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Risk management and knowledge management as a function of technology management

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Abstract

In this paper the application of knowledge as a function of risk management was represented by technological processes. As an example of this application, a simple process for manual handling of loads was given. International standards, which need to be met for safe function of this operation, provide severe and complex requirements, and require mathematical calculations and knowledge in ergonomics and mechanics. By using a corrected method, which had previously been used by the author, and considering the requirements of the standard, this paper was created to provide a risk assessment model, which can be simply and effectively used by any assessor.

Keywords: risk assessment, manual handling of loads, knowledge management.

Introduction

Knowledge management, as a process of increasing the useful knowledge in the organization, is becoming a notable component in risk management. Risk management is the most common subject in all activities today, and represents an integral part of process management. Theory of risk management has the same basics no matter which area it applies to. However, the theory can be applied only by a person who is skillful in its use in a specific area. It means that there is no universal expert in the theory of risk management. Knowledge from this area must be connected with knowledge in a specific field. This connectivity can be achieved through knowledge management and teamwork. In order to achieve high quality expertise, various experiences and skills of individuals should be compiled, assembling them into proficient knowledge.

This paper was created as a result of a series of papers about risk management in the occupational health and safety (OHS) area. With work at the Higher Education Technical School in Novi Sad (HETS) in this area, the risk assessment method for workplace and working environment was created. This assessment has been modified and corrected through practice depending on technology process and other circumstances. The method was applied in the areas of fire protection, environmental protection, information technology protection (Nikolic & Ruzic-Dimitrijevic, 2009; Nikolic, 2010). The method also included the risk calculation in relation to psycho-physical harmful effects (Amidzic & Nikolic, 2008).

It is very often the case in the OHS area to just offer already formatted forms or questionnaires which simply have to be filled in by checking. Then calculations are done without understanding the core of the problem. That way they can be used in simpler work operations and clearly defined technology processes. Such examples of workplaces are rare in praxis. Work processes are often more complex and made from a few different activities and surroundings, so there is often a need to make corrections in the application of knowledge and decision management based on more complex elements even in experts.

Risk management in the manual handling of loads, even a very simple manual operation, actually represents a process of far greater complexity. This complexity is a result of very demanding ISO standards (ISO/IEC 11228-1:2003; ISO/IEC 11228-2:2003; ISO/IEC 11228-3:2003) for application and applied risk assessment procedures which are carried out after the correction and compliance of loads. In the correction and compliance of loads phase, much knowledge about the work processes play an important role allowing application of knowledge management which leads to concrete results. This paper emphasises a definition of the technology solution itself, a choice of adequate types of workers and a way of presenting data primarily in electronic form. The practical example of a case study is represented by the greening of ground areas by defining dimensions for possible grass clipping which are manipulated and by determining the gender of workers who can be hired.

Literature review

Papers by Nikolic and Bukta (2013) and Nikolic (2013) presented a formed applicable risk assessment method for the manual handling of loads and the use of all types of carts which can be pulled or pushed. The method was formed by the combination of two different approaches in the risk assessment. The first is a method created by HETS (Nikolic & Gemovic, 2009; Nikolic, 2012) for the work environment, and the other risk assessment method, with references to the ISO 11228 standard ((ISO/IEC 11228-1:2003; ISO/IEC 11228-2,:2003; ISO/IEC 11228-3:2003), in relation to lifting, pulling and pushing loads. Two risk assessment processes were used. First, it had to be determined what was the power necessary for pulling or pushing a cart, and definition of a shape and mass of loads from the Standard. Second, accepted elements of risk assessment from the Standard, were used and amended with other factors which were included in assessment of the state. By function of state, which is a mathematical interpretation of event probability, all elements were included as elements of the work environment which defined the state of protection.

In Serbia, the regulation (Regulation of procedure of risk assessment in working place and working environment, 2006) took effect in 2006, and accordingly the obligation of creating the Act on Risk Assessment (ARA) in each workplace environment was made. Not until 2009, by the adoption of the Regulation (2006) on precautionary measures for safe and healthy work at manual handling of loads (Regulation of preventive measures of safe and healthy work in manual lifting and carrying of loads, 2009) which was reconciled with the Directive 89/391/EU, were minimum conditions for manual handling of loads defined.

Until the moment of a risk assessment, the risks of the dangers were not determined in relation to the manual handling of loads. By adoption of this Regulation, addendums had to be created in all ARAs, such that this assessment had to be included. By Regulation (2006), only the minimal conditions which employer had to fulfil were defined. The methods used in the risk assessment did not offer a solution. Actually, nothing happened because there was not enough awareness on how to carry out that assessment. The final expression was reached though, as detailed in several papers (Nikolic & Kosic, 2010; Nikolic & Ruzic, 2010; Nikolic, Ruzic-Dimitrijevic, & Bukta, 2012).

The well-known ISO Standard /IEC11228:2003 (Standard), a very complex standard, offers recommendations for the safe manual handling of loads. It is very detailed and applies to all types of loads: carrying and lifting, pulling and pushing, as well as the repetitive manual handling of small loads whose mass is less than three kilograms. The Regulation (Regulation of preventive measures of safe and healthy work in manual lifting and carrying of loads, 2009) does not recognize any of these mentioned types of the manual handling of loads and just reviews declaratively on certain measures.

Today, jobs with just one type of handling of loads are rare. Very often, form, type, dimension or something else changes. Although there are jobs that do not have the manual handling of loads as part of their description, it is requested from time to time. Manual handling of loads included more than one type of handling, constantly or occasionally, and it included dangers with the handling of loads in the three possible ways as described by the Standard.

In his paper Nikolic (2012) presented the risk assessment method, which the authors at HETS developed and applied to a large number of practical examples. In the papers by Nikolic and Ruzic (2009) Nikolic and Kosic (2010), Nikolic and Ruzic (2010), and Nikolic, Ruzic-Dimitrijevic, and Bukta (2012), the authors suggested an application of the risk assessment method in the manual handling of loads. Then, in the paper by Nikolic and Bukta (2013), the method was confirmed, but only for the case of carrying and lifting of loads. Further, the method is applied completely in specific circumstances and for the needs of external orderers (Gradsko zelenilo, 2008). Exactly in these examples, the further progress was made. Through risk assessment, it was allowed for management to make decisions in a sphere of the work organization and management..

Methodology

In the risk assessment methodology of the manual handling of loads, there are two methods. The first method – load reduction - is the direct application of the ISO standard in dealing with the issues of mass of loads, frequency of lifting, carrying the loads in non-ideal conditions, and cumulative mass. Hence, in this section, special attention is given to the correct loads such that mass, frequency, and type comply with the appropriate conditions for manual handling. This part of the risk assessment creates considerable possibilities for management with regard to decision making as a strategic element of the management process. This is exactly the subject of this paper.

The second method consists of an already known risk assessment. By definition, risk is a combination of the *probability* of occurrence of an event, the *severity* of damage, and *frequency* (Harms-Ringdahl , 2001; Macdonald, 2004). From the quantitative matrix, this definition was represented with mathematical interpretation by which risk was shown to be a result of probability (P), frequency (F), and severity of damage (S). So the formula for calculating the risk is:

$$R = P*F*S$$

Most methods used for risk assessment offer values for the probability, frequency, and severity of damage in the form of tables. From the tables, the values can be determined by free assessment and after that, it is possible to calculate the risk. The risks are valued in the method as:

- Negligible $R \leq 5$
- Low but already considerable $5 < R \leq 25$
- Increased $25 < R \leq 50$
- High $50 < R \leq 100$
- Very high $100 < R \leq 150$
- Unacceptable $150 < R$

All these elements can be represented with qualitative and quantitative values. It would be of higher quality, although not possible, to represent them comparatively, statistically, or in other more scientific ways. it is possible only in certain cases (Macdonald, 2004; Takala, 1998).

From the probability table, it is possible to establish mathematical dependency of probability (P) and number of negative observations (variable „n“), based on the total number of observations (N), in this case N = 8, as shown in Table 1.

Table 1. Mathematical dependence of probability and value of the state of protection

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
P	**0,033**	**1**	**1,5**	**2**	**5**	**8**	**10**	**15**
	almost impossible – possible only under extreme circumstances	Very low probability – But nevertheless possible	Low probability – But it can happen	Possible – But it is not usual	50% possible	Possible – Not surprise	Very possible – Should expect	certainly – it will happen for sure
$f(x) = 16,46\ (n/N)^{2,7}$ n – number of negative observations N – total number of observations								
f(x)	**0,06**	**0,39**	**1,16**	**2,53**	**4,63**	**7,57**	**11,48**	**16,46**

Dependence get by a regressive analysis of form is used for its calculation from the function dependence:

$f(x) = 16,46 * x^{2,7} = 16,46 * (n/N)^{2,7}$, where

$x = n/N$

f(x) – probability of an event
n – number of negative assessments of state of protection
N – total number of assessed values for the state of protection

The probability calculation was computed only for the assessment of the state of protection, so this function is called the function of the state of protection. It was used to determine the risk based on the work environment conditions. State of the work environment was assessed via the values of the state, and the values of the state are defined as based on the Regulation, technical standard, or based on other documentation.

So, the risk assessment in the work environment can be computed by the same formula as for the workplace, only the sign for probability is f(x), so the risk is,

$$R_i = f(x)*F*H_i*$$

Case study

The method employed was original and authentic (Nikolic, 2012). From inception, the corrections and enhancements were made to the method in order to achieve its implementation in various fields. Specific circumstances and features demanded these adjustments, offering the opportunity of widespread usage. In this way, a number of case studies, where risk assessment was conducted by using this method, are the ultimate confirmation of its versatility and applicability. The case elaborated here is an affirmation of the method's applicability to manual handling of loads.

The following example refers to the concrete work task in concrete company. Data about the job – movements and material – loads must be given in a very short, but clear form.

Workers took enveloped grass from the track, 30 cm wide, and lifted it from the ground to the required height with out-stretched hands, carried the load in a trailer, lifted it up to the level of their chest for 25 cm and with a turn of 45 degrees (maximum), put it on a trailer or handed it to a worker standing on a trailer who accepted the grass.

Additional pertinent data included:

- Frequency of the lifting of loads was 2 times per minute
- Work process lasted from 1 to 2 hours during the day
- The employee performed work activity once (day) per week
- The road for carrying the grass is up to 10 m

Conditions:

- Employer accepted condition for loads to be 25 kg for men and 15 kg for women

Task:

- Determined the length of a track on which the grass is cut based on the mass of the track and determined the gender of workers who performed the activity.

- Determined rhythm of the work and work-rest schedule for the worker, according to frequency and cumulative mass of loads.
- Determined a way of representing the result.

Research questions

In order to conduct the load corrections in relation to its individual and cumulative form (Nikolic & Bukta, 2013) the risk assessment in this study showed that both values have to be lower than reference values. Research aimed at finding answers to the following questions are very important and interesting from the point of view of production management, technology, and organization.

The first question was how to incorporate the use of both sexes in the workforce .

Referenced (recommended) load masses were, according to the Regulation (Regulation of preventive measures of safe and healthy work in manual lifting and carrying of loads, 2009), and they were different for men and women of various ages. And according to the Standard (ISO/IEC 11228-1:2003; ISO/IEC 11228-2,:2003; ISO/IEC 11228-3:2003), this mass was different and lower from the allowed value in the Regulation. Concrete limits were around 15 kg for women and 25 kg for men. The real, allowed values for load mass would be reached by the corrections of these loads. So, from this point one question follows:

> ***Research Question 1 (RQ1)*: *Which gender or categories of employees can work in a certain workplace? Which special conditions, health, physical, and psychological, are the most important?***

The second question was related to the load's shape and dimension. There are different forms, dimensions and mass of loads. Sometimes they are guided, already absolutely defined and when there is no possibility for us to influence on any of characteristics of loads.

Research Question ***2 (RQ2):*** *Which dimension and form did the load have? Dimension and form of loads include all other characteristics of loads.*

The third question was how to organize the work times and the whole process, bearing in mind that these tasks were usually performed outdoors and under special circumstances. We got an answer to the question based on two corrections in relation to frequency of loads and cumulative mass.

Research Question ***3 (RQ3):*** *How to organize working hours of employees?*

The final research question considered the system of quality management. The question was how to present the results of the risk assessment that they are simple and clear, and how to fit them in all quality systems.

*Research Question 4 (RQ4)**:** How to introduce the method in such a way to make the risk assessment completely clear and how to introduce that assessment to be identical with previous introductions?*

Results

Possible corrections of loads (Nikolic & Bukta, 2013):

Was the load mass appropriate?

Were the mass and frequency of loads appropriate, if the lifting of load was repetitive?

Was the distance between loads and body appropriate?

Was the horizontal position of loads appropriate?

Was the height of horizontal transfer appropriate?

Was there an angle of asymmetry?

Describe the frequency of handling of loads.

Describe the quality of accepting the loads.

Correction of loads was executed because of repeating cycle of lifting, angle of asymmetry due to turn of the body, position of loads during repeating, and quality of accepting the loads (13).

Reference mass of 15 kg became 10.41 kg by correction. The loads corrections and their final correction were obtained from the formulas.

For values of an angle of turn of the body, objective loads increases according K_α

$$K_\alpha = 1\text{-}2\ \alpha\ 0.003 = 1\text{-}2*45*0.003 = 0.73$$

Correction due to frequency of handling of loads K_f

$$K_f = 0.84$$

Correction of loads due to quality of accepting K_z

$$K_z = 0.95$$

Corrected mass

$$\frac{m}{K_x \cdot K_v \cdot K_\alpha \cdot K_f \cdot K_z} \leq m_{ref}$$

If specific weight of wet grass with thickness of 5 cm, 1.33 kg per dm^3, then we get length of cutting the grass,

$$3*0.5*l = 1.33 \qquad (l = 30cm)$$

Cumulative mass calculates as a product of corrected objective mass and frequency. This mass must be less from daily allowed (recommended) mass, mass per hour or mass per minute (Nikolic & Bukta, 2013).

10.41(2) = 20.42 kg per minute (less than 30kg)

20.42 (50) = 1021 kg per hour (less than1500 kg)

1021 (8) = 8160 kg per day (less than 10.000kg) if a worker would work all day.

Results are documented in Appendix A. All the input data were given in Appendix A, Table 2: data about the firm, work environment, workplace, equipment, personal protection means, workers who worked with loads, description of job, technical data and other information necessary for profound knowledge about the work process, load, equipment and working conditions.

Appendix A, Table 3 and Table 4shows the data obtained about correction of loads and cumulative mass.

In accordance with the outlined goals, it can be concluded:

On the issue of correction of loads, the value of the reference mass is taken from the Standard (ISO/IEC 11228-1:2003; ISO/IEC 11228-2,:2003; ISO/IEC 11228-3:2003). The mass of 15 kg is the basis of the decision by management that permit women to work a specific job.

A value that allowed the mass of loads can be a maximum of 10.41 kg as obtained by the correction.

Since the specific weight, thickness and width of loads are known and a cutting tool for that width of grass is made, for a defined mass of loads, length of cutting the loads must not be larger than 33 cm.

Considering the time and duration of working time, there is no need for specifying work conditions in terms of organizing work-rest schedule and rhythm of work.

Documenting of the risk assessment of the manual handling of loads completely fits into the documentation system of the school method. The risk assessment of the manual handling of loads is represented on sheet 5 in appendix, after sheet three for work environment and the sheet four for workplace as specified in ARA.

Limitations

The main task of risk assessment methods was to provide an assessment of risks in every workplace and in every work environment. A good method should be comprehensive and should be applicable in various fields and in various conditions. Keeping in mind the variety of business systems and their elements, that was not a straightforward task. The risk assessment of different phenomena is always done within certain limits.

As shown in this paper, manual handling should be specific and the model should contain an additional step, the correction of load. There are several types of operation in manual handling of loads like lifting and carrying; pushing and pulling; and handling with low loads at high frequency. The methodology is not appreciably different and in this sense, limitations can be discussed.

Conclusion

In accordance with the set objectives/issues and with the results, it can be concluded that the evidence shows that knowledge management presents a new approach to solving practical problems. This paper emphasizes solutions that enable management to make decisions about the following issues:

- Selection of gender, age, and other characteristics of workers that should be considered to perform certain technological operations,
- Defining the shape and dimensions of the cargo,
- Organization of work and planning breaks and other time, and
- Quality of documentation.

These examples show a practical way of applying risk knowledge management in order to advance technology processes.

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Biography

Bozo Nikoliæ is a professor of professional studies, Novi Sad, Serbia. He teaches courses in the fields of mechanical engineering and labor safety. He received his PhD degree in mechanical engineering from the Belgrade University in 1998. His areas of expertise are metal cutting tools, accessories, and risk assessment in the workplace and workspace.

APPENDIX A

Table 2. Results

<table>
<tr><td colspan="2">Job/Workplace
Worker,
Worker assistant, Manual worker</td><td>Department:
Production</td><td colspan="2">Company:
JKP
Gradsko zelenilo</td><td>Sheet number:
5/1</td></tr>
<tr><td colspan="3">Operation:
Establishment of Green Spaces</td><td colspan="3">Material:
Grass with soil</td></tr>
<tr><td colspan="6">LOADS DESCRIPTION:
The load is a piece of cut grass, with soil together, dimension $30*5*33cm^3$ which is enrolled in a roll of length 30 cm and in that form worker handles with it.</td></tr>
<tr><td colspan="6">DESCRIPTION AND OPERATION CHART: A worker bends, takes the loads in a roll, lifts it to upright body position with hands streched close to body, carries the load a few meters, lifts the load to the level of chest, turns body for 45^{0} and passes the load to other worker or leaves it on a necessary place.</td></tr>
<tr><td colspan="6">CHARACTERISTICS OF OPERATION:
Frequency of lifting of loads is 2 times per min.
Work process lasts from one to 2 hours during working day
Route for carrying the grass is long up to 10 m
One day per week is a working day</td></tr>
<tr><td colspan="4" rowspan="2">Workers (number and names or other identification):</td><td colspan="2">Gender of worker:</td></tr>
<tr><td>female</td><td>Male</td></tr>
<tr><td colspan="4">Necessary conditions for work (professional qualification, additional knowledge, work experience..):</td><td colspan="2" rowspan="2">Personal protective means:
Protective shoes
Coat
Gloves</td></tr>
<tr><td colspan="4">Necessary conditions for work (working hours, number of shifts, special work experiences):</td></tr>
</table>

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Table 3. Corrections of Loads

COMPANY:	**Department:** production	**Job/Workplace:** Worker, worker assistant and manual worker	**Sheet number: 5/1A**	
Serial number	**CORRECTION OF LOADS**			**Remark - addendum**
	Description of correction	**Calculation of the correction factor**	**Value**	
1	Mass of loads appropriate	Reference mass of loads is less than 25 kg for men and 15 kg for women.	25.15kg	
2	Appropriate frequency and mass	Reference values of loads mass and frequency of lifting are determining from diagram 1.	21.15kg	
3	Distance of loads from body	If distance of loads (x) is larger than 0.25 m, loads mass must be corrected by coefficient $0.25/x$.	1	
4	Vertical position of loads	For lifting of loads on height of 0.75 m, mass of loads must be corrected $K_v = 1 - 0{,}3(/0{,}75 - v/)$.	1	
5	Height of vertical moving	Lifting of loads on height larger than $d > 0{,}25$ m requires correction of mass and weight $K_d = 0.82 + 0.045/d$	1	
6	Angle of asymmetry	For values of the angle of turning the body objective loads increases according K_α $K_\alpha = 1\text{-}2\ \alpha\ 0.003 = 1\text{-}2{*}45{*}0.003 = 0.73$	0.73	
7	Frequency of handling of loads	Correction K_f is determined from the Table 1	0.84	
8	Quality of accepting the loads	Increase of loads must be corrected by K_z	0.95	
9	Corrected mass of loads		0.73*0.84*0.95*15 m =10.41kg	
10	Cumulative mass of loads	It determines according to Table number 2	20.42 kg/min <30, 1021 kg/hour <1500 8160 кg/day <10000	

CONCLUSION: m = 15 0.73 0.84 0.95 = 10.41 кг, which is less than 15 kg.
It means that women can work on these jobs as well.
Cumulative mass is calculated as a result of corrected objective mass and frequency. This mass must be less than daily allowed (recommended) mass, mass per hour or mass per minute given in Table 2.
10.41(2) = 20.42 kg per minute (less than 30kg)
20.42 (50) = 1021 kg per hour (less than 1500 kg)
1021 (8) = 8160 kg per day (less than 10.000кг) if worker would work all day.

REMARK: For the last four assessments of state (motivation, knowledge and other, communication and support of management) it is necessary to take two negative (50 %), no matter the real state.

Table 4. (part 1) Assessment of State Protection

Person in charge: B.Nikolić	**Person in charge for security:** M.Beronja	**Analysts:**	**Expert/professional**

OBSERVED ELEMENTS FOR ASSESSMENT OF STATE OF PROTECTION

Does worker work with two hands ?	Is handling calmly without sudden speedup in handling of loads?	Does worker have full support for realizing a goal?	Is width of an object suitable for worker?	Are positions of body and moves in lifting of loads usual?	Is the ground slippery or unstable?	Is there anything physically harmful?	Is there anything which can be chemically harmful?	Is only one worker at workplace t	Is there full contact of worker's feet with the ground?	Are there other working tasks during handling of loads?	Is the object with which worker handles cold, hot, dirty, slippery or contaminated?	Are microclimatic parameters and light at workplace suitable ?	Is road at workplace observable (because of dimension of loads)?	Is gravity of loads allocated in expected manner?	Is there stability of loads - loads doesn't move during handling?	Can shape and content of loads cause injures?	Are the size of workplace and route for carrying the loads suitable?	Is the ground flat?	Is there any slope or more levels for moving?	How the workers' motivation looks like?	Describe kind of knowledge, capabilities, skills, characteristics, health and age of workers?	Does the quality communication exist at workplace?	Describe the support of management?
+	+	+	+	+	-	-	+	+	-	+	-	+	+	+	+	+	+	-	-	-	-	-	-

Table 4. (part 2) Assessment of State Protection

Consulted worker	**Connection with other documents:** Act on risk assessment Systematization	**Date of creation:** December 2013.	**Number of document**	**Sheet number** 5/1B

RISK ASSESSMENT				**RISK MANAGEMENT**		**RESIDUAL RISK**					
Probability $0{,}06\left(\frac{n}{N}\cdot 8\right)^{2{,}7}$	**Frequency**	**Damage**	**Risk**	**Quality risk assessment**	**Recommended measures for reducing**	**Probability** $0{,}06\left(\frac{n}{N}\cdot 8\right)^{2{,}7}$	**Frequency**	**Damage**	**Risk**	**Conclusion**	**Recommended measures for maintaining the risk on appropriate level**
0,85	**1,5**	**2**	**2,55**	**negligible**	**no**						