author. dis. uch on competition. The degree of Dr. med. Science: special. 14.00.50 "Occupational Medicine" / FSIS "Federal Research Center of Hygiene". – Mytishchi. – 48.
15. **Iiuvinen M., Uitti J., Oksa P., Palmroos P., Laippala P., 2002 Jun.:** Respiratory health effects of long-term exposure to different chromium species in stainless steel production // Occup-Med-(Lond)., 52(4): 12-203. (in UK)/
16. **Jayawardana P.L., 2004 Dec.:** Non-specific occupational health conditions among brass workers at Gadaladeniya, Sri Lanka // Ceylon-Med-J., 49(4): 7–122.
17. **Kasyanov N., 2010.:** Ryabichev V Savchenko The analysis of existing criteria of the comfortable condition of the person at infra-red heating.// TEKA Com. Mot. i Energ. Roln. – OL PAN, 2010. – Vol. XD. – 141-147.
18. **Kasyanov N., 2010.:** Gunchenko O, Vishnevskiy D. The methods of modeling parameters of labor safety status perfection.// TEKA Com. Mot. Energ. Roln. – Lublin, 2010. – Vol. XA. – 234-242.
19. **Mizoue T., Miyamoto T, Shimizu T., 2003.:** Combined effect of smoking and occupational exposure to noise on hearing loss in steel factoiy workers // Occup-Environ-Med. Jan, 60(1): 56-9. (in Japan)
20. **Meyer J.D, Chen Y, McDonald J.C, Cherry N.M. 1997-2000.:** Surveillance for work-related hearing loss in the UK: OSS A and OPRA // Occup-Med-(Lond). 2002 Mar, 52(2): 75-9. Management system in the field of health and prevention of occupational diseases: OHSAS 18001:2007. – 2007. – 29.
21. Management system in the field of health and prevention of occupational diseases: OHSAS 18002:2000. Guidelines for the application OHSAS 18001:1999. – 2000. – 122 .
22. **Molodkina N., 2000.:** Hygienic and medical-biological criteria for assessing occupational exposure in occupational medicine: Author. dis. on competition ofr the degree of Dr. med. Science: special. 14.00.50 "Occupational Medicine" Institute of Industrial Medicine, – M.B.I. – 48.
23. **Osowole 0.S., Nwaorgu 0.G., Osisanya P.A., 2003 Sep.:** Perceived susceptibility to noise induced hearing loss and attitude towards preventive care among metal workers at Gate, Ibadan: a pilot study // Afr-J-Med-Med-Sci., 32(3). – 231.
24. **Potocki E., Novikov O., 2004.:** Analysis of the cumulative impact of harmful factors on the incidence of personnel / Life Safety. – № 5. – 14-21.
25. Public health standards for microclimate of industrial facilities: SDS 3.3.6.042-99. - [With effect from 01.01.2000]. – Kyiv: Ministry of Health of Ukraine, 1999. – 19.
26. **Sokolov E., Vetrov I., 2000.:** On the theory of occupational risk / Panferova // Health and Social Security. – M. – № 3. – 36-39.
27. **Surjuse B., Sangole S., Sangole V. 2003 Nov-Dec.:** Noise pollution and its effect on workers of the steel and iron industiy // NatI-Med-J-India., 16(6): 40-339.
28. **Simpson A.T., 2003 Nov.:** Comparison of methods for the measurement of mist and vapor from light mineral oil-based metalworking fluids // Appl-Occup-Environ-Hyg., 18(11): 76-865.
29. **Suvorov G., Denisov V., Ovakimov E., 1999.:** Assessment of the likelihood of vibration disease from the action of local vibration in concomitant factors / Occupational Health. – M. – № 5. 6-10.
30. **Tabuchi T., Kumagai S., Hirata M., Taninaka H., Yoshidai I., Oda H., 2005. Sep.:** Ito, - A Status of noise in small-scale factories having press machines and hearing loss in workers//Sangyo-Eiseigaku-Zasshi. 47(5): 31-224.
31. **Talbott E.O., Gibson L.B., Burks A., Engberg R. McHugh K.P. 1999 Mar-Apr.:** Evidence for a dose-response relationship between occupational noise and blood pressure // Arch-Environ-Health. 54(2): 71-8.
32. **Volodin I., Joffe V., 1973.:** Probabilistic models for the distribution of the number of injuries and accidents at industrial facilities // Questions of safety: temat. Sat. – M., 5-23.
33. The Law of Ukraine "On National Security" adopted by the Verkhovna Rada of Ukraine in

19.06.2003 р. № 964-IV. – [Electronic resource]. - Mode of access: http://zakon4.rada.gov.ua/laws/show/964-15.
34. **Yastremsky O., 1992.:** Modeling economic risk / O. Yastremskyi. – K. Lybed. – 176.
35. **Vetrov V., Panferova I , Hrupachev A., 1999.:** Structure of occupational exposure in the industrial sector in Russia / / Protection of Labour and Social Insurance. – M. – №7. – 45-47. (in Russian).

ПУТИ УЛУЧШЕНИЯ ВЫПОЛНЕНИЯ ИНДУСТРИАЛЬНОГО РИСКА И РАБОЧИХ УСЛОВИЙ

Дмитрий Вишневский, Николай Касьянов, Виктор Медяник

Аннотация. Статья рассматривает главные особенности существующих методов для оценки профессионального риска и выходит с их усовершенствованием.

Ключевые слова: рабочие условия, повреждение, профессиональные болезни, индикаторы индустриального риска, вредные и опасные производственные факторы(ОПФ).