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UTICAJ LJUDSKOG FAKTORA NA RIZIK U RUDNIKU POVRŠINSKOG KOPA

INFLUENCE OF THE HUMAN FACTOR ON RISKS IN AN OPEN-PIT MINE

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Ključne reči
- rizik
- ljudski faktor
- pravila i procedure

Izvod

Današnji turbulentni uslovi poslovanja se odlikuju brzim tehnološkim razvojem "post-industrijskog društva". Nove tehnologije uslovile su stvaranje novih rizika u kompleksnim tehno-društveno-ekološkim sistema i do sada je urađeno dosta posla u cilju da se odgovori na tehnološke i tehničke zahteve za bezbednošću. Ljudski faktor sa svojim ograničenjima i mogućnostima sada postaje centralna tema u istraživačkim studijama o riziku i sigurnosti. Ova studija prezentuje istraživanje koje se bavi rizikom ljudskog faktora, sprovedeno u stvarnom visokorizičnom industrijskom sistemu.

Keywords
- risk
- human factor
- rules and procedures

Abstract

Today's turbulent business conditions are characterized by rapid technological development of the 'post-industrial' society. New technologies have caused the creation of new risks in complex techno-socio-ecological systems and up to today a lot of work is done in the aim to answer to safety demand of technology and technical equipment. After all this, human factor with its limitations and possibilities is becoming the central topic in research studies about risk and safety. This study presents study about risk of human factor, conducted in the real, high risk industrial system.

UVOD

Savremena civilizacija je svojim zahtevima stavila čoveka u situaciju prevelike napregnutosti jer je očito da je unutrašnja transformacija pojedinca mnogo komplikovaniji proces od tehnološke transformacije.

Ubrzan tehnološki razvoj u XX i XXI veku doveli su do povećanih rizika u svim vidovima poslovanja. Novi rizici nastaju iz novih tehnologija, procesa i organizacije, iz novih načina primene postojećih tehnologija i od nepredviđenih konteksta ili događaja. Sa rastom broja rizika i kompleksnosti tehnološko-humanih sistema raste i broj potencijalno ugroženih ljudi, životne sredine i materijalnih resursa.

Pritisak zahteva svakodnevnog života nameće čoveku ritam koji je gotovo nesavladiv bez stresa. Sistem vrednosti moderne civilizacije upotrebio je sva sredstva da čoveka učini ambicioznijim. A onda se između njegovih očekivanja i mogućnosti pojavljuje prostor individualnog rizika, prostor u kojem se pojedinac više ne pojavljuje kao gospodar sopstvene situacije, /1/. U nametnutim okolnostima, on gubi sigurnost čoveka koji bi trebalo da realizuje svoj izbor.

RIZIK I BEZBEDNOST

Slika 1 prikazuje kompleksnost različitih uticaja na procenu rizika i bezbednosti. Na stabilnost privrednog sistema u odnosu na rizik utiču, sem delatnosti sistema koja može biti sama po sebi više ili manje osetljiva na rizik, i postojeće državne i kompanijske regulative, korporativna kultura, postojeće iskustvo o određenim tipovima rizika u zemlji i kompaniji, edukacija o bezbednosti i sami radnici.

INTRODUCTION

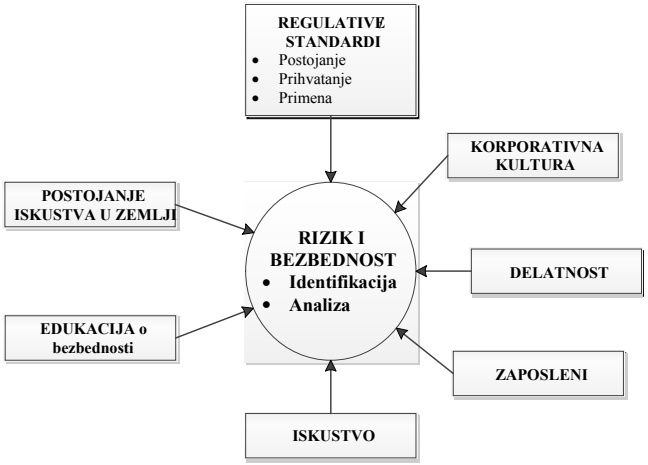
The demands of modern civilisation have put mankind into an extremely stressful situation since it is obvious that the inner transformation of an individual is a process far more complicated than a technological transformation.

Rapid technological development in the 20th and 21st century lead to increased risks in all forms of business. New risks arise from new technologies, processes and organisations, from new ways of applying existing technologies and from unpredicted contexts or events. With the increase in number and complexity of risks, number of endangered people, environments and material resources also increase.

Pressure made by demands of everyday life imposes a rhythm which is nearly insurmountable without stress. System of values of modern civilisation used all of its means to make man more ambitious. And then, between expectations and possibilities, a space for individual risks occurs, where an individual is no longer in control of his own situation, /1/. Governed by the circumstances imposed, people lose the certainty with which they should realize their own choices.

RISK AND SAFETY

Figure 1 shows the complexity of various influences on risk assessment and safety. Stability of an industrial system in terms of risk is affected by both activities of the system, which may be more or less risk sensitive, and the existing state and company regulative, corporative culture, existing experience in certain types of risks in the country and company, education on safety and the workers themselves.



Slika 1. Faktori koji utiču na bezbednost sistema, /2/

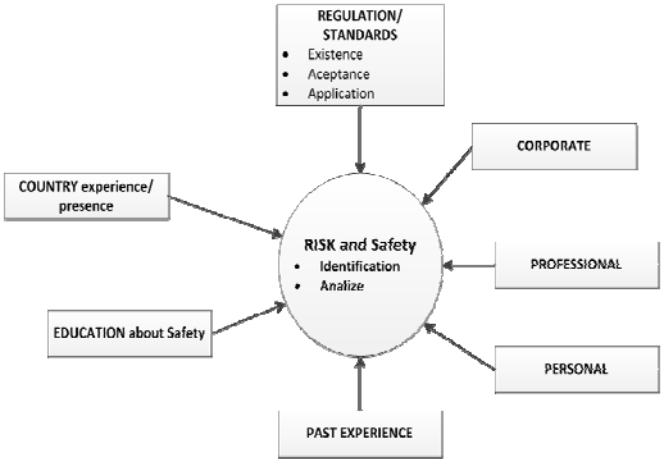


Figure 1. Factors that influence system safety, /2/.

Upravljanje rizikom sve više se standardizuje i pri tome se najčešće koriste standardi:

- ISO 31000 2009 - principi upravljanja rizicima i smernice
- Upravljanje rizikom Standard – IRM / Alarm / AIRMIC 2002 - razvijen 2002. od strane 3 glavne britanske organizacije rizika.
- ISO / IEC 31010: 2009 - Upravljanje rizikom - tehnike za procenu rizika
- COSO 2004 – Integrisani pristup upravljanja rizikom preduzeća
- OCEG „Crvena knjiga“ 2,0: 2009 - Upravljanje, rizik i usaglašenost - model sposobnosti.

RIZIK I LJUDSKI FAKTOR

Kada se govori o upravljanju rizikom, „ljudski faktor“ podrazumeva prikupljanje i analizu informacija o ljudskim sposobnostima, njihovim ograničenjima i drugim karakteristikama u kontekstu posla koji obavljaju, njihove međusobne interakcije i interakcije sa mašinama, sistemima i okruženjem u cilju da se realizuje bezbedan radni proces. Ljudi pokreću mašine, prave i podešavaju organizaciju procesa rada i primenjuju pravila i procedure. Dok se tehnologija i procesi rada danas menjaju brzo i relativno lako, za ljude to ne važi.

Savremena istraživanja koja se bave bezbednošću opisuju strategiju bezbednosti i otpornost kompanije u bezbednosnom smislu kao kombinaciju dva pristupa:

- Planski-vođen, pozitivni pristup koji naglašava uspeh i dostignuća u radnom procesu (glavni indikatori)
- Učenje iz iskustva, bazirano na refleksiji dešavanja iz prošlosti pri čemu se pronalaze modeli najbolje prakse iz prethodnih perioda (indikatori iz iskustva).

U slučaju pojave incidenta dolazi do transformacije normalnih uslova rada koji uz neočekivani događaj prelaze u nenormalne uslove rada. Ukoliko tada dođe do propusta u kontroli, ili analiza mogućih hazarda nije predvidela takav scenario, dolazi do gubitka kontrole nad radnim procesom. U slučaju da je odbrana sistema nedovoljna ili je uopšte nema, dolazi do nesreće sa posledicama koje ona izaziva. Incident može zahtevati isključenje proizvodnog sistema ili njegov smanjen rad.

Risk management is becoming more and more standardised, wherein the following standards are used:

- ISO 31000 2009 - Principles of risk management and guidelines
- Risk management standard - IRM/Alarm/AIRMIC 2002 - developed in 2002 by three main risk organisations in the UK
- ISO/IEC 31010: 2009 - Risk management - risk assessment techniques
- COSO 2004 - Integrated approach to company risk management
- OCEG “Crvena knjiga” 2,0: 2009 - Management, risk and compliance - capability model.

RISK AND THE HUMAN FACTOR

When speaking of risk management, the ‘human factor’ involves gathering and analysing information about human capabilities, limitations and other characteristics in terms of the work they perform, their mutual interaction and interaction with machines, systems and the environment for the purpose of realising a safe work process. People activate machines, make and adjust the organisation of work processes and apply rules and procedures. While technology and work processes change quickly and relatively easily today, this does not apply to people.

Modern research dealing with safety describes a safety and resistance strategy of a company in terms of safety as the combination of two approaches:

- A planned, positive approach which emphasizes success and achievements in the work process (main indicators)
- Learning from experience, based on reflection of past events, wherein models with best practice from previous periods are identified (experience indicators).

In case an incident occurs, there is a transformation of normal working conditions which turn into abnormal conditions due to an unexpected event. In case there is an oversight in control, or a scenario that was not predicted by the possible hazard analysis, control over the work process is lost. In case the system defence is insufficient or non-existent, an accident will occur, along with the accompanying consequences. The incident may require the production system shutdown or its reduced work.

Kada je 'Nacionalni odbor inspektora za kotlove i posude pod pritiskom' u Americi standardizovao svoj proces izveštavanja za prikupljanje statistike incidenata 1991. bio je u cilju stvaranja tačne i konzistentne baze podataka koja je, tokom vremena, omogućavala davanje verodostojnog načina identifikovanja i ispravljanja uzroka nesreća u vezi kotlova i posude pod pritiskom. Podaci iz 2002. godine su pokazali da je od 23 338 nesreća zabeleženih u proteklih 10 godina, 83% bilo direktan rezultat greške ljudskog nadzora ili nedostatka znanja (tj. nepravilne instalacije, nepravilnog remont, greška operatera ili loše održavanje, ne reagovanje na nizak nivo vode). Ljudski nadzor i nedostatak znanja su takođe odgovorni za 69% povreda i 60% izazvanih smrtnih slučajeva, /3/. Ljudska greška je dokumentovana kao primarni uzrok na više od 70% komercijalnih avionskih nesreća, /4/. Termin „ljudski faktor" se u literaturi koristi sa različitim značenjima. Uobičajeno se ljudski faktor bavi interfejsom čovek-mašina i prvi put se sam termin upotrebio u studiji o interakciji čoveka i mašine. Danas se pojam *ljudski faktor* koristi u širem smislu.

Prilikom analize elastičnosti pojedinih faktora rizika koji se odnose na ljudski faktor, povećana pažnja se posvećuje i kulturološkim faktorima. Istraživanje o definiciji i funkciji kulture (na primer: Hall, Adler, Hofstede, Trompenars Levis, Schvartz) su pokazala da svaka grupa ili kategorija ljudi razvija kulturne vrednosti i norme. To treba imati u vidu kada se upravlja aktivnostima u oblasti zaštite životne sredine, bezbednosti i rizika.

Sistemi za upravljanje rizikom su uglavnom orijentisani na radnika i u suštini upravljaju na bazi percepcije u cilju obezbeđivanja dobrih performansi, a percepcija nije realnost, ni činjenice.

U današnjoj eri globalizacije kada u kompanijama postoje različiti kulturni obrasci, menadžment treba da razmišlja i o interakciji organizacione kulture sa kulturnim ograničenjima na radnom mestu prilikom izgradnje korporativnih i tehničkih kulturnih koncepata. Po Hofstedu, „percepcija rizika" je najrelevantnija kategorija među dimenzijama nacionalne kulture kada je u pitanju bezbednost.

Što se tiče kulture bezbednosti u kompanijama, ostaje da se razvija kontigentan, delotvoran model koji će analizirati sigurnosnu kulturu u skladu sa kulturnim dimenzijama, specifičnim vrednosnim sistemima i organizacionim praksama.

Mnogi inženjeri su zbunjeni potrebom analize ljudskog faktora, jer ne postoji jasno definisano područje istraživanja ljudskog faktora. U cilju definisanja istraživačkog prostora vezanog za ljudski faktor, treba razmotriti interakcije ljudi sa drugim komponentama procesa kao što su:

- Interakcija sa drugim ljudima
- Interakcija sa radnim zadacima
- Interakcija sa propisima, pravilima i procedurama
- Interakcija sa okruženjem na radnom mestu
- Interakcija sa mašinama i opremom
- Interakcija sa komunikacionom tehnologijom
- Interakcija sa rukovodiocima

When the 'National board of boiler and pressure vessels inspectors' in America standardized their reporting process for gathering incident statistics in 1991, it was done for the purpose of creating an accurate and consistent database that would over time enable a trustworthy way of identifying and correcting the causes of accidents related to boilers and pressure vessels. Data from 2002 indicate that, out of 23 338 accidents recorded in the previous ten years, 83% were directly caused human supervision errors or lack of knowledge (i.e. due to inadequate installations, repairs, operator errors or poor maintenance, ignoring low water levels). Human supervision and lack of knowledge are also responsible for 69% of injuries and 60% of fatalities /3/. Human error is documented as the primary cause of more than 70% of commercial flight accidents, /4/. The term 'human factor' is used in literature with different meanings. Typically, the human factor deals with the man-machine interface and the term was first used in the studies about the interaction between man and machine. Today, the term *human factor* is used in a much broader sense.

During the analysis of elasticity of certain risk factors related to the human factor, increased attention is devoted to culturological factors as well. Research about the definition and function of culture (e.g. Hall, Adler, Hofstede, Trompenars Levis, Schvartz) have shown that each group or category of people develops cultural values and norms. This needs to be taken into account when managing activities related to protecting the environment, safety and risks.

Systems for risk management are typically worker-oriented, and essentially based on perception for the purpose of ensuring good performances, however perception is neither a reality nor a fact.

In today's era of globalisation, when companies include various cultural patterns, management should consider the interaction of the organisation culture with the limitations in the workplace during the building of corporative and technical cultural concepts. According to Hofstede, 'risk perception' is the most relevant category among the dimensions of a national culture when it comes to safety.

As for the safety culture in companies, there is a need to develop a contingent, effective model which will analyse the safety culture in accordance to cultural dimensions, specific value systems and organisational practices.

Many engineers are confused by the need to analyse the human factor, since there are no clearly defined areas of research for it. In order to define the research field related to the human factor, interactions of people with other process components need to be considered, including:

- Interaction with other people
- Interaction with work tasks
- Interaction with regulations, rules and procedures
- Interaction with the work environment
- Interaction with machines and equipment
- Interaction with communication technology
- Interaction with the managers

ISTRAŽIVANJE LJUDSKOG FAKTORA U RUDNIKU POVRŠINSKOG KOPA UGLJA

Mesto istraživanja

Istraživanje je sprovedeno u rudniku površinskog kopa uglja, u toku radnog vremena, na radnom mestu ispitanika, koristeći specijalno za tu priliku izrađen upitnik. U samom rudniku, procena rizika na radnom mestu se vidi kao proces koji, uzimajući u obzir sve aspekte rada i radne uslove, određuje rizik od povreda ili oštećenja zdravlja zaposlenog, /4/.

Kao prvi korak u identifikaciji opasnosti izvršena je identifikacija svih procesa u organizaciji za koje se pretpostavlja da imaju visok nivo rizika.

Vrednovanje nivoa rizika je izvršeno tako što su za specifične korake u procesu rada primenjeni sledeći kriterijumi:

– verovatnoća pojavljivanja,
– kriterijum zdravlja i bezbednosti na radu,
– poštovanje zakona i propisa,
– kriterijum odnosa sa okruženjem,
– kriterijum izloženosti riziku.

Analiza povrednih listi je izvršena za period 2003–2007. godine i na osnovu utvrđenih povreda određen je nivo rizika i njihova mogućnost nastupanja događaja i pri tom su sagledani sledeći parametri:

– kako identifikovati moguće udese na radnom mestu,
– verovatnoća nastupanja događaja,
– priroda povrede nastale pri udesu,
– broj lica zahvaćenih povredom.

Kategorizacija radnog mesta sa visokim rizikom se određuje aktom o proceni rizika i to je takvo radno mesto na kome i pored potpuno ili delimično primenjenih mera bezbednosti postoje okolnosti koje mogu da ugroze bezbednost i/ili zdravlje zaposlenog.

Analiza rizika se vrši kvalitativno-kvantitativnom metodom, dodeljivanjem vrednosti rizika na skali od 1 do 100. Pri tome se formira 5 kategorija rizika, /5/:

- 0-20 nizak rizik,
- 21-40 dozvoljen rizik,
- 41-60 umeren rizik,
- 61-80 povećan rizik,
- 81-10 visok rizik.

Kvalitativna analiza rizika se izvodi prema modelu prikazanom na sl. 2.

Prema *Pravilniku o prethodnim i periodičnim lekarskim pregledima zaposlenih na radnim mestima sa povećanim rizikom* (Sl. Glasnik RS, br.120/07), zaposleni se šalju na kontrolu i periodične lekarske preglede na svakih 12 meseci.

Istraživanje i analiza nesreća, /5/, koje su se desile u periodu 2010-2012, tabela 1, su pokazali da je u 95% slučajeva uzrok povređivanja bilo nesigurno ponašanje zaposlenih. Većina nepravilnosti su otkrivene u proizvodnim celinama sa rudarskom mehanizacijom.

Tabela 1. Broj povreda u periodu 2010-2012

Godina	Broj povreda
2010.	91
2011.	70
2012.	64

RESEARCH OF HUMAN FACTOR IN THE OPEN PIT COAL MINE

Research site

Research is conducted in the open pit coal mine, during working hours, at the subject's workplace, using a survey specially developed for this occasion. In the mine itself, risk assessment in the workplace is seen as a process which takes into account all work aspects and conditions, and determines the risk of injury or health conditions of employees, /4/.

As a first step in hazard identification, all processes in the organisation considered to represent significant risks are identified.

Evaluating risk levels is performed by adopting the following criteria for specific stages of the work process:

– probability of occurrence,
– health and safety criteria,
– compliance with laws and regulations,
– environmental relations criteria,
– risk exposure criteria.

Injury list analysis is performed for the period 2003–2007 and based on determined injuries, the risk level and probability of occurrence are calculated, wherein the following parameters are taken into account:

– how to identify possible accidents in the workplace,
– probability of accidents occurring,
– nature of injuries suffered due to an accident,
– number of people injured.

Categorisation of a high risk workplace is determined according to the risk assessment act, and such a workplace is defined as a workplace where there are circumstances which could endanger safety and/or employee health despite completely or partially applied safety measures.

Risk analysis is performed by using a qualitative-quantitative method, by assigning risk values on a scale from 1 to 100, where 5 risk categories are distinguished, /5/:

- 0-20 low risk,
- 21-40 allowed risk,
- 41-60 moderate risk,
- 61-80 increased risk,
- 81-100 high risk.

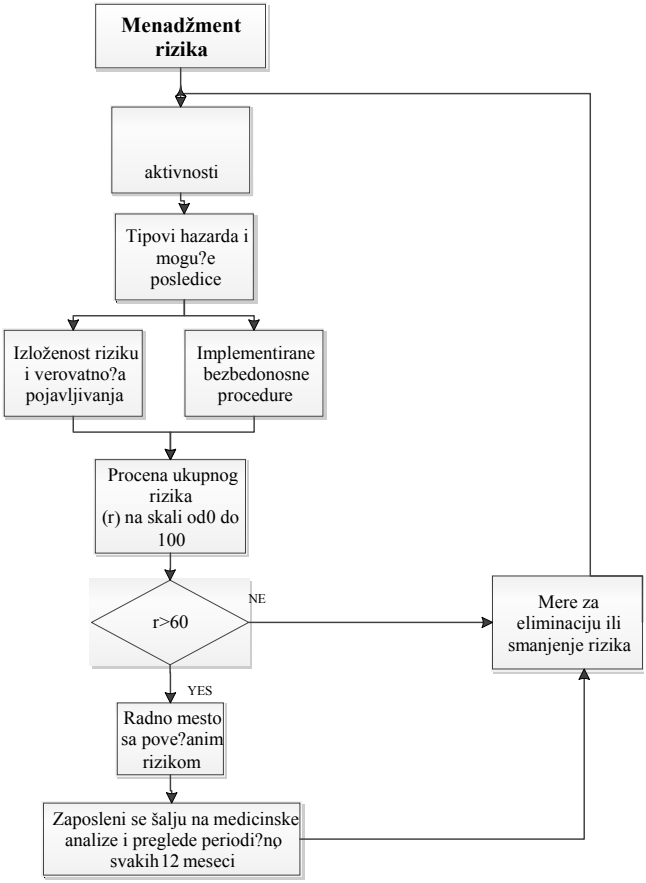
Qualitative risk analysis is performed according to the model shown in Fig. 2.

According to the *Regulations of previous and periodic physical examinations of employees in high risk workplaces* (Official Gazette, No. 120/07), employees are sent on periodic physical examinations and control every 12 months.

Accident analysis and research, /5/, involving the 2010–2012 period, Table 1, have shown that in 95% of cases injuries are caused by unsafe behaviour of employees. Most irregularities were detected in production units with mining mechanisation.

Table 1. Number of injuries in the period 2010-2012.

Year	Number of injuries
2010	91
2011	70
2012	64



Slika 2. Model upravljanja rizikom na radnom mestu

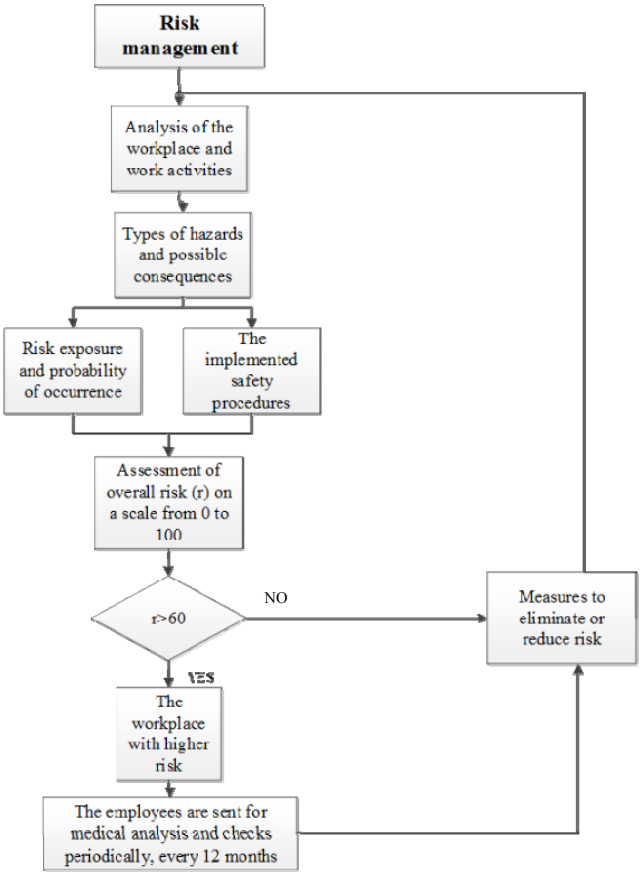


Figure 2. Risk management model of the workplace.

U toku inspekcijskih pregleda, službe rudnika su uočile nepravilnosti za koje su određene korektivne mere. Na predložene mere je reagovano u 50% slučajeva. Od 35 inspekcijskih pregleda u delu rudnika u 2012. godini, služba je jedino u 6 slučajeva dobila pismeni odgovor da je nedostatak otklonjen. Što se tiče bezbednosti i zdravlja na radu, u toku 2012. godine se desilo 5 slučajeva usmene žalbe odboru za bezbednost i zdravlje na radu. U proseku se dobija 10 pojedinačnih, usmenih žalbi godišnje od strane zaposlenih, koje se najčešće odnose na organizaciju posla.

Iz svega navedenog smo želeli istražiti uticaj karakteristika zaposlenih na poštovanje propisa i pravilnika koji se odnose na rizik i bezbednost.

Glavno i istraživačko pitanje na koje se želi odgovoriti je: Koji su relevantni faktori bezbednosti ljudskog faktora i kakav kontigentni model pokazuje njihovu interakciju?

UZORAK

Uzorak istraživanja je sadržao 476 zaposlenih. Složenost uticaja faktora koji utiču na stavove zaposlenih u odnosu na rizik je istaknuta kroz upitnik.

Informacije o ispitanicima i njihovim ličnim svojstvima su obezbedile podatke koje smo smatrali najrelevantnijim za problem istraživanja, a odnose se na sledećih pet varijabli: pol, starost, godine radnog staža, stepen obrazovanja, hijerarhijski nivo u rudniku i rad u smenama.

Definisano je pet kategorija starosne strukture ispitanika: 20-29 godina, 30 do 39 godina, od 40 do 49 godina, 50-59 godina i preko 60 godina.

During inspections of mine services, inadequacies are detected and corrective measures have been determined. These measures were reacted to in 50% of cases. Among 35 inspections in the part of the mines during 2012, the service received a written response about removing the flaws in only 6 cases. As for work health and safety, there were 5 cases of oral complaints to the health and safety board in 2012. On average, 10 individual oral complaints are made per year by employees, which are more often than not related to business organisations.

Based on all mentioned above, we wanted to investigate the effect of employee characteristics on complying with regulations and guidelines related to risk and safety.

The main research question that needed to be answered is: Which safety aspects of human factors are relevant and what kind of a contingency model shows their interactions?

SAMPLE

The research sample consisted of 476 employees. The complexity of factors that affect the attitude of employees towards risk is emphasized through a survey.

Information about examinees and their personal attitudes provided data which are considered most relevant for the problem being researched, and are related to the following five variables: gender, age, employment status, education, hierarchy level in the mine and work in shifts.

Five categories are defined based on the age of the examinees: 20-29 years, 30-39 years, 40-49 years, 50-59 and 60 years and above.

Nivo obrazovanja je definisan kroz 7 kategorija: osnovna škola, kvalifikovani radnik, visoko kvalifikovani radnik, viša škola, fakultet, master nivo i magistar/doktor nauka.

Dužina radnog iskustva je određena u pet kategorija: do 5 godina, od 5 do 14 godina, od 15 do 24 godina, od 25-34, više od 35 i više godina.

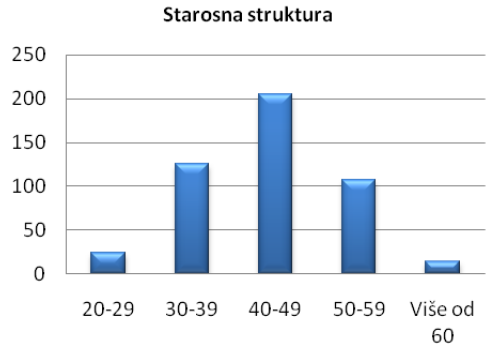
Opis uzorka

Tabela 2 prikazuje deskriptivan opis starosne strukture i radnog staža ispitanika.

Tabela 2. Starosna struktura i radni staž

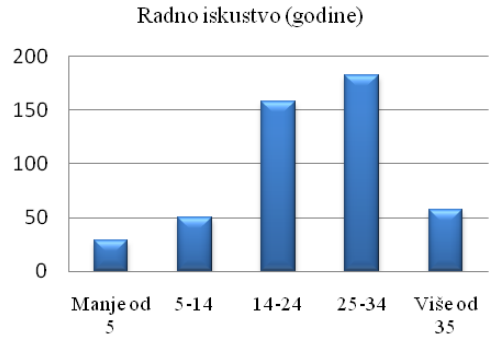
Godine života			Radni staž (godine)		
Godine	Broj radnika	%	Staž	Broj radnika	%
20-29	24	5,0	manje od 5	29	6,1
30-39	126	26,5	5-14	50	10,5
40-49	205	43,1	14-24	158	33,2
50-59	107	22,5	25-34	182	38,2
više od 60	14	2,9	Više od35	57	12,0

Slike 3-4 prikazuju dijagrame starosne strukture i radno iskustvo ispitanika.



Slika 3. Starosna struktura

Može se videti, sl. 3, da starosna struktura u uzorku prati normalnu raspodelu i da najviše ispitanika pripada starosnoj kategoriji između 40 i 49 godina.



Slika 4. Radno iskustvo

Slika 4 pokazuje da je u uzorku najveći broj ispitanika sa velikim radnim iskustvom, tj. 38,2% ispitanika ima radni staž u intervalu 25-34 godine, dok 33,2% njih pripada kategoriji 14-24 godine staža.

Obrazovna struktura ispitanika pokazuje da najveći broj njih, 44% pripada kategoriji kvalifikovani radnik, a nešto manje, 34% pripada kategoriji visokokvalifikovani radnik. 12% ispitanika ima osnovnu školu, 2% višu školu, 6% fakultet, 1% master nivo i 1% magistar ili nivo obrazovanja doktor nauka.

The education level is defined through 7 categories: elementary school, qualified worker, highly qualified worker, high school, faculty, master, PhD candidate/PhD.

Employment status is determined according to 5 categories: up to 5 years, 5 to 14 years, 15 to 24 years, 25-34 and over 35 years.

Sample description

Table 2 shows the description of the age structure and employment status of examinees.

Table 2. Age structure and employment status.

Age			Employment status (years)		
Years	No. of workers	%	Service	No. of workers	%
20-29	24	5.0	less than 5	29	6.1
30-39	126	26.5	5-14	50	10.5
40-49	205	43.1	14-24	158	33.2
50-59	107	22.5	25-34	182	38.2
over 60	14	2.9	over 35	57	12.0

Figures 3-4 show diagrams of age structure and work experience of examinees.

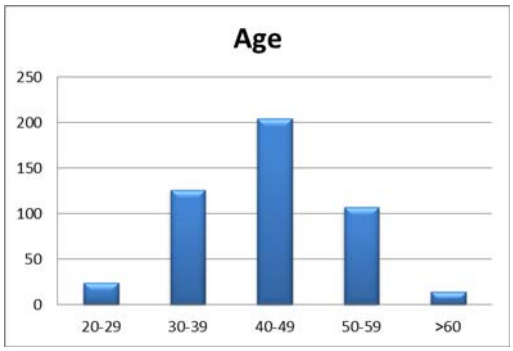


Figure 3. Age structure.

It can be seen in Fig. 3 that age structures of the sample follow a normal distribution and that most examinees belong to the category between 40 and 49 years.

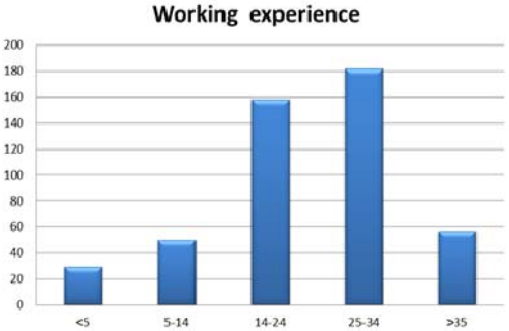


Figure 4. Work experience.

Figure 4 shows that most examinees have considerable work experience, i.e. that 38.2% have an employment status of 25-34 years, whereas 33.2% of examinees belong to the 15-25 category.

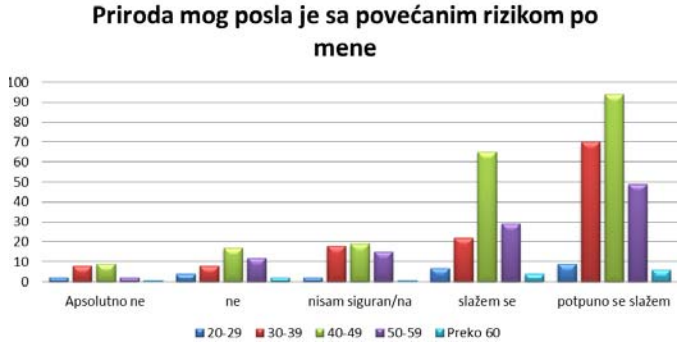
Education structure of examinees shows that the highest number, 44% belong to the qualified worker category, whereas slightly less, 34% are highly qualified workers, 12% are in the elementary school category, 2% are in high school category, 6% faculty, 1% master level and 1% with a doctoral level.

Tabela 3 prikazuje korelaciju obrazovanja i položaja zaposlenih u rudniku. Može se videti da postoji jaka pozitivna korelacija između stepena formalnog obrazovanja i hijerarhijskog nivoa ispitanika.

Tabela 3. Korelacija obrazovanja i položaja u rudniku

		Obrazovanje	Hijerarhijski nivo
Obrazovanje	Pirsonova korelacija	1	,522**
	Sig. (2-strane)		0
	N	476	476
Hij.nivo	Pirsonova korelacija	0.522**	1

Slika 5 prikazuje vezu radnih mesta ispitanika sa aspekta rizika i njihovih godina. Može se videti da najrizičnije poslove obavljaju radnici starosne strukture između 30 i 59 godina.



Slika 5. Rizik na radnom mestu

ODREĐIVANJE GLAVNIH FAKTORA

Da bismo odredili glavne faktore koji utiču na rizično ponašanje, primenili smo faktorsku analizu uz ekstrakcioni metod glavnih faktora (*Extraction Method: Principal Component Analysis*).

Tabela 4. KMO i Bartletov test opravdanosti metode

KMO i Bartletov test		
Kajzer Mejer Olkinova mera adekvatnosti uzorka		,841
Bartletov test sferičnosti	Približno Hi-kvadrat	9344,383
	df	1225
	Sig.	,000

Provera da li je skup podataka prikladan za faktorsku analizu: kako je KMO = 0,841 > 0,6 i nivo značajnosti Sig = 0,000 < 0,05 to je uslov primenljivosti opravdan.

Nakon inicijalne ekstrakcije smo primenili:

1. Kajzerov kriterijum latentnog korena po kome bilo koji individualni faktor treba da objasni varijansu bar jedne promenljive, ako ga treba zadržati za interpretaciju. Zato se faktori koji imaju latentne korene ili karakteristične vrednosti veće od 1, smatraju značajnim; a faktori sa latentnim korenima manjim od 1, se smatraju beznačajnim i oni se izostavljaju.
2. Dijagram prevoja - kada je broj komponenti dobijen na ovaj način još uvek veliki broj, posmatra se i dijagram prevoja (*Scree plot*), sl. 6.

Na taj način smo uzeli u razmatranje 8 faktora. Nakon primene Varimaksove rotacije sa Kajzerovom normalizacijom (*Rotation Method: Varimax with Kaiser Normalization*) dobili smo tabelu 5.

Table 3 shows the correlation between employee and education of the employees in the mine. It can be seen that there is positive correlation between the degree of formal education and hierarchy levels of examinees.

Table 3. Correlation between education and position in a mine.

			Education
Education	Pearson Correlation	1	Hierarchical position
	Sig. (2-tailed)		,522**
	N	476	0
H.position	Pearson Correlation	0.522**	476

Figure 5 shows the relation between the examinee's position from the standpoint of risk, and their age. It can be seen that tasks involving highest risks are typically performed by workers whose age ranges from 40 to 59 years.

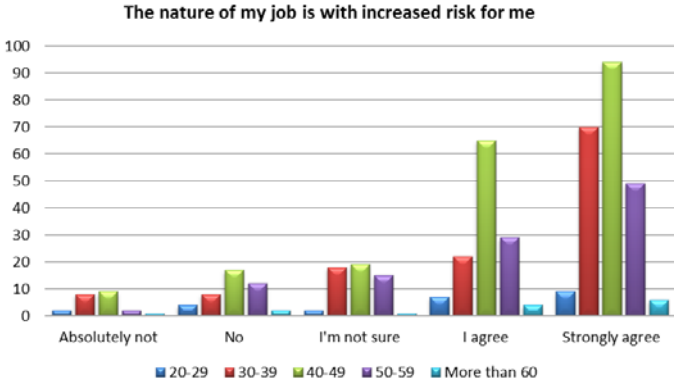


Figure 5. Risk at the workplace.

DETERMINING THE MAIN FACTORS

In order to determine the main factors which affect the risk behaviour, factor analysis is applied along with the Extraction Method: Principal Component Analysis.

Table 4. KMO and Bartlett's Test of method justifiability.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,841
Bartlett's Test of Sphericity	Approx. Chi-Square	9344,383
	df	1225
	Sig.	,000

Checking if the data set is appropriate for the factor analysis: since KMO = 0.841 > 0.6 and the level of significance, Sig = 0.000 < 0.05, the justifiability condition is fulfilled. Upon initial extraction, we have applied the:

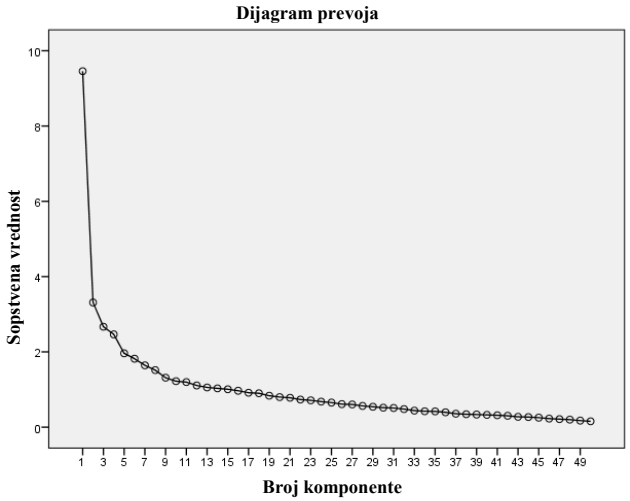
1. Kaiser criteria of latent root according to which the individual factor should explain the variance of at least one variable, if it needs to be kept for interpretation. Thus, the factors which have latent roots or characteristic values greater than 1, are considered significant; whereas factors with latent roots smaller than 1, are considered insignificant and are neglected.
2. Inflection diagram - when the number of components obtained in this way is still considerable, the inflection diagram needs to be considered (*Scree plot*), Fig. 7.

In this way, 8 factors have been taken into consideration. Upon applying Varimax rotation with Kaiser normalisation (*Rotation method: Varimax with Kaiser Normalisation*), Table 5 is obtained.

Table 5. Principal component analysis. / Tabela 5. Analiza glavnih komponenata

Rotated Component Matrix[a]								
	Component							
	1	2	3	4	5	6	7	8
Spreman na saradnju / Ready to cooperate	,732							
Koncentrisan / Concentrated	,729							
Dobro se osećam / Feels good	,717							
Srećan / Happy	,691							
Otvoren / Open	,691							
Efikasan / Efficient	,687							
Društven / Social	,682							
Zadovoljan svojim životom / Satisfied with own lives	,680							
Pouzdan / Reliable	,587							
Ostaću zaposlen ovde sledećih 5 godina / I will remain employed here next 5 years	,527					-,337		
Oprezan sam / Cautious	,471							
Pravila su mi vazna / Rules are important to me	,424	,357						
Kada primetim nesto što možda može dovesti do probleme ili nezgode, moja reakcija zavisi od moje procene opasnosti / When I notice anything that may lead to problems or accidents, my reaction depends on my hazard assessment	,384	,338						
Taktičan sam / I am tactful	,349							
Za poboljšanja-potrebna obuka / For improvement-need training	,332				,309			,301
Rukovodioci kontrolišu bezbednost / Managers control safety		,742						
Imam podršku kolega / I have my colleagues' support		,738						
Dobri odnosi sa kolegama / Good relationships with colleagues		,728						
Moj rukovodilac me podržava / My manager supports me		,727						
Dobra komunikacija sa kolegama / Good communication with colleagues		,726						
Menadžeri objašnjavaju bezbednost/Managers explain safety		,714						
Za bezbednost su svi potrebni / For the safety - all are necessary	,360	,664						
Radim u grupi / I work in groups		,537						
Nejasna pravila / Unclear rules	,312	,467						-,434
Neophodno je nekada odstupiti od pravila/ Sometimes it is necessary to deviate from the rules			,773					
Menadžeri su svesni odstupanja od pravila / Managers are aware of the deviation from the rules			,722					
Druge kolege krše pravila / Other colleagues violates the rules			,713					
Zdrav razum je važniji od pravila / Common sense is more important than rules			,591					
Odstupam od pravila / I am deviating from the rules			-,429					
Moj posao je rizičan po mene / My job is risk for me				,763				
Moj posao je rizičan po druge / My job is risk for others				,680				
Pol / Gender				-,571	,407			
Ceo posao je generalno rizičan / Work is generally risky				,375	,350			
Važno je da radnici učestvuju u izradi pravila / It is important that workers participate in drafting the rules				,371				,323
Nivo obrazovanja / Education level					,708			
Hijerarhijska pozicija / Hierarchy level					,649			
Rad u smenama / Working in shifts				,390	-,642			
Bolje bih radio ako povremeno odem na obuku / I'd do better if occasionally have training					,464			
Radni staž / Work experience						,896		
Godine života /Age						,887		
Problem su pravila / Problem with rules							,608	
Važna su dobra pravila / Good rules are important							,567	
Volim svoj posao / I love my job							,470	
Prekršaj i akcija / Violations and action							,440	
Pravila i informacije / Rules and information							,401	
Propisi su objavljeni / Regulations are announced		,415						,566
Pravila su komplikovana / The rules are complicated		,393						,523
Zadovoljstvo znanjem / Satisfaction with knowledge	,326	,378						-,490

Ekstracioni metod: Metod glavnih komponenti/Extraction Method: Principal Component Analysis.
Rotacija: Varimaks sa Kajzerovom normalizacijom/ Rotation Method: Varimax with Kaiser Normalization.
a. Rotacija konvergira u 13 iteracija/ a. Rotation converged in 13 iterations.



Slika 6. Dijagram prevoja

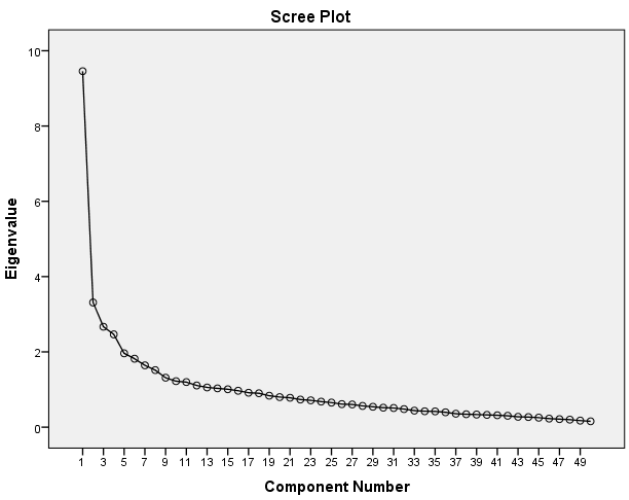
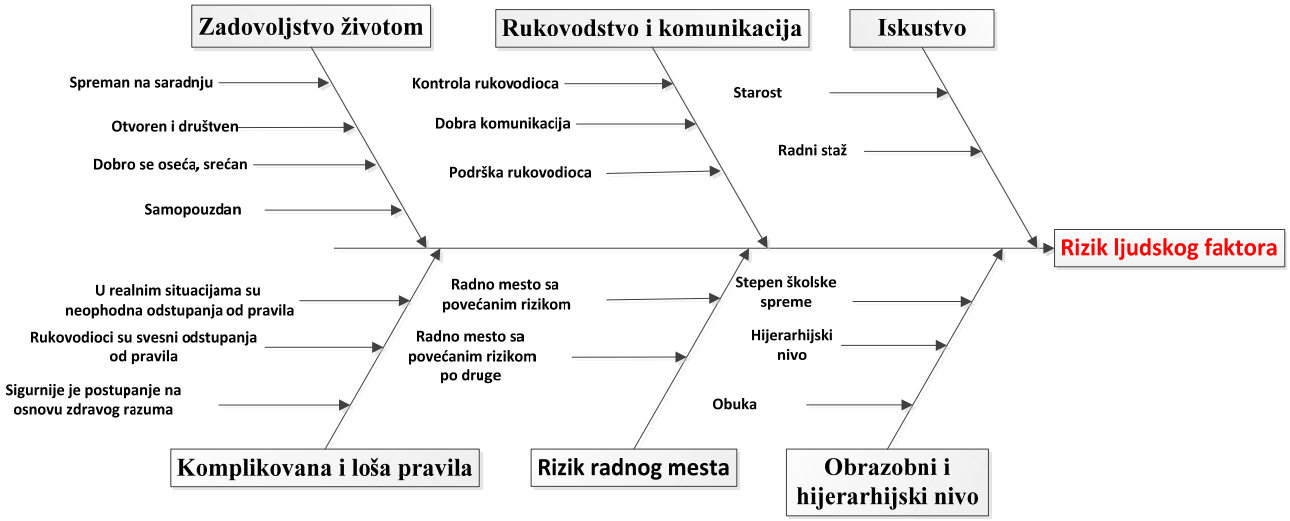


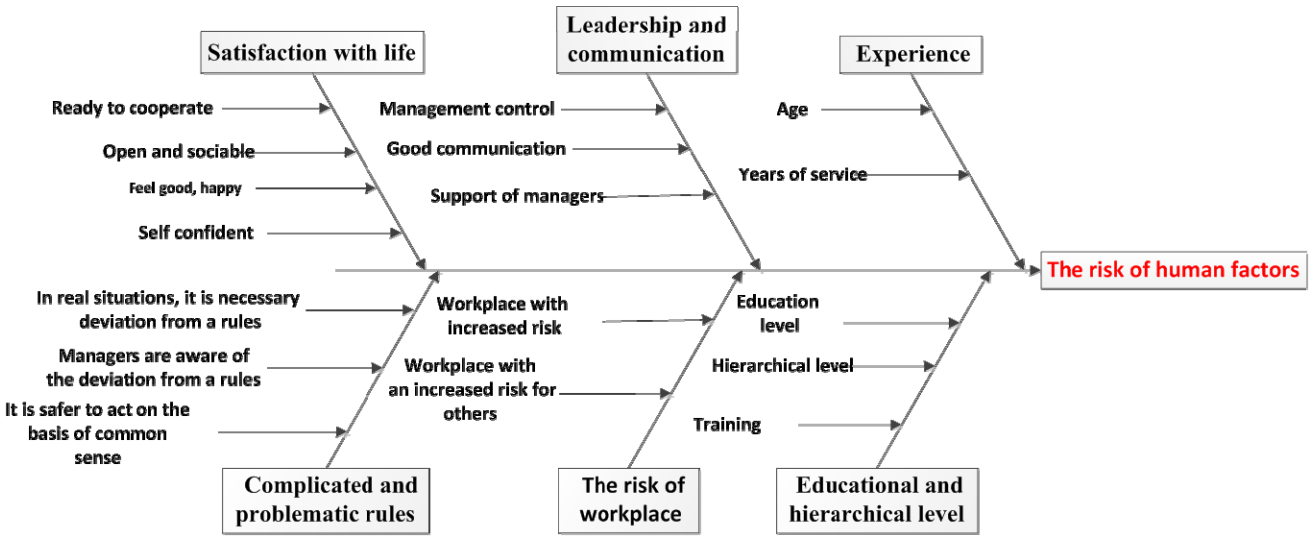
Figure 6. Scree plot.

Analizom dobijenih rezultata izdvojili smo 6 glavnih faktora: Faktor 1–Zadovoljstvo životom; Faktor 2–Rukovodstvo i komunikacija; Faktor 3–Komplikovana i problematična pravila; Faktor 4–Rizik radnog mesta; Faktor 5–Obrazovni i hijerarhijski nivo; Faktor 6–Iskustvo.

Analysis of obtained results allowed us to distinguish six main factors: Factor 1–Satisfaction with life; Factor 2–Management and communication; Factor 3–Complicated and problematic rules; Factor 4–Workplace risk; Factor 5–Education and hierarchy level; Factor 6–Experience.



Slika 7. Model uticaja ljudskog faktora na rizik / Figure 7. The model of human factor influence on risk.



Slika 7 predstavlja model komponenti koji utiču na rizik ljudskog faktora, dobijenih metodom faktorske analize. Prikazani su glavni faktori: zadovoljstvo životom, preko spremnosti na saradnju, otvorenosti i društvenosti, osećanja sreće i samopouzdanja; rukovodstvo i komunikacija, preko kontrole i podrške rukovodioca i dobre komunikacije; komplikovana i problematična pravila, preko stavova da su u realnim uslovima i situacijama neophodna odstupanja od pravila i da je sigurnije postupanje na osnovu zdravog razuma, kao i mišljenja da su rukovodioci svesni odstupanja od pravila; rizik radnog mesta, rizik radnog mesta koje nosi rizik po samog radnika ili druge; obrazovanje i hijerarhijski nivo preko stepena školske spreme, pozicije na poslu i obučenosti i iskustvo preko godina života i radnog staža.

Ispitivanje faktora koji utiču na odstupanje od pravila

Da bismo uporedili faktore koji utiču na odstupanje od pravila i propisa, primenili smo T-test nezavisnih uzoraka na dve grupe ispitanika: one koji su se izjasnili da krše pravila i propise, i one koji to ne rade.

Analiza pokazuje da je 109 (22,9%) onih koji su se izjasnili da krše pravila i propise, dok se 367 (77,1%) ispitanika izjasnilo da ne krši pravila i propise, Tabela 6.

Tabela 6. Broj ispitanika po pitanju kršenja pravila

	Broj	Procenat	Ispravno %	Kumulativno %
Odstupam	109	22,89916	22,89916	22,89915966
Ne odstupam	367	77,10084	77,10084	100
total	476	100	100	

Nezavisna varijabla „odstupam“ je data u dva stanja (da, ne), a nezavisne varijable su pol ispitanika, godine života, hijerarhijski nivo, rizik radnog mesta i hijerarhijski nivo.

Tabela 7 prikazuje srednju vrednost, standardnu devijaciju i standardnu grešku za ispitivane promenljive.

Tabela 7. Ispitivanje uticaja zavisnih varijabli na kršenje pravila i propisa po varijabli: Odstupam

	Odstup.	N	Srednja vrednost	Standardno odsupanje	Standardna greška
Pol	Da	109	1,02	0,135	0,013
	Ne	367	1,08	0,278	0,015
Godine	Da	109	2,95	0,821	0,079
	Ne	367	2,91	0,919	0,048
Hijerarh. nivo	Da	109	1,76	1,433	0,137
	Ne	367	1,79	1,411	0,074
Rizik rad. mesta	Da	109	4,12	1,078	0,103
	Ne	367	4,02	1,2	0,063
Srećan	Da	109	3,74	1,092	0,105
	Ne	366	4,26	0,88	0,046

Tabela 8 prikazuje rezultate T-testa za poređenje dve grupe radnika u zavisnosti od toga da li odstupaju od pravila i propisa ili ne. Značajne razlike u poređenju grupa smo dobili u odnosu na pol ispitanika i njihov osećaj stepena sreće. T-testom nezavisnih uzoraka dobili smo značajne razlike u odstupanju od pravila i propisa za muškarce i žene: T(476) = 3,401, p = 001 (obostrano). Razlika između srednjih vrednosti po grupama (prosečna razlika) je –0,066, a 95% jeste interval pouzdanosti za prosečnu razliku (–0,104; –0,028). Pošto nije zadovoljen uslov jednakosti varijansi (Sig < 0,05), posmatrali smo podešene vrednosti u drugom redu tabele 7.

Figure 7 represents the model of components that affect the human risk factor, obtained by factor analysis method. Main factors are shown, including life satisfaction, through readiness to cooperate, be open and social, feeling happy and self-confident; management and communication, through control and support of managers and good communication; complicated and problematic rules, through attitude that real conditions and situations require deviations from rules and that acting in accordance with common sense is safer, along with the opinions that managers are aware of deviations from rules; workplace risk associated with risks for workers themselves, or others; education and hierarchy level, through degree of education, position at work and training and experience based on age and employment status.

Testing of factors that influence the deviation from rules

In order to compare factors which affect deviation from rules and regulations, the T-test of independent samples is applied to two groups of examinees: those who admitted that they break rules and regulations and those who do not.

Analysis has shown that 109 (22.9%) claimed that they break rules and regulations, whereas 367 (77.1%) claimed that they do not break rules and regulations, Table 6.

Table 6. Number of examinees according to rule breaking.

	Frequency	Percent	Valid %	Cumulative %
I deviate	109	22,89916	22,89916	22,89915966
I don’t deviate	367	77,10084	77,10084	100
total	476	100	100	

The independent variable ‘I deviate’ is given in two states (yes, no), whereas dependent variables include gender, age, hierarchy level, workplace risk, and satisfaction with life. Table 7 shows the mean values, standard deviation and standard error for tested variables.

Table 7. Group Statistics for variable: I deviate from the rules and regulations

	I deviate	N	Mean	Std. deviation	Std. error mean
Gender	Yes	109	1.02	0.135	0.013
	No	367	1.08	0.278	0.015
Age	Yes	109	2.95	0.821	0.079
	No	367	2.91	0.919	0.048
Hierarchy level	Yes	109	1.76	1.433	0.137
	No	367	1.79	1.411	0.074
Workplace risk	Yes	109	4.12	1.078	0.103
	No	367	4.02	1.2	0.063
Happy	Yes	109	3.74	1.092	0.105
	No	366	4.26	0.88	0.046

Table 8 shows the results of T-test for comparing of two groups of workers depending on whether they deviate from rules and regulations or not. Significant differences in group comparison are obtained relative to gender and the degree of happiness of examinees. The T-test of independent samples showed significant differences in rule and regulation deviations for men and women: T(476) = 3.401, p = 001 (mutual). The difference between mean values per group (average difference) is –0.066, and 95% reliability interval for the average difference is (–0.104, –0.028). Since the condition of variance equality is not met (Sig < 0.05), adjusted values in the second row of Table 7 are observed.

Tabela 8. T-test. EVA Equal Variance Assumed EVNA Equal Variance Not Assumed Independent Samples Test

		Equality of variances		T-test for Equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	Interval of the	
									Lower	Upper
Gender	EVA	26.173	.000	-2.396	474	.017	-.066	.028	-.120	-.012
	EVNA			-3.401	376.624	.001	-.066	.019	-.104	-.028
Age	EVA	3.936	.048	.478	474	.633	.047	.098	-.146	.239
	EVNA			.508	195.312	.612	.047	.092	-.135	.228
Hierarchy level	EVA	.169	.681	-.186	474	.853	-.029	.154	-.332	.275
	EVNA			-.184	174.884	.854	-.029	.156	-.336	.279
Workplace risk	EVA	2.375	.124	.783	474	.434	.100	.128	-.151	.352
	EVNA			.830	194.365	.408	.100	.121	-.138	.338
Happy	EVA	12.213	.001	-5.100	473	.000	-.519	.102	-.719	-.319
	EVNA			-4.543	152.150	.000	-.519	.114	-.745	-.293

Table 8. T-test. EVA Pretpostavljena jednakost varijansi, EVNA Ne podrazumevana jednakost varijansi Nezavistan test uzoraka

		Jednakost varijansi		T-test jednakosti srednjih vrednosti						
		F	Sig.	t	df	Sig. (2-tailed)	Razlika sred. vrednosti	Razlika stand. greški	Interval	
									Donji	Gornji
Pol	EVA	26.173	.000	-2.396	474	.017	-.066	.028	-.120	-.012
	EVNA			-3.401	376.624	.001	-.066	.019	-.104	-.028
Godine	EVA	3.936	.048	.478	474	.633	.047	.098	-.146	.239
	EVNA			.508	195.312	.612	.047	.092	-.135	.228
Hijerarhijski nivo	EVA	.169	.681	-.186	474	.853	-.029	.154	-.332	.275
	EVNA			-.184	174.884	.854	-.029	.156	-.336	.279
Rizik radnog mesta	EVA	2.375	.124	.783	474	.434	.100	.128	-.151	.352
	EVNA			.830	194.365	.408	.100	.121	-.138	.338
Srecan	EVA	12.213	.001	-5.100	473	.000	-.519	.102	-.719	-.319
	EVNA			-4.543	152.150	.000	-.519	.114	-.745	-.293

T-testom nezavisnih uzoraka je dobijeno da i varijabla „srećan“ utiče na odstupanje od pravila i propisa: T(476) = 4,543, p = 0 (obostrano). Razlika između srednjih vrednosti po grupama (prosečna razlika) je –0,519, a 95% interval pouzdanosti za prosečnu razliku je (–0,745; –0,293). Pošto nije zadovoljen uslov jednakosti varijansi (Sig < 0,05) posmatrali smo podešene vrednosti u drugom redu Tab. 7.

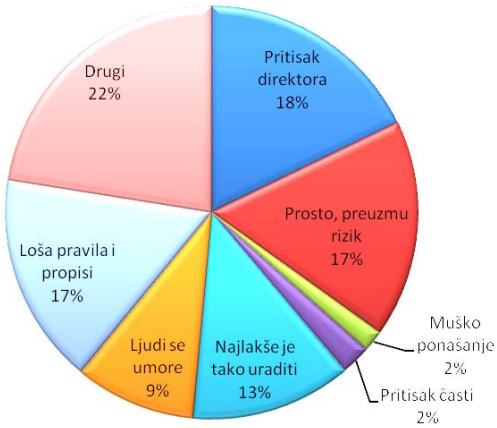
Posmatrali smo uslov jednakosti varijansi i pošto on nije zadovoljen, tj. Sigma je manja od 0,05, gleda se drugi red koji daje prilagođen proračun T-testa. Interesantno je primetiti da nismo dobili značajan uticaj starosne strukture, stepena rizičnosti radnog mesta i hijerarhijskog nivoa na odstupanje od pravila i propisa.

Slika 8 prikazuje strukturu razloga koji utiču na kršenje pravila i propisa i preuzimanje rizika.

The T-test of independent variables reveals that the variable ‘happy’ affects deviation from rules and regulations: T(476) = 4.543, p = 0 (mutual). The difference between mean values per group (average diff.) is –0.519, and the 95% reliability interval for the average difference equals (–0.745; –0.293). Since the condition of variance equality is not met (Sig < 0.05), adjusted values in the second row of Table 7 are observed.

The condition of variance equality is observed, and since it is not met, i.e. Sig < 0.05, the second row is taken into account for the purpose of performing an adjusted T-test. It is interesting to notice that there is no significant effect of age structure, level of workplace risk and hierarchy on deviations from rules and regulations.

Figure 8 represents reasons for undertaking risks and breaking rules and procedures.



Slika 8. Razlozi za preuzimanje rizika

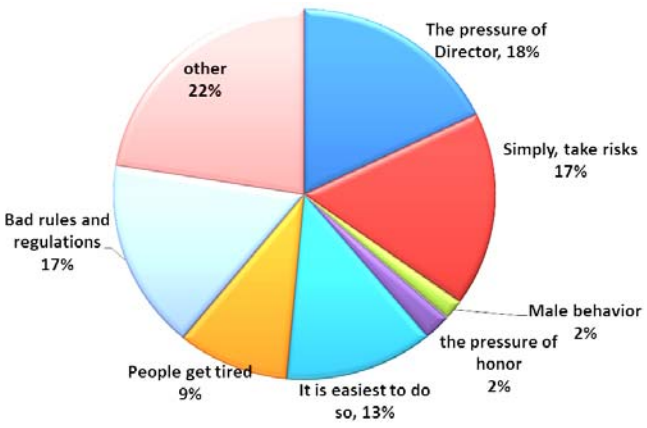


Figure 8. Reasons for undertaking risks.

Slika 9 prikazuje akcije koje se u rudniku preduzimaju, nakon utvrđivanja kršenja pravila i propisa.

Slika 9. Akcije nakon kršenja pravila

Figure 9 shows actions taken after determining that rules and regulations are broken, in case of a mine.

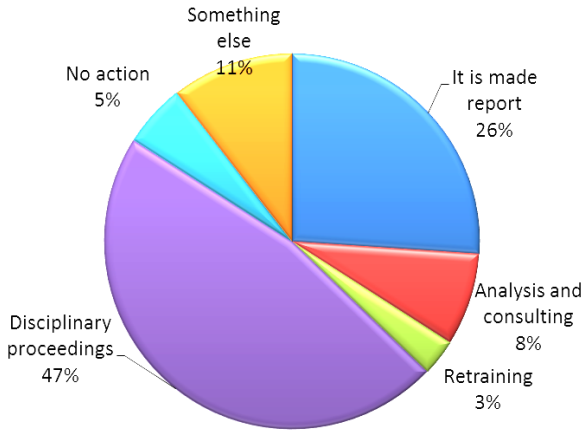


Figure 9. Actions taken upon braking rules.

ZAKLJUČAK

Regulatorni zahtevi za bezbednost na radnom mestu su faktori koji primoravaju kompanije da posvete značajnu pažnju razmatranja ljudskog faktora u upravljanju rizikom i poboljšanju bezbednosti rada.

U današnje vreme, kada se uvođenjem sve oštrijih standarda kvaliteta, bezbednost tehničkih sistema podiže na sve viši nivo, dok čovek sa svojim osobinama ne može da prati takav trend, smanjenje rizika ljudskog faktora predstavlja suštinski najvažniji korak u smanjenju rizika industrijskih i privrednih sistema.

Međutim, brojna pitanja se moraju rešiti u cilju izrade standarda u regulisanju rizika od ljudskog faktora.

ZAHVALNICA

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CONCLUSION

Regulatory requirements for workplace safety represent factors that force companies to devote considerable attention to considering the human factor in risk management and improvement of safety at work.

Nowadays, when quality standards become more and more strict, safety of technical systems raises everything to a higher level, while humans with their characteristics cannot keep up with such a trend, the reduction of risks related to the human factor represents the essentially most important step in risk reduction in industrial systems.

However, numerous questions need to be answered so to develop a standard for regulating human factor related risk.

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LITERATURA – REFERENCES

1. Kirin, S., Gavrić, G., Čukanović Karavidić, M., *Ekonomski i humani razlozi borbe protiv stresa*, HR konferencija Upravljanje kvalitetom ljudskih resursa, Savremeni trendovi, Beograd, 2014.
2. Kirin, S., Miljanović, I., Milutinović, A., *General approach to risk management in emergency condition in mining*, XLI Simposium on operations research, Divčibare, 2014.
3. http://www.achrnews.com/articles/boiler-accident-reports-to-err-is-human
4. http://www.boeing.com/commercial/aeromagazine/aero_08/human_textonly.html
5. Privredno društvo „Termoelektrane i kopovi Kostolac d.o.o.“: *Idejni projekat mera unapređenja aktivnosti i procedura*, mart 2013.
6. Kovač, P., Rodić, D., Pucovsky, V., Mankova, I., Savković, B., Gostimirović, M., *A review of artificial intelligence approaches applied in intelligent processes*, J of Production Engineering, 2012, Vol.15, No 1, pp.1-6, ISSN 1821-4932.
7. Fedajev, A., Mihajlović, V., *Neuronske mreže kao metod multivarijacione analize*, Univerzitet u Kragujevcu, Ekonomski fakultet, jun 2009.