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Modification of selected occupational risk assessment method

A. Kania*, M. Spilka, K. Wieczorek
Institute of Engineering Materials and Biomaterials, Silesian University of Technology
ul. Konarskiego 18a, 44-100 Gliwice, Poland
* Corresponding e-mail address: aneta.kania@polsl.pl

ABSTRACT

Purpose: The aim of this paper is to present a modification of a popular occupational risk assessment method named Risk Score. Moreover, occupational risk assessment for the vibration damping test station at the final assembly line of shock absorbers was shown.

Design/methodology/approach: The study showed the imperfection of the original Risk Score method. According to the proposed modification of the method the occupational risk assessment at the selected workstation in the production plant was carried out.

Findings: The characteristics of the original Risk Score method was presented. The changes in the underlying method were introduced. Next the original Risk Score method with its modification have been compared.

Research limitations/implications: In the article the individual steps taking into account the improvements of the original Risk Score method were discussed. The popular Risk Score method compared with its modification on the example of shortened card of the occupational risk assessment at the position.

Practical implications: The modified method is more accurate, reliable and effective. That can be observed in the case of risk valuation for the selected threats at the position.

Originality/value: The modified Risk Score method significantly improve the whole process of assessment and can be used for the occupational risk assessment at each position.

Keywords: Safety and health management; Occupational risk assessment; Risk score method; Modified risk score method

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INDUSTRIAL MANAGEMENT AND ORGANISATION

1. Introduction

The occupational risk is the notion defined as probability of the undesirable threats appearance relating to work done and lead to losses connected with employees and their health. The source of incidents are the threats occurring in the work environment or they are derivative of improper duties realization at the position [1,2].

The occupational risk assessment should be carried out whenever the company creates new positions or new guidelines which concern positions are introduced e.g. change of protection measures [3,4]. The aim of this action

is to identify threats occurring at the positions and minimize their undesirable results [2]. It is necessary to show the personnel and supervising services that after analyze of information derived from the work environment all possible protective measures used, and the risk is at an acceptable level. In the longer perspective, this allows to ensure continuous improvement in the occupational health and safety, and contributes to improve the employees awareness [5].

In order to the occupational risk assessment carried out it is necessary to usage techniques that meet certain conditions. The basic requirement is compatibility with a valid legislation (Constitution, Labour Code, industry standards, etc.). Moreover, the method used for the risk assessment should be possibly well-matched to the character of the enterprise. It is necessary that the method was simple, understandable and relatively inexpensive [3,4,6].

In practice, there are many different methods for the occupational risk assessment. One of them is three-stage method which is described in PN-N-18002 standard in detail. Other methods are: FMEA (Failure Mode and Effects Analysis), PHA (Preliminary Hazard Analysis), JSA (Job Safety Analysis), HAZOP (Hazard and Operability Studies), PSA (Process Safety Analysis), TJA (Total Job Analysis), etc. Noteworthy is also very popular and practical the Risk Score method [1-15].

2. Characteristics of Risk Score method

Risk Score method is used to estimate the risk of human and material losses that may occur during specific activities realization in determined time set. It is a factor method because the failure and threats levels (values for the risk calculation) are not expressed in the strict manner but by contractual numerical scales. In this method the risk is the product of three parameters [7]:

- exposure for threat,
- probability of the threat appearance,
- effects of unfavorable event.

The risk is calculated from formula [8]:

$$R = S \cdot E \cdot P \quad (1)$$

where:
R - risk,
S - potential effects of threat,
E - exposure for threat,
P - probability that threat occur.

The values of individual factors are estimated according to Tables 1-3.

After determination of risk (R) factor one can start valuation of risk according to Table 4.

Table 1.
Potential effects of threat (S) [9]

Value S	Valuation of losses	Human losses	Material losses
100	major catastrophe	many fatalities	> 30 mln PLN
40	catastrophe	several victims	10-30 mln PLN
15	very large losses	one dead	0.3-1 mln PLN
7	large losses	hard injury	30-300 000 PLN
3	average losses	absenteeism	3-30 000 PLN
1	small losses	need for first aid	< 3 000 PLN

Table 2.
Exposure for threat (E) [9]

E value	Characteristics
10	constant
6	frequent (daily)
3	occasional (once per week)
2	chance (once per month)
1	minimum (a few times a year)
0.5	insignificant (once a year)

Table 3.
Probability that threat occur (P) [8]

P value	Characteristics	Probability [%]
10	very probable	50
6	quite possible	10
3	practically possible	1
1	unlikely, but possible	0.1
0.5	occasionally possible	0.01
0.2	Possible to consideration	0.001
0.1	theoretically possible	0.0001

Risk Score method is one of precise occupational risk assessment methods. The aim of proposed changes is increase of its accuracy in even greater extent.

Table 4.
Valuation of risk (R) [8]

RISK			
R value	Risk	Risk acceptability	Activities
R<20	very low	acceptable	suggested control
20≤R<70	low		control needed
70≤R<200	medium		need improvement
200≤R<400	high	not acceptable	need immediate improvement
R≥400	very high		indicated work stoppages

3. Proposition of Risk Score method modifications

After analysis of Risk Score method the following changes proposed:

- E factor (Table 2) - exposure for threat - extended by an additional line, position frequent (daily) divided into two: "frequent (up to two times a day)" - value of E = 6 and "very frequently (several times per day)" - value of E = 8. The characteristics of a factor - frequent (daily) - in the original method is inaccurate. "Daily" should mean 1 or 2 times per day and more what makes the risk is much higher;
- method was extended by a second formula which calculates the occupational risk - R2 (2) after preventive and safety measures application. It creates value of R1 (value of the risk before the measures will be implemented) and W factor - factor of used measures. The formula of (1) is unchanged, only symbol of R was replaced by R1 for distinction the risk before and after evaluation;

$$R2 = R1 \cdot W \tag{2}$$

where:
R1 - value of calculated risk before preventive and protective measures usage,
R2 - value of calculated risk after preventive and protective measures usage,
W - factor of used actions and preventive or protective measures.

- table classifying preventive and protective measures has been elaborated (Table 5). These measures were grouped based on degree of risk reduction e.g. for a fire from A group - work health and safety and fire protection training, from B group - equipped a position with a safety fire extinguisher, from C group - use of an alarming and fire protection system at the enterprise. The difficulties can be repeated in A and B group "personal protective equipment". They have been included in both groups. This is dictated by the large number of different types of personal protective measures for the same threat, which in different ways and with different intensity eliminate its impact e.g. for hearing protection from A group - ear earplugs, B group - hearing protectors, for eye protection from A group - goggles, from B group - closed goggles;

Table 5.
Preventive and protective measures, shortened designation

Group	PREVENTIVE AND PROTECTIVE MEASURES
A	➢ personal protection measures ➢ occupational health and safety or fire protection trainings ➢ job trainings ➢ recurrent trainings ➢ first aid trainings ➢ use of signs at the enterprise area ➢ use of light and sound signs at the enterprise area ➢ use of signboards, information posters at the enterprise area ➢ use of industrial mirrors at the enterprise area ➢ organization of a room "First aid" in the production hall
B	➢ personal protection measures ➢ use of well-matched floor surface for the conditions occurring in the working environment ➢ use of balustrades, stairs and ladders about standard sizes at the enterprise area ➢ use of the rule "beyond the reach of the hand" ➢ use of safety switch - "red mushrooms" ➢ position equipment in safety fire extinguisher ➢ use of periodic inspections and measurements system at the position ➢ modernization of a work organization at the position ➢ elaboration of intercompany procedures, instructions, standardizations etc.
C	➢ use of an alarming and fire protection system at the enterprise area ➢ use of room dedusting, ventilation and air conditioning system ➢ assurance of roads, transitions about appropriate sizes, equal and rigid at the enterprise area ➢ use of distancing devices at the position: fences, bridges, ambidextrous and contactless safety devices, protective devices which repel ➢ during designing and positions modernization take into account: transition openings and their proper, standardized dimensions, an access openings and their proper, standardized dimensions ➢ use of construction which prevent reaching upper limbs to the danger zones ➢ use of construction which prevent reaching lower limbs to the danger zones ➢ automation/ robotics/encapsulation of a process ➢ modernization of a position/technological process ➢ use of monitoring, control, protective systems ➢ machine, device replacement ➢ renovation, maintenance, service of a machine/device

- to the method third formula (3) was included. It shows a factor value of used activities or applied preventive and protective measures (W). It consists of the values of A parameter, B parameter and C parameter. The parameter values according to Table 6 are determined;

$$W = A \cdot B \cdot C \quad (3)$$

where:
W - factor of used activities or applied preventive and protective measures,
A - value of A parameter,
B - value of B parameter,
C - value of C parameter.

Table 6.
Values of used preventive and protective measures; A, B, C parameters

Parameter	Number of used measures			
	0	1	2-3	4-5
A	1	0.9	0.8	0.7
B	1	0.6	0.5	0.4
C	1	0.3	0.2	0.1

Table 7.
Estimation of W factor

No.	Parameter			W
	A	B	C	
1	12	13	14	15

Table 8.
Step 1 - Identification of threats

No.	Threat	Kindof factor	Possible threat sources	Possible threat effects
1	2	3	4	5

- table evaluating applied preventive and protective measures (Table 7) for W factor was elaborated. On the basis of used measures, using the table of W factor, its value can be determined e.g. after usage of three measures from group A, two from group B and the one from group C the value of W factor is equal: $W = 0{,}8 \times 0{,}5 \times 0{,}3 = 0{,}12$;
- additional table for W factor estimation was also elaborated (Table 8). It consists of the following columns: 1 - No., 12 - A parameter, 13 - B parameter, 14 - C parameter and 15 - W value.

Below, the occupational risk assessment according to the proposed modification of the Risk Score method:
Step 1 - to identify threats at the position the table should be elaborated; columns 2-5 (Table 8).
Step 2 - based on the Tables 1-3 the values of factors S, E and P should be specified; columns 6-8.
Step 3 - factors, S, E, P should be multiplied according to the formula (3).
Step 4 - received risk value should be inscribed into the Table, R1; columns 9 and 11.
Step 5 - based on the Table 4 the calculated risk (R1) should be evaluated and inscribed into the table, columns 9 and 11.
Step 6 - used preventive and protective measures should be defined and inscribed into the table; column 10.
Step 7 - based on the Table 5 a group of used preventive and protective measures should be determined. Next the values of A, B, C parameters should be also determined.
Step 8 - values of A, B, C parameters should be inscribed into the table of the evaluation of W factor (columns 12-14), next the value of W factor is calculated (3) (column 15).
Step 9 - values of R1 and W should be multiplied according to 2 formula; columns 11 and 15.
Step 10 - received the risk value should be inscribed into the table, R2, column 16.
Step 11 - calculated risk R2 should be evaluated according to the Table 4 and the value should be inscribed into the table, column 16.
Step 12 - based on received results the activities must be taken. When the risk is not acceptable the preventive and protective measures must be used.

4. Example of the shortened occupational risk assessment at the selected position

The analyzed position is the damping test of the absorber strength - Test Press. The automatic machine for tests and strength measurements is used there.

The list of activities carried out before work, during work, after work and forbidden activities, the means of work (machines, devices, tools) and necessary equipment of the worker with personal protective equipment is in the intercompany position instruction of the occupational health and safety.

Tables 9 and 10 presented the shortened card of the occupational risk assessment at the selected position elaborated according to the original Risk Score method and modified method

Table 9.
Shortened occupational risk assessment at the damping force of the shock absorber test station - original Risk Score method (R: v.h - very high, h - high, m - medium, l - low, v.l - very low)

No.	Threat	Kind of factor	Possibile threat sources	Possibile threat effects	before an action usage				Preventive and protective measures	after an action usage			
					S	E	P	R		S	E	P	R
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	electro-magnetic radiation	physical, hazardous, burdensome	Test Press machine and other devices at the hall, wires and electrical systems	worse memory, general weakness, lack of concentration and difficulty work, headaches and vertigoes, changes in eyesight, lower productivity, efficiency and quality of work, symptoms of cardiovascular, nervous, hormonal system	7	10	10	700 (v.h)	modernization of machine and shielding usage; periodic inspections and measurements; safety trainings	7	10	1	70 (l)
2	Impact of immovable objects	physical, hazardous	impact of the costructional Test Press or other element, impact of the position equipment, collision with a stationary forklift truck	bruises, concussion, fractures - injury at work	3	10	3	90 (l)	use of marking of protruding parts of machine; safety trainings; job-trainings	3	10	0.5	15 (v.l)
3	Fall on the same level, slip	physical, hazardous	uneven and slippery surface, disorder at the position	concussions, dislocations, fractures -injury at work	3	6	6	108 (m)	use of work standarization at the position; use and marking of places for storage of tools and auxiliary devices (magnetic strips for tools, separation of place for tools truck by yellow line); safety and first aid trainings; hall fitment in dressing and first aid point	3	6	1	18 (v.l)
4	Collapse of the lower level	physical, hazardous	fall down the stairs	concussions, dislocations, fractures, death - injury at work, occupational disease	7	6	6	252 (h)	use of safety and information signs; use of stairs, balustrades and barriers about normalized dimensions; use of yellow-dark warning tape on steps, balustrades and barriers; safety and first aid trainings; hall fitment in dressing and first aid point	7	6	1	42 (l)

Table 10.
Shortened occupational risk assessment at the damping force of the shock absorber test station - modified Risk Score method (Table does not include columns 3, 4, 5, 10 - they are the same as in Table 9)

No.	Threat	before an action usage				after an action usage								
		S	E	P	R	R1	A		B		C		W	R2
1	2	6	7	8	9	11	12		13		14		15	16
1	Electromagnetic radiation	7	10	10	700 (v.h)	700	0.9	1	0.6	1	0.3	1	0.162	113.4 (m)
2	Impact of immovable objects	3	10	30	90 (m)	700	0.8	3	1	0	1	0	0.8	72 (m)
3	Fall on the same level, slip	3	8	6	144 (m)	144	0.8	2	0.5	2	1	0	0.4	57.6 (l)
4	Collapse of the lower level	7	8	6	336 (h)	336	0.7	4	0.6	1	1	0	0.42	141.1 (m)

5. Conclusions

The changes introduced in the Risk Score method made possible precisely determination of the W value by specifying the group and the specific amounts of individual prevention and safety measures at the position. This allows to exactly specify how taken actions and applied measures affect the safety and eliminate the various threats.

The modified method is more accurate, reliable and effective what can be observed in the case of risk evaluation for following threats: fall on the same level, slip or collapse of the lower level.

The most important goal of the proposed modification was to implement the values of used preventive and protective measures. In the practice and literature there is no method which include such W factor. The introduction into equation of A, B, C parameters allows to obtain high accuracy of the result by the evaluation of all taken actions.

Additional information

Selected issues related to this paper are planned to be presented at the 22nd Winter International Scientific Conference on Achievements in Mechanical and Materials Engineering Winter-AMME'2015 in the framework of the Bidisciplinary Occasional Scientific Session BOSS'2015 celebrating the 10th anniversary of the foundation of the Association of Computational Materials Science and Surface Engineering and the World Academy of Materials and Manufacturing Engineering and of the foundation of the Worldwide Journal of Achievements in Materials and Manufacturing Engineering.

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