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Review paper

ONE APPROACH TO RISK MANAGEMENT MODELLING: A CASE STUDY

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Abstract. *Safety in the use of available resources requires serious consideration of test and evaluation strategies that provide an accurate assessment of risks. Risk management, as a continous process involves different aspects of possible hazards. In this paper, we present a general modelling of risk management through modelling of identification, analysis and risk evaluation. A grade for quantitative classification of risk is defined, which enables a clear distinction between the case when the risk is low and its assessment is not required and the case of extremely high risk which is practically impossible to reduce. The proposed model is applied to the real world case study as the analysis of risk for the environment of a driver. Based on the collected data, regarding the difficulty of work, emotional and mental load, micro climate parameters and amount of light, hazards are identified, established and risk levels of potential undesired events are assessed.*

Key Words: *risk-based approaches, risk management, modelling, risk level.*

INTRODUCTION

Risk assessment is, according to the existing regulations and directives (Direktiva EU 89/391 EEC, OECD studies in in risk management, 2006, etc), based on the systematic record-keeping and estimation of potential factors and possible types of hazards at work and in the working environment which can cause injuries at work, professional diseases, diseases related to work and other diseases of employees. The term risk management is also used to denote the process of identification, control and reducing the risk to an acceptable level in the context of the existing social and economic factors. The key characteristic of this process is the interdependence of the technical and technological as well as management aspects. It is important to keep in mind the role of the state as the regulator

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of the process, which can significantly affect the business environment with positive regulations. Risk management also combines the measures and procedures of prevention, preparation and response to the appearance of accident, as well as repair of the existing situations in order to create the conditions in which risk is acceptable. Therefore, risk management represents a combination of several analyses whose aim is to safely use the available resources by using the risk assessment results. In that sense Kennedy (2002) states that risk management involves economic, legal, political, health, social and other aspects of possible hazards and that it represents a continuous process. Authors Bonic and Djordjevic (2012) state that the potentials of internal auditing in risk management are determined by the scope of internal auditing and are linked to the providing of the assurance of efficacy and effectiveness of risk management process.

There is no doubt that approaches based on *RBA* (*Risk-Based Approaches*) which are used in functioning, control, maintenance and management of work and similar processes represent an important element in contemporary working conditions. According to many authors (Andjelkovic and Stankovic, 2001, Gotoh and Konno, 2000, Jenkins-Smith and Kunreuther, 2001, Sarin and Wakker, 1998, Vujosevic, 2008), standards (Australian/New Zealand Standard, 2004 and 2005, American National Standard, 2005, European Agency for Safety and Health at Work, 2006) and the results gathered from the practice, one model and one aspect of the RBA application are presented in this paper.

This paper is organised in the following way: after the introduction, in Part 2 a theoretical background of research is presented in the form of a review of the bibliography used. Part 3 is related to modelling of identification procedures, analysis and risk evaluation. In Part 4 of the paper, a real world case study is presented: the analysis of risk for the work place of a driver. The Final Part of the paper presents the key considerations.

2. THEORETICAL BACKGROUND OF THE REASERCH

European Union practice, as well as the process of development of certain projects (Rimap, Saferenet, Fitnet, Trends and others), and according to some authors (Betford and Cooke, 2001, Cox, 2002), has raised a number of important questions from several areas related to RBA. These are:

- Laws and standards;
- Data reliability;
- Human factor;
- Risk management expenses;
- Age of factory and the amortization level;
- Requirements for safe and compatible equipment, special tools, etc.

Laws and standards come first in this list because they are vague and are not defined well. Moreover, laws and standards related to designing and production are developed and harmonised at the European level, while the laws related to inspection/control and maintenance are present solely at the national level.

Data reliability is very important for *RBA* so it is necessary to find information and advices about hazards and risks relevant to particular industries and according to Australian Government statutory agency (2011), information and advices are available from regulators, industry associations, unions, technical specialists and safety consultants. Manufacturers and suppliers can also provide information about hazards and safety precautions for specific processes (instruction manuals).

Based on HM Treasury United Kingdom's economics and finance ministry (2004), managers at each level need to be equipped with appropriate skills which will allow them to manage risk effectively and the organisation as a whole needs a means of being assured that risk management is being implemented in an appropriate way at each level. According to The World Bank Transport Note (2005), first step towards effective risk management is risk registration, which includes:

- recognition that a particular set of risks are relevant in planning and implementing;
- identification of these risks, and at a very basic level, indication of factors that are linked to those risks

When a risk is identified, it's first assessed to ascertain the probability of occurring, the degree of impact to the schedule, scope, cost, and quality, and then prioritized. Risk events may impact only one or while others may impact the project in multiple impact categories. According to HHS (U.S. Department of Health & Human Services) the probability of occurrence, number of categories impacted and the degree to which they impact the project will be the basis for assigning the risk priority. All identifiable risks should be entered into a risk register, and documented as a risk statement.

RBA appeared in the late 1970s of the 20th century, first in the petrol and chemical industries, and later it was widely used in the nuclear plants in Europe and Japan, as stated by Marais and Wecker (1998). Today it is widely used in nuclear plants, multinational companies and small-sized companies. Certain industries, such as processing and chemical industries, and nowadays more and more energy and oil industry, set the risk of fault as the basis for managing production process. The reason for this lies in the potential advantages of risk management, such as:

- Increase of safety and reliability of factory; and
- Decreasing the expenses of maintenance by eliminating inefficient procedures and increasing the inspection intervals.

According to European medicines agency (2013), *RBA* is used for medical equipment and should result in a more cost effective use of resources. As stated in RBA Guidance for accountants (2008), countries will need to make their own determinations to apply a risk-based approach. This method is very important for understanding the risk of maintenance and how it impact on the quality, safety and efficacy of activities.

Identifying hazards in the workplace involves finding things and situations that could potentially cause harm to people. According to Australian Government statutory agency (2011), it is very important to consult workers about potential hazards. Hazards generally arise from the following aspects of work and their interaction:

- physical work environment;
- equipment, materials and substances used;
- work tasks and how they are performed and
- work design and management.

In OHSAS 18001, it is stated that, when it comes to thermal powerplants, maintenance of boilers and watersupply (pipes) during the life cycle reaches 10% of total maintenance of the entire factory. Moreover, additional expenses caused by risk management and potential hazards can be such that they can endanger the profitability of the functioning of the entire factory. This is why it is important to find the right balance among:

- the aims reached by the measures for risk reduction;
- expenses of risk reduction measurement application;
- ratio of price/profit (expected benefits from the given activities).

In that sense, the general aim of risk assessment, according to Kennedy (2002), is to enable health protection of the employees by planning and administering the corrective preventive measures, such as:

- selecting safe raw materials and materials which are used for work;
- safe organization and work regime;
- maintenance of working equipment so that is functions properly;
- securing prescribed conditions for safe work;
- capacitating employees for safe work;
- providing adequate means for general and personal protection of employees at work;
- preventive medical examination of workers;
- informing workers about the risks and measures for protection during work, etc.

The law does not expect organizations to eliminate all risk, according to Health and Safety Executive – HSE (2011), but it is required to protect people as far as reasonably practicable. Based on RBA Guidance for accountants (2008), focusing on higher risk threats should mean that beneficial outcomes could be achieved more effectively.

When the failure mode occurs, according to Moubray (1997), it is important to have all relevant information about the hazard, so the questions should be:

- what is the evidence the failure has occurred;
- in what way does it pose a threat to safety or the environment;
- in what way does it affect production or operations;
- what physical damage is caused by the failure;
- what must be done to repair the failure.

Act on risk assessment should serve as a basis for forming appropriate written instructions, instructions and orders, which secure that the employees do their work in a safe way and in accordance with the regulations. Based on the results of the conducted risk assessment, the improvement of the existing condition should be secured; that is, raising the level of safety and health at work in a working environment to the prescribed level.

3. MODELLING OF IDENTIFICATION, ANALYSIS AND RISK EVALUAITON

By risk identification a set of potential risks in the system is identified as well as their causes, that is occurrence scenario. Risk identification should cover all risks in the system, risks caused by environment and outer factors, as well as occasional risks. The aim of risk identification is to provide data for analysis processes and risk evaluation.

It should be stressed that there is no universal approach to the risk identification process, which would guarantee efficiency of the process in all situations. Company management should, based on their knowledge and experience, create or choose a model of risk identification, which is the most suitable one for the organization in question. Moreover, the management should develop the ability of the organization to identify risk by using various techniques and tools. Possible techniques for risk identification are: check lists, professional judgement, process flow charting, brainstorming, system analysis, scenario analysis, hazard and operability studies, third party risk analysis, management oversight and risk tree, FTA (Fault Tree Analysis), FMECA (Failure Mode Effects and Criticality Analysis), RCA (Root Cause Analysis), etc.

After risk identification is completed, risk analysis should be conducted to provide necessary information for its evaluation on the basis of which the decisions about safety are made. Risk analysis consists of:

- description of the issue that is being analysed;
- identification of staff which conducts risk analysis; and
- data from the analysis.

For each identified hazard, by using criteria from the risk management plan, a decision must be made on whether the risk is low and its reduction is unnecessary. In that sense, the concept of risk consist of three components:

- probability of hazard occurrence; that is, how often it can occur,
- consequences of this hazard; that is, its significance and
- frequency of the accident occurring.

Methods, which could be used, for determining an acceptable risk are the following:

- using internal standards which can point out the acceptability of a certain type of product or individual risk;
- following appropriate instructions, for example using the single failure philosophy (IEC/TR 60513:1994);
- comparison of risk levels with the data of machines and equipment being used.

In that sense, a clear distinction must be made between the case when the risk is low and its assessment is not required and the case of extremely high risk, which is practically impossible to reduce. With the first case, the decision on whether the risk is so low that its reduction is unnecessary should be made once for each identified hazard. The stages of risk assessment present this clearly. After the stage "Choosing the optimal option" or "Verification of the assessment draft" the entire process can be brought back to additional consideration (Figure 1).

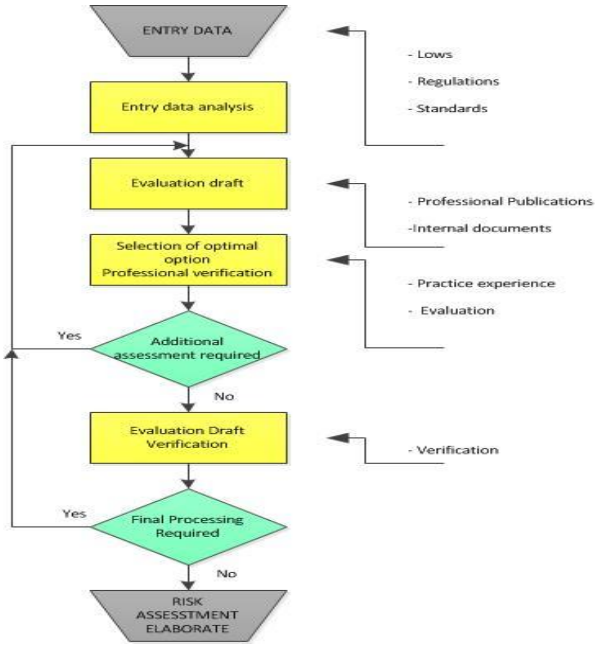

Fig. 1 Risk assessment steps

A grade used for quantitative classification of risk represents the result of multiplication of the grade of hazard occurrence probability and the grade of the damage significance level. Based on the grade, risk (according to SRPS EN 1050, 2005), can be classified into three areas (Figure 2):

- the area of wide acceptability,
- ALARP (As Low As Reasonable Practicable); that is, the area of anticipated low values and
- the area that is not tolerated.

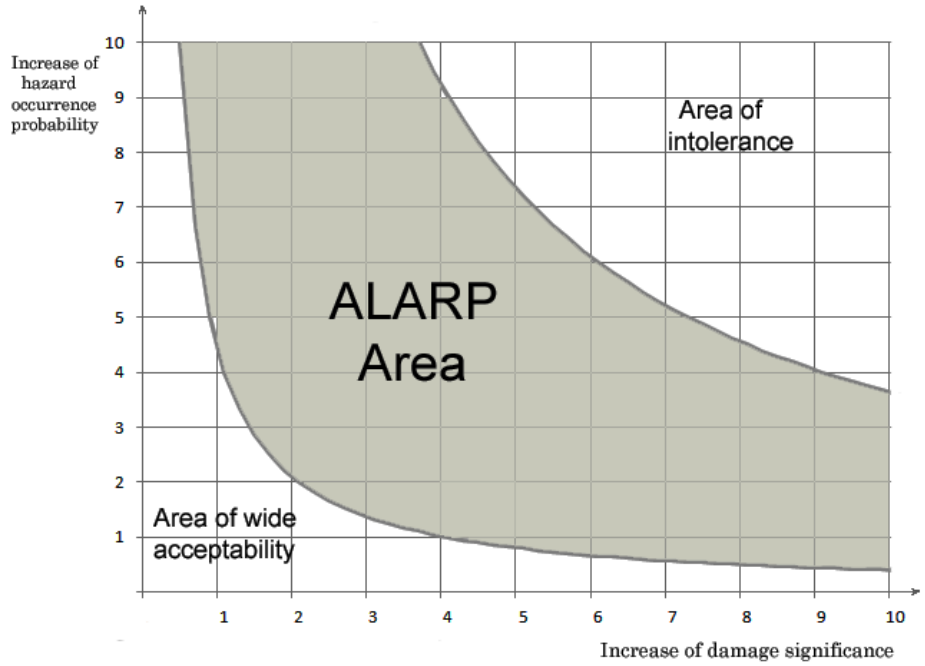

Fig. 2 Three risk areas

Area of wide acceptability (risk grade ≤ 4): Risk is so low that in comparison with other risks it is insignificant. In this case, risk can be considered acceptable.

ALARP area (4 < risk grade ≤ 36): Risks in this area should be analysed by taking into consideration the consequences of risk reduction, which have technical and economical aspects. Risk is acceptable if the benefit exceeds the risk. If risk is not compensated though benefit, it is not acceptable.

Area of intolerance (36 < risk grade ≤ 100): Area in which there is no risk tolerance. However, it is important to point out that in some cases risk cannot be reduced.

Based on everything stated above, a general model of risk management can be defined (Figure 3) which should not be regarded as universal. However, by applying the situational approach, it can serve as a basis for generating a model in concrete situations.

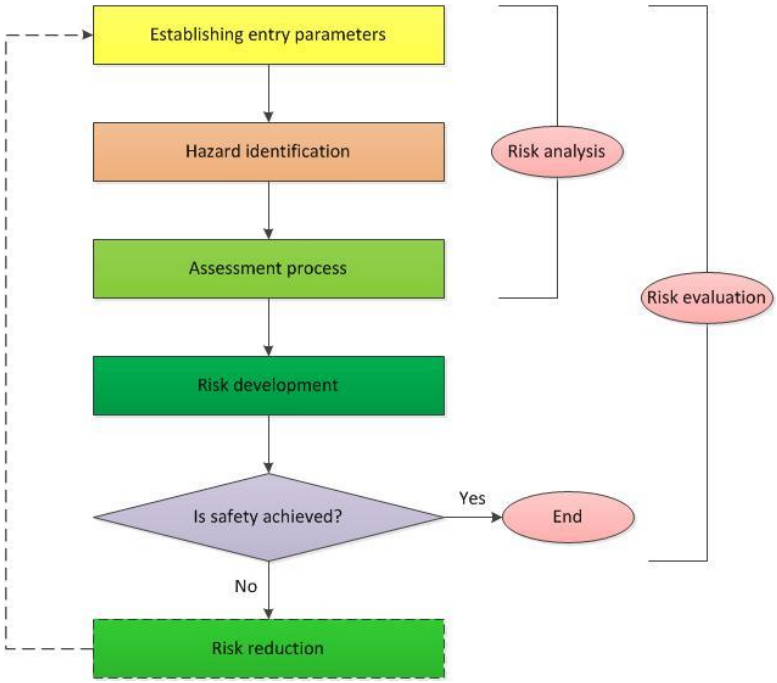

Fig. 3 Risk Management Model

4. Case Study: Risk Assessment for the Work Place of a Driver

For risk assessment for the work place of a driver, based on Hopkins, (2005), and Marais and Wecker (1998), SME method is used. Regarding the difficulty of work, it can be said that the employee's work is dynamic, occasionally monotonous; the rhythm is dictated by the needs of the user. Regarding the emotional load, it is stated that negative emotional factors are present during work as a result of higher level of responsibility. When it comes to mental load, it is stated that the quantity of information, which is to be mentally processed, is lower than the capacity of the central nervous system. Microclimate parameters are in the comfort zone for summer and winter periods (air-conditioned and heated premises). Measured value of light is in accordance with prescribed values. Based on everything stated above, it can be concluded that for performing of the required works and tasks, an employee must have at least average capabilities and psychosensory functions.

Based on the collected data, hazards for the work place of a driver and in the working environment are identified and established and risk levels of potential undesired events are assessed (Table 1). In doing so, the risk level *(R)* is determined as follows:

$$R = C \cdot P \cdot F$$

Where are:
C – consequence or expected measure of damage,
P – probability of the accident occurring and
F – frequency of the accident occurring.

For quantitative classification of the consequence level, grades from 1 to 10 are used. However, grade 1 is used for hazards whose consequence is minimal. For quantitative classification of the probability of accident occurrence, grades from 0 to 10 are used. Grade 0 denotes hazards, which cannot appear for the work place in focus, and grade 1 denotes hazards with the minimal probability of appearance. Also, the frequencies of the accidents occurring are valuated from 1 (per year), 2 (monthly), 3 (weekly) to 6 (daily). The consequence measures of hazards, the probabilities of occurrence and the related frequencies should be estimated by the company for each possible hazard taking into consideration short-term and long-term effects.

Table 1 Hazards and risk levels

Ordinal number/ Code of hazard	IDENTIFIED HAZARDS	RISK EVALUATION			
		C	P	F	Risk level R = C · P · F
1/03	Internal transport and driving a vehicle within the factory and in public transport	2	1	6	Acceptable 12
2/04	Usage of dangerous materials (for example petrol) which can start a fire or explosion	2	0,5	2	Acceptable 2
3/07	Contact with dangerous surfaces (floors and all types of stair treads), contact with surfaces when working on field or in buildings, (floors, cases vehicles, machines and devices, staircases and similar), which have sharp edges, coarse, slippery or greasy surfaces or bulging parts.	1	3	6	Acceptable 18
4/10	Possibility of sliding on wet, icy, snow covered entrances, pedestrian walkways and roads of communication.	2	6	1	Acceptable 12
5/10	Possibility of sliding or stumbling when moving in limited working space.	1	3	6	Acceptable 18
6/13	Possibility of falling down the stairs in the working space.	1	3	6	Acceptable 18
7/13	Handling especially dangerous means of work.	3	3	3	Low 27
8/14	Snake, bee, tick, wasp bite, etc. in the open space	2	6	3	Low 36
9/15	Hazards from direct contact with parts of electrical installations and equipment under voltage	6	0,5	6	Acceptable 18
10/16	Hazard from indirect contact with metal masses which come in contact with electricity when out of order	6	1	6	Low 36
11/22	Noise produced by the working devices with motors	1	3	6	Acceptable 18
12/27	Hazardous micro climatic influences when working outdoors (petrol stations, warehouses, etc.)	1	6	3	Acceptable 18
13/30	Effort and physical strain (manual transport of load, various prolonged increased physical activities, etc.)	1	6	3	Acceptable 18
14/31	Positions that are not physiological (prolonged sitting and standing)	1	3	6	Acceptable 18
15/33	Responsibility when receiving and transmitting information, application of appropriate knowledge and skills.	1	3	6	Acceptable 18
16/32	Strains when completing working tasks (monotony-stress)	1	3	6	Acceptable 18
17/33	Conflict situations at work with clients and other employees	1	6	3	Acceptable 18
18/34	Working longer than full working time and working during holidays and weekends.	1	3	6	Acceptable 18
19/34	Standby duty or on-call duty	1	10	2	Low 20

Based on the assessed risks, the measures for removing, reducing or preventing risks are presented in Table 2.

Table 2 Measures for removing, reducing or preventing risks

Ordinal number/ Code	Risk Level	Measures	Time period for conducting measures
9/13	27	Strict application of safety rules when using dangerous means of work	Continuously
10/14	24	Using appropriate protective working shoes and clothes	Continuously
12/16	36	Regular control of electric installations, control of electric cables for devices and equipment	Continuously

By analyzing hazards at the work place of a driver and in the working environment and by risk assessment, it was established that the majority of risks is in the area of acceptability and there are no risks that belong to the area of intolerance. For hazards with the risk level of $R \leq 20$, it is not suggested to conduct any special measures for removing, reducing or preventing risk. Mandatory use of protective hygienic and sanitary measures and means of personal protections prescribed at the work place.

5. CONCLUSION

The basic principle in every hazard analysis is that there are no working activities without risk. Risk management is a complex and specific activity, which requires multidisciplinary approach. The success of analysis and setting up of an efficient system for risk management depends on several factors. The team which conducts the analysis must have the necessary knowledge required to complete the task in a quality way. It should consist of professionals, who are familiar with the methodology of risk assessment, technological process in focus, occupational and health safety, fire protection, environmental protection, etc.

The basic conclusion of the research is that the suggested risk management model consists of a larger number of simultaneous and sequential activities at different organizational levels which are realized through various activities and methods with the application of specific criteria and recommendations for those work positions which have increased risk of injuries, development of professional diseases and damage to health. In addition to this, economic profitability from adequate and professional risk assessment should not be neglected. This means that nowadays risk no longer represents just the question of safety or the question of the level or the amount of application of regulations and procedures, but that it has become an economic category as well.

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JEDAN PRISTUP MODELIRANJU UPRAVLJANJA RIZIKOM: STUDIJA SLUČAJA

Bezbednost korišćenja raspoloživih resursa zahteva pažljivu primenu strategija za testiranje i evaluaciju koje obezbeđuju preciznu procenu rizika. Upravljanje rizikom, kao kontinualan proces, obuhvata različite aspekte mogućih rizika. U ovom radu je predstavljen opšti model upravljanja rizikom putem modeliranja identifikacije, analize i evaluacije rizika. Definisana je mera za kvantitativnu klasifikaciju rizika koja omogućava preciznu distinkciju slučajeva kada je rizik mali i procena nije potrebna od slučajeva ekstremno visokog rizika kojeg je praktično nemoguće redukovati. Predloženi model je primenjen na studiji slučaja analize rizika u okruženju vozača. Rizici su identifikovani i definisani na osnovu prikupljenih podataka koji se odnose na težinu posla, emocionalan i mentalni naboj, mikro klimatske parametre i količinu osvetljenja u okruženju. Takođe su procenjeni nivoi rizika mogućih neželjenih događaja.

Ključne reči: *pristupi zasnovani na riziku, upravljanje rizikom, modelovanje, nivoi rizika*