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Inženjerstvo zaštite

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From Editor's desk

"Nije dovoljno imati znanje; treba ga primeniti. Nije dovoljno hteti nešto; treba delati.''
Johan Wolfgang von Goethe

Fakultet zaštite na radu je u fazi reakreditacije studijskih programa i usvajanja novog studijskog programa osnovnih akademskih studija - Zaštita od požara. Cilj uvođenja ovog studijskog programa je obrazovanje studenata za profesiju diplomiranog inženjera zaštite od katastrofalnih događaja i požara, koji stiču kompetencije da identifikuju potencijalne opasnosti i rizike od požara i daju predloge mera za prevenciju, reagovanje i saniranje šteta i posledica požara, što čini ovaj program društveno korisnim i opravdanim. Časopis Inženjerstvo zaštite nudi svim naučnim i stručnim radnicima koji se bave problematikom zaštite od požara mogućnost da prezentuju rezultate svojih istraživanja i dobru praksu u cilju unapređenja razvoja naučne oblasti Inženjerstvo zaštite životne sredine i zaštite na radu.

"Knowing is not enough; we must apply. Willing is not enough; we must do.''
Johan Wolfgang von Goethe

Faculty of Occupational Safety is currently in the process of re-accreditation of existing study programs and the adoption of a new study program of basic academic studies - Fire Protection. The aim of this study program is to prepare students for their future occupation of Bachelor with Honours in Disaster and Fire Safety Engineering, and to enable them to acquire competencies to identify potential hazards and risks associated with fires and be able to propose preventive measures, respond to fire and repair fire damage, which makes this program socially useful. *Safety Engineering* journal is an opportuity to all scientists and professionals in the field of fire protection to present their research results and good practice with the aim to foster the development of Environmental Engineering and Occupational Safety.

On behalf of the editors
Prof. Dr. Dejan Krstić

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EFFECTS OF USING METAL FRAME GLASSES EXPOSED TO ELECTROMAGNETIC RADIATION FROM MOBILE PHONE

Abstract: *The aim of this study is to estimate the effects of metal frame glasses on the electric field distribution and Specific Absorption Rate (SAR) inside the model of a human head. The numerical solution of the equations of electromagnetic wave propagation has been used to obtain the electric field distribution and values of SAR in the vicinity of the metal frame glasses, exposed to cell phone radiation at the frequency of the 3G mobile network. The assessment of these effects has been performed during the conversation over a mobile phone. In order to obtain the most accurate results, the realistic 3D model of the human head, as well as the model of metal frame glasses have been created. For evaluating the mentioned effects, a comparative analysis of models with and without glasses has been carried out. Therefore, the obtained results are presented within different biological tissues and organs from which the human head model was made.*

Key words: electric field distribution, specific absorption rate, mobile phone, metal frame glasses.

INTRODUCTION

In the last few years, the modern world has significantly increased the use of mobile devices especially due to the development of their advantages. However, since the mobile phone is a source of electromagnetic radiation located near the human head, this development has led to serious concerns about the potential health risks caused by prolonged exposure to electromagnetic radiation. Hence, the major expansion of these devices turned the focus toward the research of the impact of electromagnetic waves on the human body and the estimation of health risks. During the conversation over the mobile phone, the most exposed organ to electromagnetic radiation is the ear, while in the case of texting and surfing the Internet, it is the eye. Besides, the attention should be paid to the presence of metal frame glasses, which affects the electric field distribution and amount of absorbed energy, since the metal frame is a very good conductor.

Based on previous studies, the safety measures that prescribe the maximum allowable levels for exposure to electromagnetic fields are adopted in safety standards [1-4]. Also, the electromagnetic field has been characterized as potentially carcinogenic to humans and classified as a group 2B carcinogen [5]. Initial studies, that refer to the interaction between the human body and EMF from the mobile phone, were based on very simple models that contained only one or several layers that were supposed to represent the human head tissue characteristics. Results obtained using this kind of model are questionable because they do not fully reflect the real state of certain tissues. Because of their simplicity, these models could not consider the boundary conditions at the transitions between different biological tissues and organs [6-9]. Numerous studies refer to the impact of electromagnetic radiation from mobile phones within a more complex, 3D model of a human head. These realistic models represent the actual state of the human head but many of these studies are not focused on the impact of electromagnetic radiation in the presence of metal objects [10-14].

Some studies on the effects of electromagnetic radiation from mobile phones have found that the objects in the vicinity of the human head have caused a significant influence on the electric field distribution and could be considered as a potential health hazard to human body [15, 16]. In these studies, it can be found that the SAR values can be several times larger in the presence of metallic objects.

Some investigations refer to the estimation of the effects of glasses on the SAR inside the human head, resulting from wireless eyewear devices at the phone call state. In [17], the authors have found that the maximal SAR in the ocular tissues with glasses is even six times higher than that without glasses. In [18], the authors found that simulated SAR values are somewhat higher than authorized levels with preoccupant high electromagnetic field distribution close to the eye of the user. Also, one study deals with the simulation of the effects of RF electromagnetic radiation from a mobile phone in the presence of metal frame glasses. Simulations are performed using a very simple model of head, modeled as a three-layer sphere with two little balls representing the eyes [19].

It is common for people who have vision problems to wear glasses. Today, the frames of glasses can be made from different materials but the metal frame, as an excellent conductor, significantly changes the electric field distribution and values of SAR from the mobile phone during the conversation or texting. This study deals with the effects of a mobile phone conversation in the presence of metal frame glasses with the aim to determine the changes in electric field distribution and values of SAR within the human head model. This investigation is focused on the electric field distribution within the biological tissues of the human head that are in the vicinity of the glasses frame. The shape of the anatomical human eye model and its features have an important role for the absorption of electromagnetic energy, as well as the operating frequency and the distance between the electromagnetic source and the exposed object. The numerical calculation of the electric field and the amount of the absorbed electromagnetic energy have been performed at the frequency of 900MHz which is typical for the 3G mobile network.

NUMERICAL METHOD AND MODELING

Model

In order to determine the electric field distribution and values of SAR within the human head with metal frame glasses exposed to the radiation from the mobile phone, the 3D realistic human head model has been developed. It was necessary to create this model with features as close as possible to the real human head. The process of modeling has been performed in few stages. First, the realistic model of a human head was modeled with following tissues and organs: Cortical Bone, Brain, Cerebrospinal Fluid, Fat, Cartilage, Pituitary Gland, Spinal Cord, Muscle, Eyes, Skin, Tongue and Teeth (Figure 1).

The human head model was developed so that the anatomical and morphological characteristics correspond to an average adult person (Figure 2) [20-22]. After designing, the complete model was used for simulation of the propagation of the electromagnetic waves. The layers must be ideally superimposed in order to properly consider the boundary conditions at the separation area between two tissues, during the propagation of EM waves from one tissue into another.

The cross-section of the human head model with biological tissues and organs (Table 1) is shown in Figure 1. Numerical designations for tissues and organs from Figure 1 correspond to the numerical designations in Table 1.

Assessment of the effects of exposure to mobile phone radiation is based on the prediction of the induced internal electromagnetic field and the amount of absorbed electromagnetic energy in the human head. The shape of the anatomical human head model and its features have an important role for the absorption of electromagnetic energy, as well as the operating frequency and the presence of other objects. Hence, in order to obtain the most accurate results of the electric field and the SAR inside the human head, in the presence of metal frame glasses, a model of glasses had to be also created (Figure 3b). The material used for the glasses frame is the aluminium with the electrical conductivity σ= 3.56x107S/m.

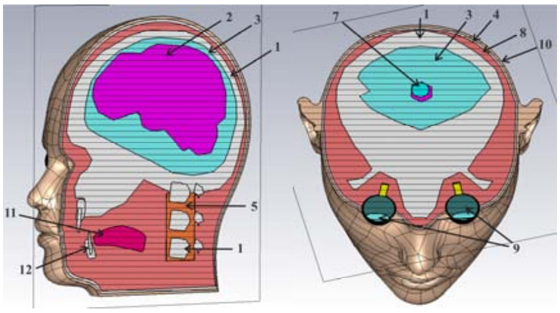


Figure 1. *Cross-section and construction of the human head model*

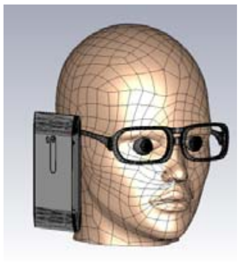


Figure 2. *External appearance of the human head model*

a) *b*)

Figure 3. *External look of smartphone and glasses*

Before any numerical calculation, the electromagnetic characteristics of biological tissues and organs (permittivity, conductivity and permeability) should be defined, in order to understand the interaction between electromagnetic radiation and the body. The effects of propagation, reflection, and attenuation of electromagnetic waves in the body depend on these electromagnetic properties. For each biological tissue used in a model, the appropriate electromagnetic parameters are given in Table 1 [23].

As a source of electromagnetic radiation, the mobile phone which characteristics correspond to an actual smartphone, has been developed (Figure 3a). The mobile phone model contains the following parts: the display, mobile housing and planar inverted F antenna (PIFA). The planar inverted F antenna, as a source of electromagnetic radiation, was modeled for the frequency of 900MHz with the output power P=1W [24] and the impedance Z=50Ω. Generally, the construction of PIFA depends on the producer. One way of PIFA performance, its construction and radiation pattern at certain frequencies can be found in [25].

Table 1. *Electromagnetic properties of tissues of the human head model at 900MHz.*

	Biological tissue		3G 900MHz	ρ [kg m^{-3}]
1.	Cortical Bones	ε_r	12.45	1908
		σ[Sm^{-1}]	0.143	
2.	Brain	ε_r	49.4	1046
		σ[Sm^{-1}]	1.26	
3.	Cerebrospinal Fluid	ε_r	68.60	1007
		σ[Sm^{-1}]	2.410	
4.	Fat	ε_r	11.30	911
		σ[Sm^{-1}]	0.109	
5.	Cartilage	ε_r	42.70	1100
		σ[Sm^{-1}]	0.782	
6.	Pituitary Gland	ε_r	59.70	1053
		σ[Sm^{-1}]	1.040	
7.	Spinal Cord	ε_r	32.50	1075
		σ[Sm^{-1}]	0.574	
8.	Muscle	ε_r	55.00	1090
		σ[Sm^{-1}]	0.943	
9.	Eyes	ε_r	49.60	1052
		σ[Sm^{-1}]	0.994	
10.	Skin	ε_r	41.40	1109
		σ[Sm^{-1}]	0.867	
11.	Tongue	ε_r	55.30	1090
		σ[Sm^{-1}]	0.936	
12.	Teeth	ε_r	12.50	2180
		σ[Sm^{-1}]	0.143	

In order to create the numerical model with the appropriate electromagnetic properties of biological tissues and organs and to determine the spatial distribution of the electromagnetic field within the model, which originates from a mobile phone, we used the CST software package [26]. This software is based on the FIT (Finite Integration Technique) method [27].

Before any numerical calculation, the key step is to create the mesh of elements. A finer mesh means a greater number of elements, which makes the results more accurate. On the other hand, a finer mesh requires more powerful hardware and computational time (that can last for days for some applications). Therefore, it is essential to find the proper balance between result accuracy and time.

SAR calculation

SAR (Specific Absorption Rate) is a measure of the amount of radiofrequency (RF) energy absorbed by the body from the source of electromagnetic radiation. SAR provides a straightforward means for measuring the RF exposure characteristics of the source of electromagnetic radiation, to ensure that they are within the safety guidelines prescribed by adequate safety standards.

When the electromagnetic wave spreads through the human tissue, the energy of electromagnetic waves is absorbed by the tissue. The value of SAR describe the interaction of electromagnetic waves with biological tissues and can be defined as the speed of power dissipation normalized by the density of the material, as in the following equation [28]:

$$\mathrm{SAR} = \frac{\sigma}{\rho}|E|^2 \tag{1}$$

where σ is the electrical conductivity (S m^{-1}) and ρ is the density of the tissue (kg m^{-3}). It should be also noted that the electric field E (V/m) is the r.m.s. value.

In addition, it is very important to define averaged SAR as the ratio of the power absorbed in the tissue and the weight of that biological tissue. This averaged SAR is obtained by integrating the following expression:

$$\mathrm{SAR}_{av} = \frac{1}{V}\int_V \mathrm{SAR}\,\mathrm{d}V = \frac{1}{V}\int_V \frac{\sigma}{\rho}|E|^2\,\mathrm{d}V\ . \tag{2}$$

Mass averaged SAR is typically calculated for a sample of 1g (SAR_{1g}) and a sample of 10g (SAR_{10g}) but in this study, SAR will be averaged for 1g.

RESULTS

In this section, the electric field distribution and the amount of absorbed energy, during the conversation over the cell phone, are represented within the model of a human head with previously mentioned features. The position of curves (C1, C2 and C3) used for numerical calculation of electric field and SAR are shown in Figure 4. All curves are located in planes normal to the plane of the cell phone. Curve C1 is at the level of the handles, while curve C2 is located below and C3 is located above the level of curve C1. Accordingly, this study is focused on the absorbed energy of the electromagnetic waves in different biological tissues that are located at the level of metal frame glasses. Comparative analysis of the obtained results, for the models with and without glasses, has been carried out.

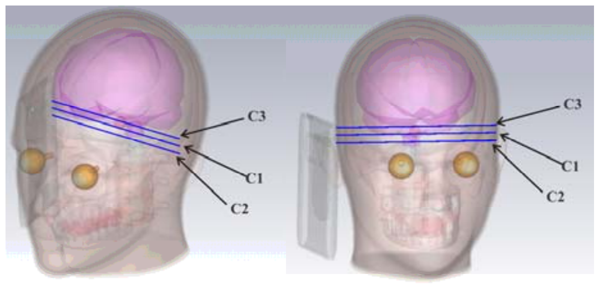
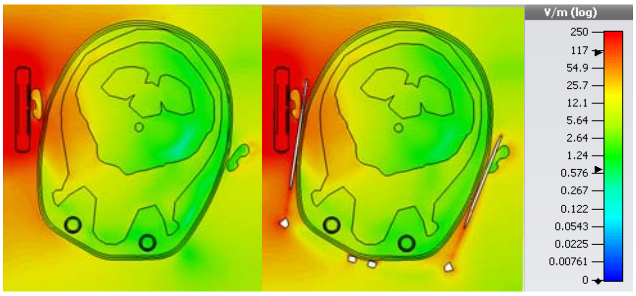


Figure 4. *Human head model with curves for evaluating electric field and SAR.*

Electric field distribution

Comparative analysis of the electric field distribution within the models with and without glasses, at the mentioned frequency, is presented in this section. The electric field strength in horizontal cross-sections, at the same levels as the curves mentioned above, for the model with (right side) and without glasses (left side), is shown in Figure 5. Models with and without glasses are represented at the same figure to make results comparable. Further, on the right side of the figures, the maximum value of the electric field in the color palette is set to be the same for both models, also to achieve easier comparison of the electric field distribution.

It is important to mention that the allowable value of the electric field, prescribed by the standard, is 41V/m at 900 MHz [1-4], for the free space when the human is absent.



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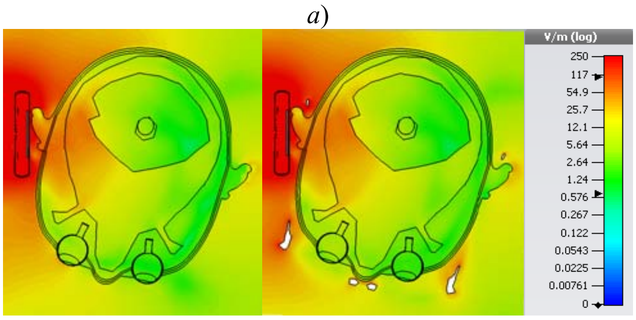

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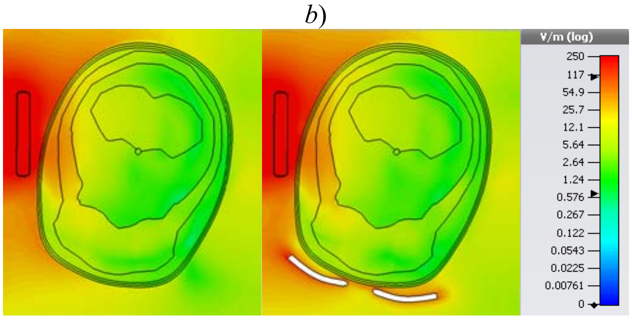


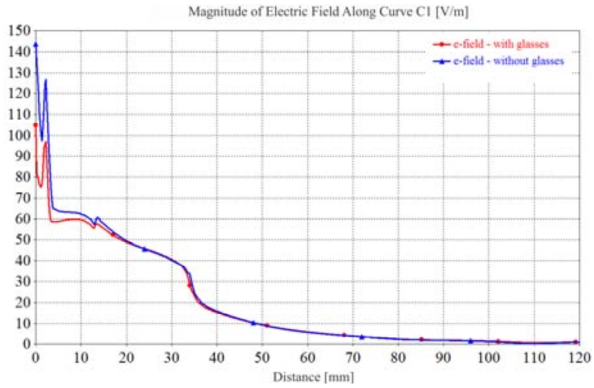
c)

Figure 5. *Spatial distribution of electric field a) C1cross-section, b) C2cross-section and c) C3cross-section*

Figure 6 shows the dependence of the electric field along the curves C1, C2 and C3 as a function of the distance from the radiation source, at the mentioned frequency, for the models with and without glasses. This dependence refers to the plane that passes through the different biological tissues and contains the curves C1, C2 and C3.

According to previous figures, it is evident that the maximum value of the electric field for both models occurs in the surface layers of the model. While spatial distribution of the electric field shown in Figure 5 is similar for both cases – with and without glasses, graphs of the electric field strength in Figure 6 show that the electric field is lower for the model with glasses. The maximum values of the electric field inside different biological tissues, for the models with and without glasses, are represented in Table 2. Only the results obtained in biological tissues on which the glasses have an influence are represented in this table. Biological tissues, on which the influence of glasses is negligible, are omitted because the electric field is almost the same for models with and without glasses.

It can be seen from Figure 6a (curve C1) that the maximum value of the electric field is in skin and amounts 104.85 V/m in the presence of glasses, while this value for the model without glasses is higher and amounts 143.69 V/m. It is evident that the highest influence of glasses on electric field strength is inside the skin since this biological tissue is the nearest to the metal frame.



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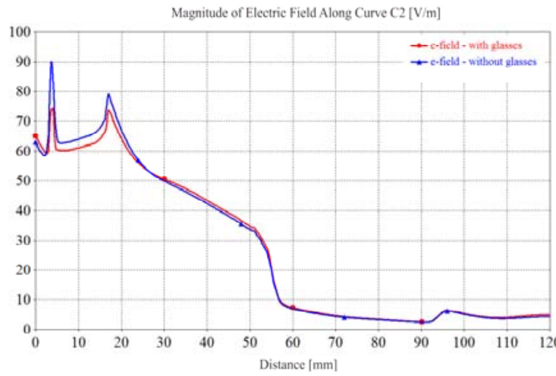

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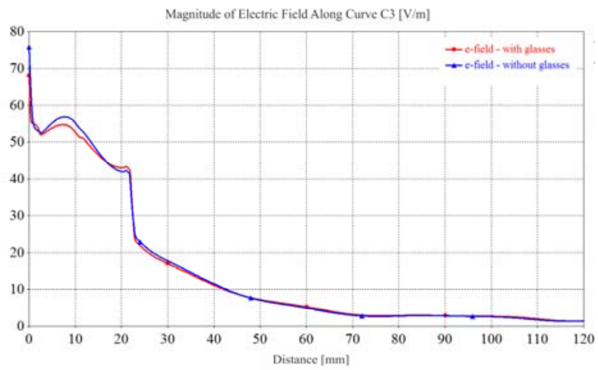


c)

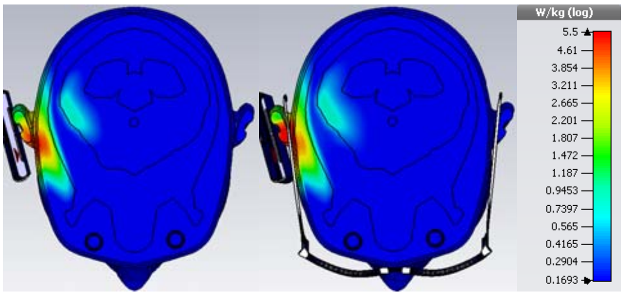
Figure 6. *Electric field strength along the curve a) C1, b) C2 and c) C3*

According to the obtained results, represented in Table 2, the decrease in electric field values in the following tissues is as follows: Fat – 29.86 V/m, Muscle – 23.69

V/m, Skull – 5.653 V/m and Cerebrospinal Fluid – 2.51 V/m. The decrease for the other tissues is negligible because they are farther away from the metal frame and their influence is very low.

Table 2. *Maximum value of the electric field strength inside the certain biological tissue [V/m].*

Biological tissue	Model without glasses	Model with glasses
	E[V/m]	E[V/m]
Skin	143.69	104.85
Fat	126.78	96.92
Muscle	87.31	63.62
Skull	61.083	55.43
Cerebrospinal Fluid	33.96	31.45



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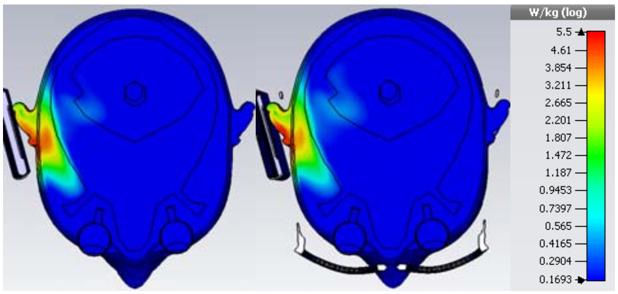

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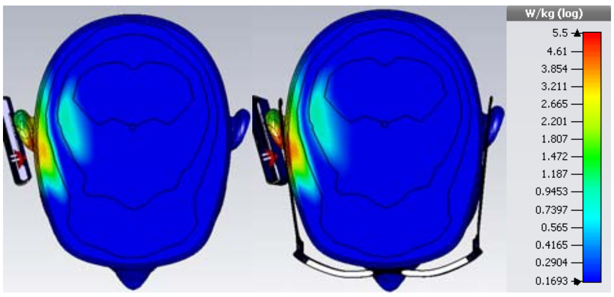

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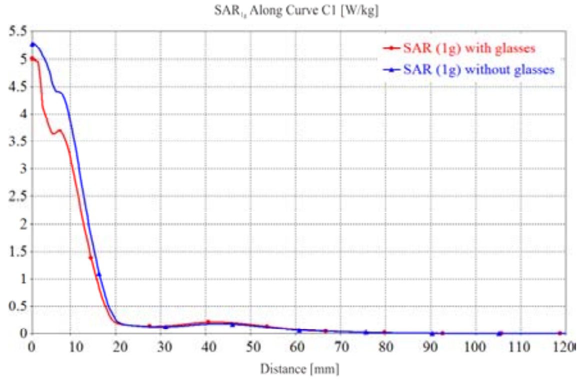
Figure 7. *Specific absorption rate - SAR_{1g} a) C1-cross-section, b) C2-cross-section and c) C3-cross-section*

SAR distribution

This section refers to a comparative analysis of the SAR values averaged for 1g (SAR_{1g}) within the models (with and without glasses) at the mentioned frequency. The amount of absorbed energy from a mobile phone in the horizontal cross-sections, previously presented, located at the level of glasses handles, is shown in Figure 8. These cross-sections contain curves C1, C2 and C3.



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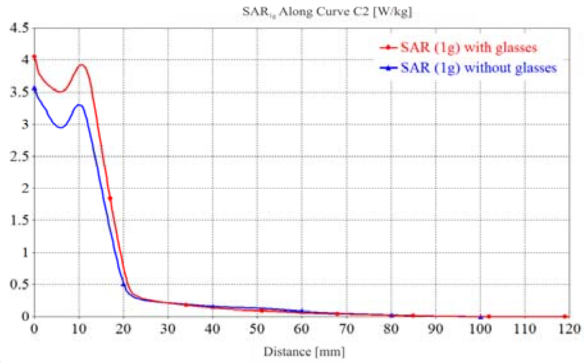

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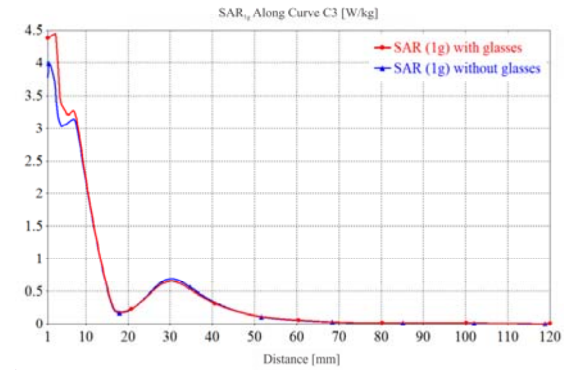

c)

Figure 8. *Specific absorption rate - SAR_{1g} a) C1-cross-section, b) C2-cross section and c) C3-cross section*

The models with glasses (right side) and without glasses (left side) are represented in the same figure to enable comparison. On the right side of the figures, the maximum value of SAR_{1g} in the color palette is set to be the same for both models, also for the easier comparison of SAR_{1g} values within the model.

There is considerable confusion and misunderstanding about the meaning of the maximum reported Specific Absorption Rate (SAR) values for cell phones (and other wireless devices). According to appropriate safety standards, the limit of SAR per 1g tissue should not exceed 1.6W/kg for public exposure from mobile phones [2].

Figures 8a, 8b and 8c show the dependence of the SAR_{1g} values along the curves C1, C2 and C3 on the distance from the radiation source respectively. According to the obtained results represented in previous figures, it is evident that the maximum values of absorbed energy for both models occurs in the surface layers of the model.

Based on Figure 7, the distribution of SAR_{1g} values is similar for both models (with and without glasses). According to the results represented along the curves mentioned above, a significant decrease of the SAR_{1g} value in the presence of glasses with aluminium frame can be noted. The SAR_{1g} peak values inside the different biological tissues for the models with and without glasses are represented in Table 3. The highest influence of glasses on the amount of absorbed energy can be noted in the tissues that are nearest to the metal frame (Figures 7 and 8).

Table 3. *Maximum value of SAR_{1g} [W/kg]*

Biological tissue	Model without glasses	Model with glasses
	SAR_{1g}[W/kg]	SAR_{1g} [W/kg]
Skin	5.299	5.02
Fat	5.18	4.82
Muscle	4.58	3.65
Skull	2.06	1.63
Cerebrospinal Fluid	0.353	0.335

It can be seen from Figure 8 (curve C1) that the maximum value of the SAR_{1g} is inside the skin and it is 5.02 W/kg in the presence of glasses, while this value for the model without glasses is higher and amounts – 5.299 W/kg. According to the obtained results, represented in Table 3, we can observe that the decrease in the amount of absorbed energy in other tissues is as follows: Fat – 0.36 W/kg, Muscle – 0.93 W/kg, Skull – 0.43W/kg and Cerebrospinal Fluid – 0.018 W/kg. The decrease for the other tissues is negligible because they are farther away from the metal frame and their influence is very low. However, the value of the SAR_{1g} within both models inside certain tissues is larger than the maximum allowed values.

CONCLUSION

This study investigated the electric field distribution and the values of the Specific Absorption rate within biological tissues in the vicinity of metal frame glasses, during the conversation over a mobile phone. The numerical calculation was performed for the frequencies of the 3G mobile network. Also, a comparative analysis of the models with and without glasses has been presented.

According to the obtained results for the electric field strength inside the biological tissues in the vicinity of the metal frame glasses, it can be concluded that the maximum values of the electric field are lower when the glasses are present. The highest influence of glasses on electric field strength can be observed inside the tissues which are nearest to the metal frame.

The maximum value of the electric field in the absence of glasses is almost 1.4 times higher than the electric field obtained for the model with glasses. According to values in Table 2, the differences in the electric field strength can be observed. Electric field strength is lower in the presence of glasses, and this decrease for following tissues amounts: Skin – 27%, Fat – 25%, Muscle – 27%, Skull – 9%, and Cerebrospinal Fluid – 7%. The decrease in case of other tissues is negligible since they are farther away from the metal frame.

Therefore, it can be concluded that the presence of glasses with the metal frame decreases the electric field in the biological tissues located near to the frame. However, it should not be forgotten that the value of the electric field inside certain tissues, despite the decrease of almost 30% when the glasses are present, overcomes the allowed values prescribed by safety limits.

Regarding the obtained results that refer to the amount of absorbed energy, a significant decrease in the SAR_{1g} value can be noted in the presence of glasses with aluminium frame. Based on the values shown in Table 3, it is evident that the decrease in the amount of absorbed energy in the presence of glasses inside the following tissues amounts: Skin – 5.2%, Fat – 6.9%, Muscle – 20%, Skull – 25% and Cerebrospinal Fluid – 5%. As for the electric field, the value of the SAR_{1g} within both models inside the certain tissues is larger than the maximum allowed values prescribed by safety limits.

In general, based on the results obtained for the electric field strength and the amount of absorbed energy from the mobile phone along the curves, it is evident that the influence of the glasses is the highest for the tissues that are nearest to the frame of glasses. Since the aluminium frame is a good conductor, in its presence large amount of electric field is directed away. Therefore, every time we wear glasses during the conversation over the cell phone, the metal frame of glasses behaves as a kind of shield.

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EFEKTI UPOTREBE NAOČARA SA METALNIM OKVIROM PRILIKOM IZLOŽENOSTI ELEKTROMAGNETNOM ZRAČENJU

Dejan Jovanović, Vladimir Stanković, Dragana Živaljević, Dragan Vučković, Simona Ilie

Rezime: *Cilj ovog istraživanja je procena uticaja naočara sa metalnim okvirom, na raspodelu električnog polja kao i na specifičnu konstantu apsorpcije (Specific Absorption Rate - SAR), unutar modela ljudske glave. Za dobijanje raspodele električnog polja i vrednosti SAR u okolini naočara sa metalnim okvirom, kada je čovek izložen zračenju mobilnog telefona sa 3G frekvencijom mobilne mreže, primenjeno je numeričko rešavanje jednačina prostiranja elektromagnetnih talasa. Izračunavanje ovih efekata izvršeno je za vreme korišćenja funkcije poziva mobilnim telefonom. Da bi se dobili najtačniji rezultati, kreirani su 3D modeli ljudske glave i metalnog okvira naočara. Za procenu pomenutih efekata izvršena je uporedna analiza modela sa i bez naočara. Takodje, dobijeni rezultati su dati za prostor unutar različitih bioloških tkiva i organa koji čine model ljudske glave.*

Ključne reči: rapodela električnog polja, Specifična konstanta apsorpcije, mobilni telefon, naočare sa metalnim okvirom.

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SOLID WOOD FLAMMABILITY TESTING

Abstract: *Household furniture usually contains at least partly some kind of wood material which brings additional fire hazards in enclosures. The number of different wood products is used in furniture manufacture and each of these classes has different flammability characteristics. In this work, we conducted a number of experiments to assess these characteristics for solid oak and fir board samples. Experiments were conducted on mass loss calorimeter for heat fluxes of 30 40 and 50 kW/m². Obtained results were in close agreement with the literature findings.*

Keywords: solid wood, enclosure fire, flammability, combustion.

INTRODUCTION

According to the Food and Agriculture Organization of the United Nations (FAO), industrial round-wood removals worldwide in 2018 reached 2.028 million m³ [1]. Sawn-wood production was on the level of 493 million m³, while global wood-based panel production reached 408 million m³ [1]. Sawn hardwood is an important wood product. It is used for the production of furniture (29 percent) as well as for moldings (20 percent), structural housings (18 percent), floorings and paneling (8 percent), and decoration (8 percent) [2]. From these figures, it is clear that considerable quantities of wood material are used for producing household furniture. Wood is flammable and as such presents fire hazards. Enlarged quantities of wood in enclosures consequently bring elevated fire risk. Wood for furniture comes in different forms - as solid wood, particleboard, plywood, fiberboard and each of these classes has different flammability and combustion characteristics. This asks for a systematic approach that will provide insights into the combustion behavior of different wood products and help to improve the existing fire models.

Combustion of wood and charring materials, in general, is a complex process. It encompasses many sub-processes. Water evaporation is the first process that starts when the specimen is exposed to incident heat flux. Pyrolysis/gasification follows. This second stage is often called devolatilization. During this phase, the material loses light volatile compounds generated as a result of thermal degradation of main biomass building compounds: cellulose, hemicellulose, and lignin. The combustion process starts when the concentration of volatiles and temperatures reach appropriate levels. Ignitability of tested material highly depends on the presence of ignition source. Ignition temperatures are considerably lower for piloted ignitions. Flaming combustion proceeds after the ignition. It highly depends on the production rate of volatiles from burning material. Flaming combustion ceases when the concentration of volatiles drops below the lower flammability limit. Onwards combustion proceeds as char burning. This phase is also called glowing.

In order to assess the fire risk in enclosures and develop reliable numerical models, flammability and combustibility characteristics of materials should be known with acceptable accuracy. Most reliable results regarding the fire performance of materials can be gathered from intermedium to large scale fire tests: Single Burning Item (the SBI) EN 13823 [3], ISO 9705 [4], ASTM E1474 [5] and ASTM E2067 [6]. While being accurate and reliable these tests are expensive and cumbersome. However, Babrauskas showed that the number of results from full-scale fire tests can be predicted, with acceptable accuracy, from tests performed on bench-scale instruments [7]. The most frequently used instrument for performing bench-scale experiments and gathering relevant flammability and combustibility data is the cone calorimeter developed by NIST (National Institute of Standards and Technology) in the eighties. Material testing should be conducted according to ISO 5660 [8].

This paper aimed to study combustibility and flammability studies of solid wood board specimens used for fabricating household furniture. Oak *(Quercus cerris)* and Fir *(Abies alba)* wood samples with a thickness of 10 and 20 mm were tested. Experiments were performed under the three incident heat fluxes of 30, 40, and 50 kW/m².

MATERIALS AND METHODS

Materials

Experiments were performed on solid wood boards from oak and fir. Wood specimens were provided from the local sawmill. The samples were cut to a dimension of 100 x 100mm. Specimen thicknesses were 10 and 20 mm. Before tests, samples were wrapped with Al foil. Ceramic fiber blankets were placed below the samples. In between the bottom of the sample holder and ceramic blanket, the ceramic block was fitted. All the tests were performed with the retainer frame. Samples before the test are shown in Figure 1.

Figure 1. *Fir (left) and Oak (right) board samples*

Samples were conditioned in laboratory (temperature 22 ± 2 ^{0}C and relative humidity 50 ± 5%) for two months before testing. Testing for each material and heat flux was repeated at least twice in order to check the repeatability of obtained results. All the samples were tested in a horizontal position.

Composition and heating values for higher heating values for Fir and Oak are shown in Table 1. Data were compiled from various resources [9]. The composition is reported on a mass basis, for dry samples. Heating value is expressed for higher heating value (Hh) in [kJ/kg]. Values fluctuate through literature but provided numbers present averages. From the table, it is obvious that values are very similar for different wood species tested.

Table 1. *Composition and heating values of fir and oak*

	C	H	O	N	S	A	Hh
Fir	50.35	6.14	43.18	0.05	-	0.28	21101
Oak	49.89	5.98	42.57	0.22	0.05	1.29	19992

Method

Mass loss calorimeter apparatus

Experiments were performed in Mass loss calorimeter made by Fire Testing Technology - FTT (East Grinstead, UK). Mass loss calorimeter is a device used for reaction-to-fire characterization of a solid sample in a similar way as in cone calorimeter. The material testing procedure is set up in ISO 17554 [10] and EN ISO 13927 [11]. Apparatus was put in a specially designed fume cupboard in order to extract the fire effluents. Installation is shown in Figure 2.

Figure 2. *Mass loss calorimeter inside the specially designed fume cupboard*

Exhaust gas system with appropriate ports for gas sampling and temperature and velocity measurement was manufactured according to requirements defined in ISO 5660 [8].

Calibrations were performed before the tests. Three calibration procedures were undertaken. Initially, the cone heater was calibrated for incident heat fluxes of 30, 40, and 50 kW/m^2. Calibration was performed with the Schmidt-Boelter water-cooled heat flux meter (Medterm, Huntsville, USA). In the second step, the thermopile system was calibrated with methane sand burner for appropriate heat release rates. Calibration was performed for 5 kW, 4 kW, 3 kW, 2 kW, 1 kW, 0.75 kW and 0.5 kW. Finally, the load cell was calibrated, zeroed, and spanned for expected specimen masses.

Distance between the exposed surface of tested samples and the cone heater was set to 25 mm. Additionally, volumetric flow in the exhaust gas system was set to 0.024 m^{3}s^{-1}. Combustion tests were performed under the well-ventilated conditions.

Results and discussion

During the tests following parameters were recorded/calculated:

- Ignition time (s)
- Flameout time (s)
- Peak HRR (kW/m²)
- Peak EHC (MJ/kg)
- Peak MLR (g/s)
- Time to peak HRR (s)
- Time to peak EHC (s)
- Time to peak MLR (s)
- Mean HRR (kW/m²)
- Mean EHC (MJ/kg)
- Mean MLR (g/s)
- Total heat release (MJ/m²)
- Percentage mass lost (%)

Results for both specimens, for three tested incident heat fluxes, are summarized in Table 2.

Table 2. *Flammability parameters for fir and oak*

	Incident heat flux (kW/m^2)	**30**	**40**	**50***
Ignition time (s)	Oak (*Quercus cerris*)	83	30	25
	Fir (*Abies alba*)	55	16	11
Flameout time (s)	Oak (*Quercus cerris*)	1737	1433	565
	Fir (*Abies alba*)	1252	1199	452
Peak HRR (kW/m²)	Oak (*Quercus cerris*)	158.88	193.02	317.80
	Fir (*Abies alba*)	164.73	170.09	242.26
Peak EHC (MJ/kg)	Oak (*Quercus cerris*)	79.45	79.33	69.00
	Fir (*Abies alba*)	79.03	78.90	79.36
Peak MLR (g/s)	Oak (*Quercus cerris*)	0.23	0.19	0.27
	Fir (*Abies alba*)	0.21	0.18	0.26
Time to peak HRR (s)	Oak (*Quercus cerris*)	1430	1186	403
	Fir (*Abies alba*)	1040	981	319
Time to peak EHC (s)	Oak (*Quercus cerris*)	564	155	490
	Fir (*Abies alba*)	836	1073	396
Time to peak MLR (s)	Oak (*Quercus cerris*)	87	1097	417
	Fir (*Abies alba*)	68	24	81
Mean HRR (kW/m²)	Oak (*Quercus cerris*)	79.09	101.93	169.24
	Fir (*Abies alba*)	97.13	95.89	139.61
Mean EHC (MJ/kg)	Oak (Quercus cerris)	11.40	12.40	14.00
	Fir (Abies alba)	14.60	14.19	15.38
Mean MLR (g/s)	Oak (Quercus cerris)	0.06	0.07	0.11
	Fir (Abies alba)	0.06	0.06	0.08
Total heat release (MJ/m²)	Oak (Quercus cerris)	131.51	143.25	91.74
	Fir (Abies alba)	117.02	113.52	61.70
Percentage mass lost (%)	Oak (Quercus cerris)	76.20	76.68	80.17
	Fir (Abies alba)	83.49	81.87	84.44

Of all parameters describing fire behavior, the heat release rate can be regarded as the single most important variable in fire hazard [12].

Heat release rates for both materials for all tested heat fluxes are shown in Figure 3.

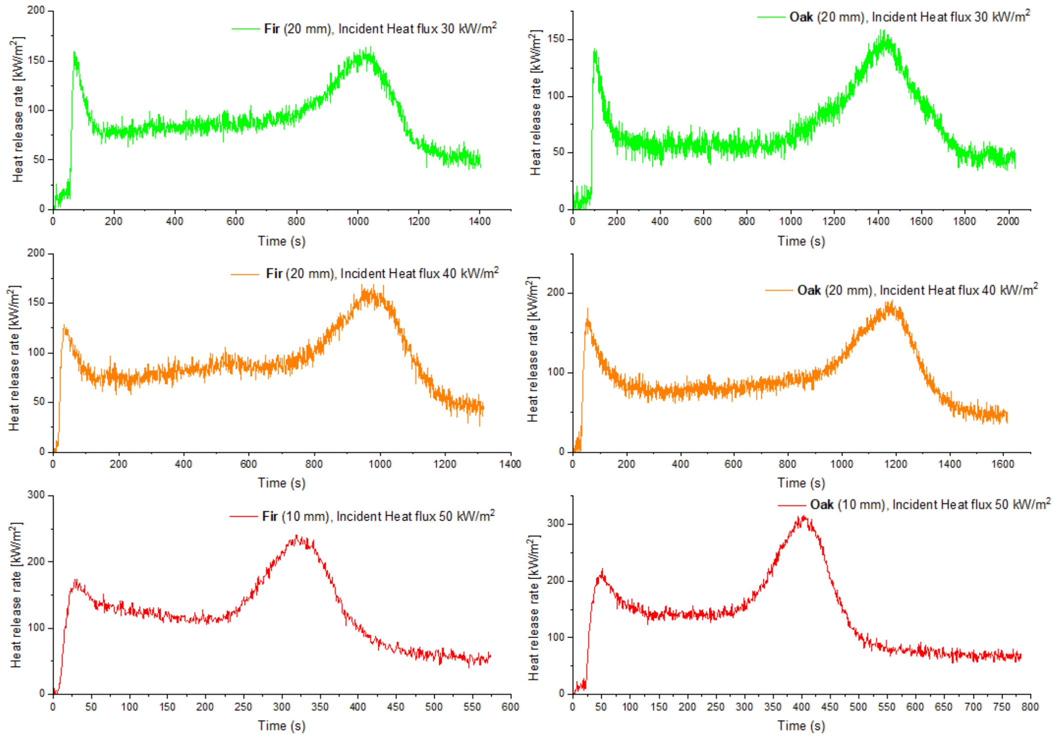

Figure 3. *Heat release rates for Fir and Oak for different incident heat fluxes*

As was expected rising heat flux reduces ignition time. It is noticeable shorter for fir specimens. Additionally, the heat release rate curves have a similar shape. This shape is characteristic of charring materials. The first peak corresponds to the ignition of volatiles. Afterward, a period of sustained flaming follows. Next, a higher peak emerges at the moment when heat from the surface of the specimen reaches the bottom end of the material. From this moment on, the material starts burning from the whole volume. Obtained results were compared with findings from the literature [13,14]. Similar profile shapes were noticed.

CONCLUSION

In this work flammability and combustibility characteristics of two solid wood types were experimentally determined. From this work following conclusions can be derived:

- Heat flux of less than 30 kW/m^2 is sufficient to ignite fir and oak solid wood boards;
- Critical flux should be searched in the range between 20 and 30 kW/m^2;
- Ignition time (for piloted ignition) is considerably shorter for fir than for the oak. This observation is more pronounced for higher heat fluxes;
- Heat release rate profiles have two pronounced peaks, which corresponds very well with literature findings and
- Fir burns much faster than oak.

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ISPITIVANJE UPALJIVOSTI DRVETA

Milan Protić, Nikola Mišić, Miomir Raos, Srećko Sekulić

Rezime: *Nameštaj u domovima najčešće u izvestoj meri sadrži drvo što uvećava požarno opterećenje u zatvorenim prostorima. Za izradu nameštaja se koriste različite vrste drveta čije se karakteristike upaljivosti značajno razlikuju. U ovom radu izvršeno je ispitivanje karakteristika upaljivosti uzoraka hrasta i jele. Ispitivanja su izvršena na kalorimetru za ispitivanje toplotne snage za toplotne flukseve od 30, 40 i 50 kW/m^2. Dobijeni rezultati su u saglasnosti sa rezultatima iz literature.*

Ključne reči: drvo, požari u zatvorenim prostorima, upaljivost, gorivost.

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ANALYSIS OF MAGNETIC FIELD DISTORTION IN VARIOUS TYPES OF BEDS WITH FERROMAGNETIC MATRESSES

Abstract: *Ferromagnetic elements in the furniture, especially beds, influence the changes in the magnetic field distribution in this area. In this way, an inhomogeneous magnetic field whose values are higher than the Earth's natural magnetic field is generated. The presence of humans or their body parts in anomalous magnetic fields has become the focus of health concerns. For this reason, the magnetic field for different types of beds with ferromagnetic parts, such as mattresses, has been calculated in this paper. Our results showed that exposure to magnetic fields revealed the zones with higher magnetic induction for some type of beds. In the end, new material and new design processes have been suggested in order to maintain a healthy lifestyle.*

Keywords: *beds with ferromagnetic mattresses, magnetic field calculation, anomalous magnetic field, health risk.*

INTRODUCTION

Electromagnetic sources and different types of ferromagnetic objects in modern living spaces generate changes in magnetic fields. Obtained magnetic fields that people spend most of their time are significantly different from Earth's natural magnetic field (EMF), and they are known as Anomalous Magnetic Fields (AMF). Spending a long period of time in the AMF can produce significant health effects according to existing scientific knowledge [1, 3, 5].

It is not difficult to verify that animals and humans are electromagnetic beings and it is logical that electromagnetic fields affect chemical, physiological and biological processes [2].

Unfortunately, the impact of electromagnetic fields at the cellular level and organelle-level up to the molecular level has not been fully explained, which certainly slows down the development of medicine. The cell metabolism is trained by an electric field on both sides of the cell membrane and magnetic properties of cell organelles and local magnetic fields in cells manage the functions of organelles and processes [7, 1, 9, 10], and the immune properties of the whole body [12, 5].

Generally, people spend a lot of time in beds, and if the body is in an anomalous position, electric and magnetic fields in biochemical processes in cell and cell organelles are not regular, which ultimately leads to histopathological changes in the cell. For all these reasons, it is important that humans remain in the natural fields, while in the modern living environment, we should take into account what kind of EM fields he/she lives in [6, 11].

Respecting the fact that ferromagnetic objects in the magnetic field can be magnetized and, in this way, change magnetic field and made different distribution concerning the initial field, the goal of this investigation was to evaluate this effect. One way to determine the spatial distribution of these fields is the numerical calculation of the magnetic field using numerical methods, and another way is by measurement. This paper is focused on the calculation of the magnetic field for different types of beds with mattresses with ferrite core (springs).

MODELS OF BEDS

In general, there are three types of beds: single, bunk bed and sofa bed. All types of beds are shown in Figure 1 and Figure 2.

A bunk bed is a type of bed in which one bed frame is stacked on top of the other (Fig 1b). A sofa bed is typically a sofa or couch that, underneath its seating, hides a metal frame that can be unfolded or opened up to make a bed (Fig. 2).

Figure 1. *Types of bed: a) single bed, b) bunk bed*

Figure 2. *Sofa bed (unfoldable and foldable)*

Modern beds are constructed with parts of steel and mattress from springs. Bonnell spring mattress systems are the most traditional type of innerspring mattress. The Bonnell coil (spring) has an hourglass shape (wider at the bottom and the top than the middle) and is interconnected with a mesh of metal to make the spring system.

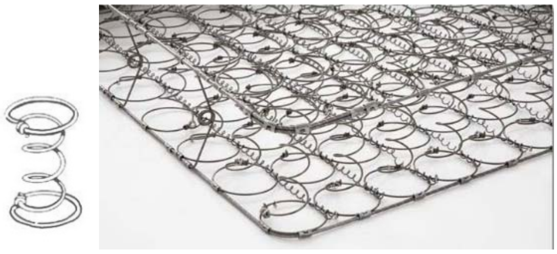

Figure 3. *Geometry of spring and mattress*

NUMERICAL CALCULATION OF MAGNETIC FIELD IN BEDS

A simplified model for each model of the bed has been made so that simulation could be performed. Simplified models fit beds with wooden construction without metal frames. In this construction, there are mattresses with a steel wire core with helical compression spring, usually from a ferromagnetic material. In Figure 4, there is a simplified model of bed without a frame which consists of 5x9 springs of 15 cm radius and 20 cm high.

Springs are helicoidal structures made up of 6 coils having approximately the same radius, with the central coils having about 10% smaller radius. The conductive material interconnects the springs, while the ends of the springs do not end at the same angle. This provides the reality of the wire core structure that is achieved in the production of this mattress. The mattress was set at a height of 25 cm from the ground.

To provide the reality of the initial data in the simulation model, the intensity of the magnetic induction of the natural Earth magnetic field by the proton magnetometer was measured in the area of Nis. The mean value of the natural magnetic field $B = 47,8 \mu T$ was measured. This value was used to determine the initiative magnetic field in the airspace during the simulation. The springs (helix) and circular cross-section constructing profiles are made from ferromagnetic material with $\mu_r = 1000$, $\sigma = 1.04 \cdot 10^{-7}$ S/m. The magnetization curve for the helix material at the operating point are defined by values $H = 38$A/m, $B = 0.6$T . Earth is modeled as a parallelepiped bigger than the bed with electromagnetic characteristics $\varepsilon_r = 2.53$, $\rho = 1550 \cdot \text{kg/m}^3$.

A preferred simulation method for calculating the magnetic flux density is the Finite Integration Technique. This method has been applied within the software package CST Studio Suite by CST - Computer Simulation Technology.

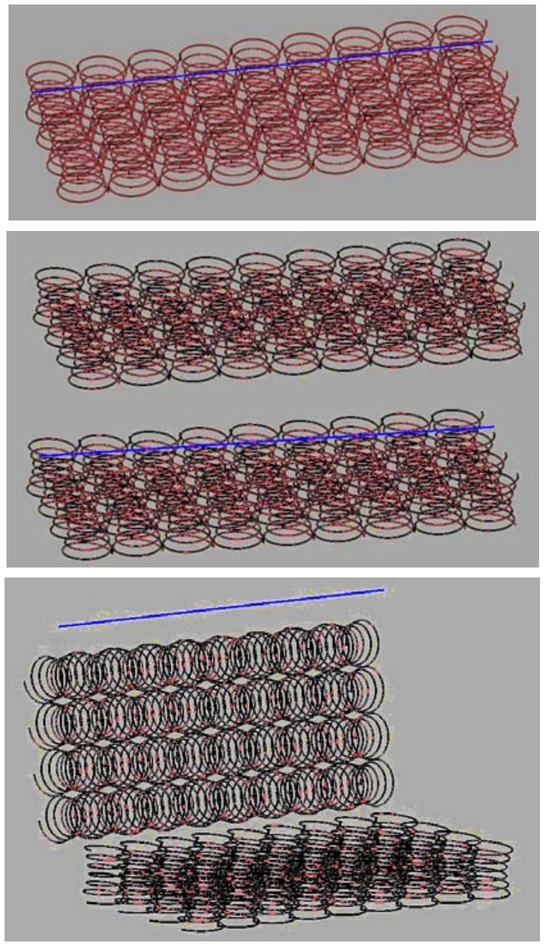

Figure 4. *The models of beds with mattress: a) single bed, b) bunk bed, c) sofa bed*

RESULTS OF SIMULATION MAGNETIC FIELD

For the simulated parameters, the calculation of the magnetic field in the immediate surroundings of the construction was carried out. Some of the results are shown in the form of a diagram of different cross-section bad and man in lying position which represents the distribution of magnetic flux density, and graphics and tables.

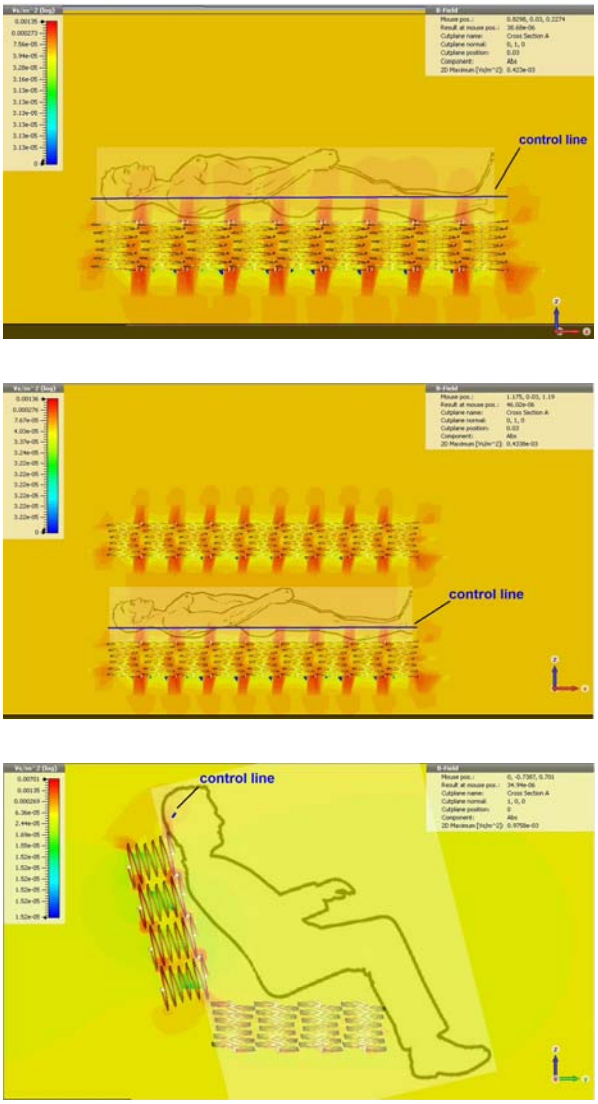

Figure 5. *Magnetic flux density $B[\mu T]$ a) single bed model, b) bunk bed, c) sofa bed*

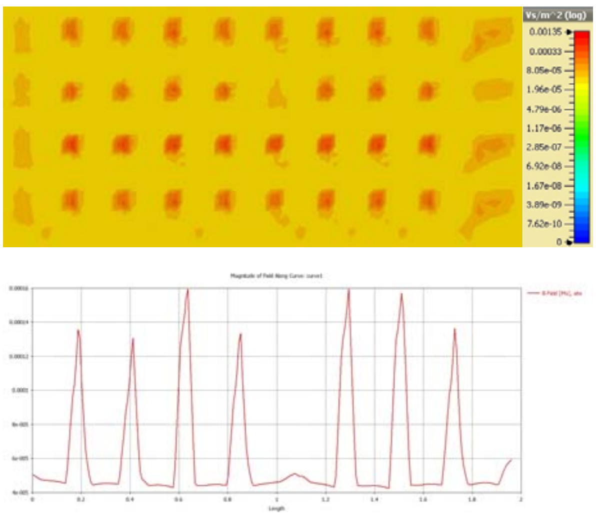

Figure 6. *Magnetic flux density $B[\mu T]$ for a single bed at a distance of 5cm from the mattress core along the control line*

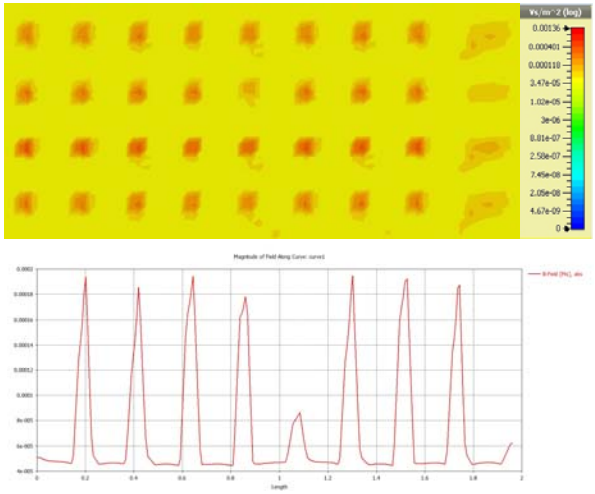

Figure 7. *Magnetic flux density $B[\mu T]$ for bunk bed at a distance of 5cm from mattress core along the control line*

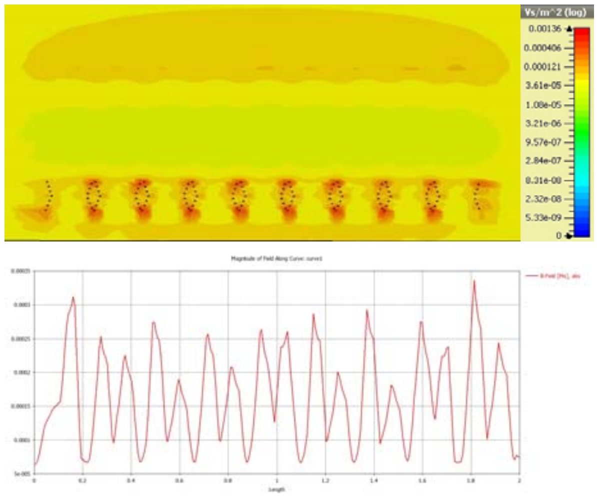

Figure 8. *Magnetic flux density $B[\mu T]$ for a sofa bed at a distance of 5cm from the mattress core along the control line*

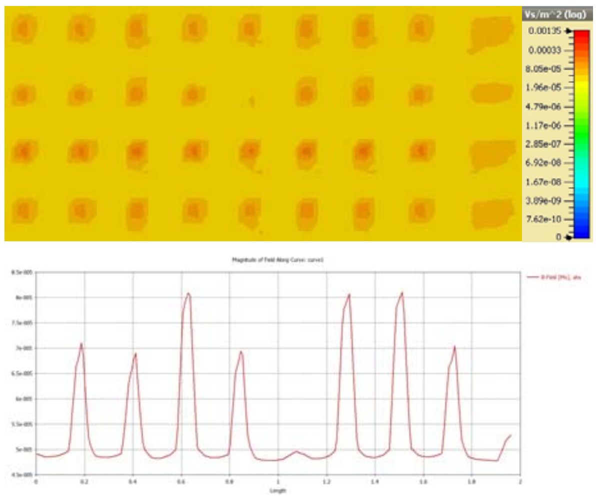

Figure 9. *Magnetic flux density $B[\mu T]$ for a single bed at a distance of 10 cm from the mattress core along the control line*

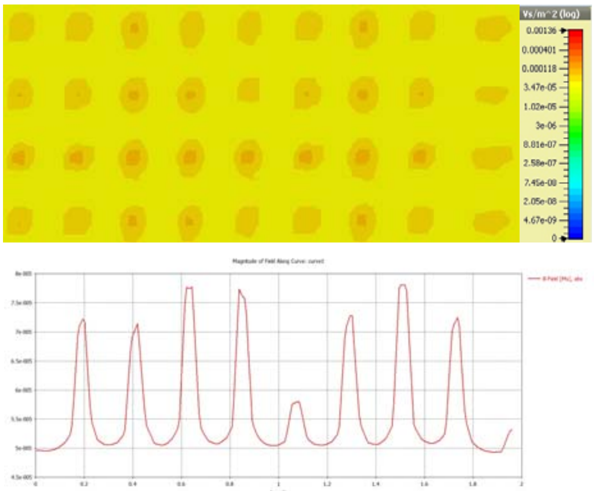

Figure 10. *Magnetic flux density* $B[\mu T]$ *for a bunk bed at a distance of 10 cm from the mattress core along the control line*

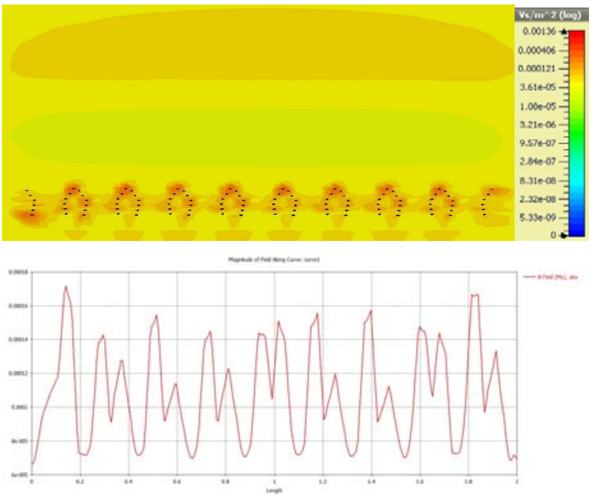

Figure 11. *Magnetic flux density* $B[\mu T]$ *for a sofa bed at a distance of 10 cm from the mattress core along the control line*

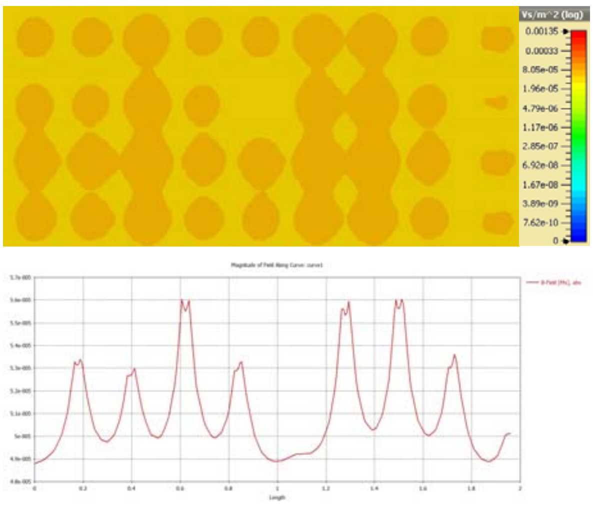

Figure 12. *Magnetic flux density* $B[\mu T]$ *for a single bed, at a distance of 15 cm from the mattress core along the control line*

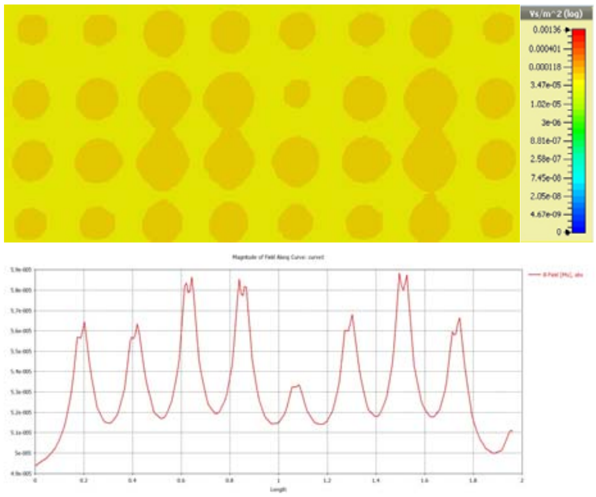

Figure 13. *Magnetic flux density* $B[\mu T]$ *for a bunk bed at a distance of 15cm from the mattress core along the control line*

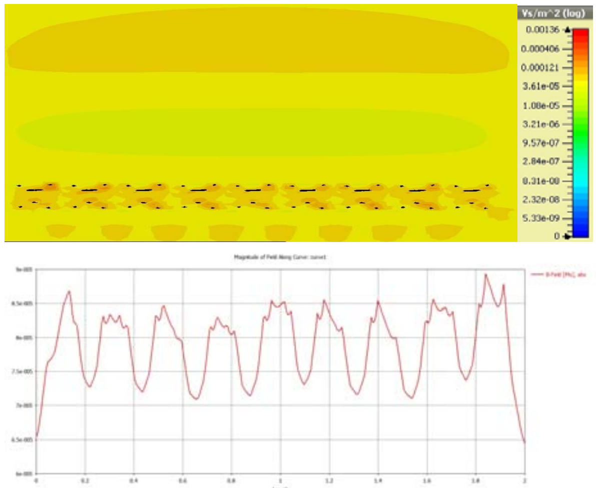

Figure 14. *Magnetic flux density* $B[\mu T]$ *for a sofa bed at a distance of 15 cm from the mattress core along the control line*

Table 1. *Magnetic flux density* $B[\mu T]$*, for different bed models, at a distance of 5cm from the mattress core*

Model of bed	$B_{min}[\mu T]$	$B_{max}[\mu T]$	ΔB $[\mu T]$	$\frac{\Delta B}{B_{Earth}}[\%]$
Single	46.92	159.08	112.16	234.64
Bunk bed	47.85	194.51	146.66	306.82
Sofa*	68.82	338.21	269.39	563.57

* *in the head area*

Table 2. *Magnetic flux density* $B[\mu T]$*, for different bed models, at a distance of 10 cm from the mattress core*

Model of bed	$B_{min}[\mu T]$	$B_{max}[\mu T]$	ΔB $[\mu T]$	$\frac{\Delta B}{B_{Earth}}[\%]$
Single	48.02	80.58	32.56	68.11
Bunk bed	49.50	78.12	28.62	59.87
Sofa*	69.41	172.61	103.2	215.48

* *in the head area*

Table 3. *Magnetic flux density* $B[\mu\text{T}]$, *for different bed models, at a distance of 15 cm from the mattress core*

Model of bed	$B_{\min}[\mu\text{T}]$	$B_{\max}[\mu\text{T}]$	ΔB [μT]	$\frac{\Delta B}{B_{Earth}}$[%]
Single	48.92	56.24	7.32	15.31
Bunk bed	49.88	58.82	8.94	18.70
Sofa*	71.56	89.02	17.46	36.52

** in the head area*

CONCLUSION

The calculation of the magnetic field for three different types of beds in the immediate surroundings of the mattress was carried out.

The comparison of the values obtained by the simulation and the values obtained by measuring a similar physical model showed a satisfactory agreement.

The following figures show the distribution of magnetic flux density in the bed area where the human body rests.

The results show that the largest change in magnetic induction is relative to the natural magnetic field near the mattress, which can be seen in Table 1, where this relative deviation is 354% for the single bed, 306% for the bunk bed model and 563% for sofa bed. This means that a person while sleeping in such beds has a very inhomogeneous exposure of certain organs to the magnetic field, which will define different metabolic activities in certain parts of the organs. This certainly does not contribute to natural functions during the period of rest, which as a consequence, could bring about significant health effects.

Increasing the distance from the mattress leads to a decrease in the relative deviation, which can be seen in Table 2 and Table 3.

The spatial distribution of the magnetic field shown in the figures indicates the maxima of the magnetic induction for the springs axis and the ends of the springs. Analysis of the size of the springs to the relative deviation indicates that the springs of the smaller radius of the helicoid and the mass itself give lower intensities of magnetic induction (magnet flux density), i.e. it can be said that the magnetic field is more homogeneous compared to mattresses with larger springs.

For bunk beds, homogeneity can be observed over the entire height of the bed, i.e. deviations are far smaller compared to other bed models, Fig. 5b.

In the case of sofa beds, the results show that the maximum of the magnetic field is at the height of the head, i.e. approximately in the occipital part of the head. Some knowledge from the literature [6, 10, 14] indicates a possible impact on the clogging of blood vessels in the area of the nape and head and the increase in blood pressure.

In general, it may be noticed that the intensity of magnetic flux density decreases with the distance from the mattress, which will produce unequal exposure to the magnetic field of individual organs depending on the physiological position when sleeping.

It has been proven that ferromagnetic objects in human proximity lead to a change in the homogeneity of the natural ambient magnetic field and staying in an anomalous magnetic field can be considered undesirable.

Manufacturers of the ferromagnetic furniture should adopt new data about the health hazard of their products on the functioning of natural biological mechanisms.

Research should continue to investigate what level of anomalous magnetic fields in the sleeping space can be harmful to human health.

The research results should provide healthy electromagnetic conditions for people in their actual environment, similar to those generated in natural electromagnetic fields.

ACKNOWLEDGEMENT

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ANALIZA PROMENE MAGNETNOG POLJA U RAZLIČITIM TIPOVIMA KREVETA SA FEROMAGNETNIM DUŠEKOM

Darko Zigar, Dejan Krstić, Uglješa Jovanović

Rezime: *Feromagnenti delovi nameštaja a posebno kreveti dovode do promene magnentog polja. Na taj način se stvara nehomogeno magnentno polje čije su vrednosti veće od prirodnog magnentnog polja zemlje. Boravak dela tela ili celog tela u anomalijskim magnetnim poljima se povezuje sa zdravstvenim problemima. U ovom radu se izračunava magnetno polje za različite vrste kreveta sa feromagnetnim delovima kao što je dušek. Prikazani su rezultati koji definišu oblasti u kojima je magnetna indukcijom povećana u odnosu na prirodno magnentno polje za neke vrste kreveta, a da bi kreveti omogućavali zdrave životne uslove neophodni su novi materijal i novi proces dizajniranja u procesu proizvodnje.*

Ključne reči: kreveti sa feromagnetnim dušekom, proračun magnentog polja, anomalijsko magnentno polje, zdravstveni rizik.

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ANALYSIS OF THE PROPER FUNCTIONING OF FORKLIFT BRAKES

Abstract: *The aim of this paper is to analyze the safety of forklift brakes. The research methodology used to analyze forklift brake safety is presented using the checklist descriptive method. The study was conducted on 127 forklifts with an average age of 15 years, where it was found that about 10% of the forklifts did not have a proper parking brake and that about 2% of the forklifts had defective service brakes. Finally, the results obtained from the research on brake safety have been discussed and further research has been proposed.*

Key words: forklift, brake, methodology, research, analysis, checklist.

INTRODUCTION

Packaging is a technological process of putting a box around a product, sealing and marking a product which has been packed [1]. Three types of packaging goods are shown in Figure 1 [2].

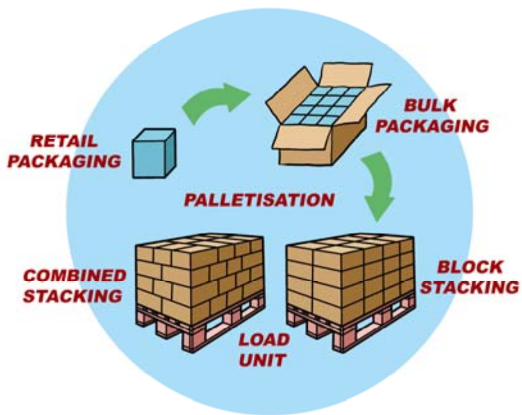

Figure 1. *Types of goods packaging (adapted from Vladić, 2005)*

According to [3], after palletization, the product (pallet + cargo) is wrapped with stretch foil. According to [4], it is additionally secured to prevent cargo from being shattered as well as to increase the stability, thus maintaining complete safety during transport, storage and handling.

The technical base of the palletizing system consists of forklifts and pallets [5]. The pallet is a wooden base, made of boards of standard dimensions, to which various types of goods are loaded. This is how a compact and solid pallet unit is being formed. As stated by [6], a pallet without a forklift would be a static unit, like a wagon without a locomotive. The pallet unit is easily and simply transferred and stacked with a forklift.

Forklifts are powered industrial trucks, which are used in warehouses, factory halls, cargo terminals and other workspaces for handling various types of cargo.

It is a well-known fact that collisions and rollovers are the most common causes of death when working with forklifts. In line with [7], official data released by the OSHA (Occupational Safety and Health Administration) indicate that 96,785 forklift accidents occur in the USA, including 61,800 minor accidents, 34,900 serious accidents and 85 fatal accidents. Comparing the total number of forklifts (855,785) in the US with the total number of occupational injuries, we have found that 11% of forklifts are expected to be involved in minor or major accidents.

The common fatal injuries when operating forklifts are: crushed by tipping vehicle (42%), crushed between a vehicle and a surface (25%), crushed between two vehicles (11%), being struck or run over by a forklift (10%), struck by falling material (8%) and fall from a platform on the forks (4%) [7,8].

Forklift trucks, as self-propelled vehicles used for indoor transport, shall be subjected to periodic inspection and testing not later than three years from the date of the previous inspection and check. A legal entity certified to perform inspection and testing of work equipment, after inspection and check of the forklift truck must provide an expert opinion on forklift safety and prescribed occupational safety measures.

For safe operation of forklifts, it is necessary to examine parking and service brakes, light and sound signaling, the limit switch with a retractable overhead guard, tires, wheels and hydraulic control system. The parking brake must be applied when loading, unloading, lifting and lowering loads to achieve greater stability and to prevent the forklift from tipping over. In case you have to park a lift truck on an incline, it is essential to use the parking brake and secure the forklift against self-propelling forward or backward.

The service (foot) brake is a casual brake designed to slow down and stop the forklift.

RESEARCH METHODOLOGY

DEFINING THE PROBLEM

The problem with the research is the lack of current knowledge about the implementation of protective measures in forklifts, and especially those related to brake malfunction or inefficiency. Based on previous experience, it has been observed that common forklift dysfunction or brake malfunction can significantly increase the potential risk of accidents due to collisions or tipping over. No available research has been found in domestic and foreign literature covering the previously highlighted problem.

RESEARCH OBJECTIVE

The main objective of the research is to determine the percentage of forklifts with defective or inefficient brakes (parking and service brakes) compared to the total number of forklifts analyzed in the company. A specific aim of the study is to determine the causes of parking and service brake malfunctions.

RESEARCH HYPOTHESIS

The assumption is that, within the group of analyzed forklifts, a more pronounced problem would be the failure or inefficiency of the parking brake compared to the service brake.

RESEARCH METHODS

The existing checklists in the Republic of Serbia mostly offer YES / NO answers, with YES being answered for dangerous conditions and NO in other questions, so there is a problem of transparency. It has been suggested that the newly created checklist should contain answers such as "dangerous", "not relevant" and "safe", which even by a quick inspection can easily and quickly identify the number of dangerous conditions in a given checklist. After completing the checklist, appropriate corrective actions must be proposed if the answer is "dangerous" [9,10]. Based on the daily forklift truck checklist [10,11,12,13] and expert findings for periodic forklift truck inspections, there are additional questions on forklift truck safety in the new checklist. A descriptive method was used to prove or disprove the research hypothesis. An example of a completed checklist for the safety analysis of the front forklift truck is given in Table 1. In this paper, there will be additional comments only for questions 8 and 9, referring to the analysis of parking and service brakes.

RESEARCH SAMPLE

The study involved a sample of 127 forklifts, with an average age of about 15 years. The data on brake safety and functionality were collected and analyzed. The survey was conducted in 46 enterprises in the municipalities of Novi Sad (83 forklifts), Be□ej (25), Temerin (12) and Beo□in (7), with the duration of two months (May-June 2017). Diesel forklift trucks comprised almost 50% (62 trucks), while there were 34 electric and 31 gas-powered forklifts.

Table 1. *The analysis of counterbalanced forklift safety (D – dangerous, N/R – not relevant, S – safe)*

THE ANALYSIS OF COUNTERBALANCED FORKLIFT SAFETY				30	15.05.2017.
Employer's name and headquarters					
Activity (the area of work)		Metal processing industry			
Type of equipment	Counterbalanced forklift	Drive	Electric		
Manufacturer	Nissan	Production year	2005.		
Type / model	NO 1L 15 HQ	Load capacity in tons	1,5		

No:	The question	Comment	D	N/R	S	Recommended corrective measures
1.	Overhead Guard / Roll Over Protection Frame	Overhead Guard is in a good state. No visible damage and cracks.				
2.	Access to the driver's seat (3-point contact - steps and grab handles)	There is a handrail on a part of the frame structure. The floor is low - there is no step, but it can be accessed safely. Steps and grab handles are in good condition and clean.				
3.	Load handler (forks or other, fork lock - spring/pin) and telescope	The forks and telescope were not distorted or cracked. The forks are properly positioned, there are fuses with studs for the L/R forks.				
4.	Control mechanisms	Prevention of unauthorized - a key removed from the ignition switch.				
		All control commands are appropriate.				
		The emergency shutdown device is not installed.				
		There is an undamaged sticker with legible command marks.				

5.	Lift assembly (chains, limit switches)	The limit switch is in operation, it automatically stops lifting the forks upon reaching extreme upper position.				
6.	Sound signaling	The forklift is equipped correct sounding siren.				
		Reversing beeper exists and is operational.				
7.	Light signaling	There is a correct rotary light.				
		There is a functional headlight and tail light.				
		There is a proper STOP light.				
		There are flashing lights.				
8.	PARKING BRAKE	The parking brake does not work.				Repair the parking brake
9.	SERVICE BRAKE	The service brake is operational. The forklift stops by pressing the service brake (mechanical brake principle) and release the gas pedal.				
10.	Hydraulic system (hydraulic cylinders, hoses, connections)	The hydraulics for lifting and moving the forks, as well as for changing the slope of the mast, work flawlessly.				
11.	Load capacity chart	There is a graphical representation of the load capacity chart - the metal plate is damaged and the date is unreadable.				Place load capacity chart
12.	General and technical data plate	The metal plate is damaged, but the data is legible.				
13.	Signs - Notification, Warning and Prohibition (Labels)	Labels are legible and not damaged.				
14.	Safety belt	The belt is embedded and is correct.				
15.	Tires and wheels	The solid tires are damaged. It has three wheels, which is in good working order, there no distortion. All nuts secure and in place.				Replace tires.

RESULTS AND DISCUSSION

The research results on forklift brakes safety are given in Table 2. Based on these data, it is evident that the hypothesis was proved. In analyzed forklifts, a more pronounced problem was the lack of proper parking brake (11.02%) in comparison to the malfunction of service brake (1.57%).

Table 2. *Results of the analysis of forklift brakes reliability*

		Number of forklifts						
		Municipality of Novi Sad	Municipality of Bečej	Municipality of Temerin	Municipality of Beočin	Total number of forklifts/ answers	Number of negative (dangerous) answers	%
		83	25	12	7			
BRAKES	**Parking**	10	2	1	1	**127**	**14**	**11,02**
	Service	1	1	0	0		**2**	**1,57**

Of the 127 analyzes forklifts, 13 had a defective or inefficient parking brake, while one forklift did not have a parking brake. Two forklifts were found to have a malfunctioning service brake.

Forklifts that have a malfunctioning or inefficient parking and/or service brake become potentially more dangerous for indoor transport, due to the possibility of collisions with stationary objects or workers.

The most common causes of malfunction or inefficiency of the forklift parking brake are malfunctions of the parking brake system and the hand cable cracks. The most common causes of service brake malfunction are mechanical damage to the cylinder (brake wheel cylinder and master brake cylinder), wear of the brake lining or brake drum, lack of brake oil, and oiled brake lining.

In order to extend the service life of the forklift brakes, it is necessary to check the brakes regularly by an authorized service center, as well as to avoid abrupt braking by the operator/driver. It is proposed to install an electronic speedometer to limit the maximum speed of forklifts used within the plant and the warehouse (limited to 5 km/h) and forklifts used in the outside area of the plant (limited to 10 km/h). The installation of an electronic speedometer enables the simultaneous reduction of the brake pad length and the brake system wear.

CONCLUSION

A descriptive research, relying on a newly developed checklist for the safety assessment of the observed sample is a significant contribution to obtaining data about the functionality and safety of parking and service brakes.

The objective of this research was achieved through the analysis of brake safety on a selected sample of 127 forklifts, where it was found that 11.02% of the observed forklifts had a problem with malfunction or inefficiency of the parking brake, and that 1.57% of the total number of forklifts had a problem of service brake malfunction.

Further research should be directed towards analyzing the functionality of forklift brakes on a much larger sample. Also, research should be extended to the remaining questions from the new checklist for Forklift Safety Analysis.

Injuries at work, resulting from a forklift collision or overturns, can be prevented with the help of efficient preventive measures. Forklift trucks safety is achieved by investing in forklift maintenance and by organizing professional training for employees. Routine inspections should ensure that a forklift truck has proper parking and service brakes, audible alarms, steering mechanism, and a hydraulic system. In order to reduce the number of work injuries, the forklift driver/handler must take care of the forklift load, the way it is stacked and secured to the load, as well as to avoid sharp aggressive turns, excessive speeds and sudden braking/acceleration.

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ANALIZA ISPRAVNOSTI KOČNICA KOD VILJUŠKARA

Dušan Gavanski, Azra Korjenic

Rezime: *Cilj rada je analiza ispravnosti kočnica kod viljuškara. Prikazana je metodologija istraživanja koja se koristila za analizu ispravnosti kočnica kod viljuškara, i to metodom deskripcije pomoću ček-liste. Istraživanje je sprovedeno na uzorku od 127 viljuškara prosečne starosti 15-tak godina, pri čemu je utvrđeno da na oko 10% viljuškara ne postoji ispravna parkirna kočnica, a na oko 2% viljuškara su neispravne radne kočnice. Na kraju su prodiskutovani dobijeni rezultati istraživanja ispravnosti kočnica kod viljuškara i predložena su dalja istraživanja.*

Ključne reči: viljuškar, kočnica, metodologija, istraživanje, analiza, ček-lista.

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INACTIVATION OF TOXIC METALS FROM WASTE GALVANIC SLUDGE BY OTHER HAZARDOUS WASTE

Abstract: *The paper presents the process of inactivation of toxic metals from waste galvanic sludge by other waste materials such as waste sludge from the technological process of iron production, waste ash from thermal power plants, zeolite and waste cathode glass. Inactivation is performed by the sintering process at high temperatures. The obtained sintered product has such a structure that where toxic metals present in it can not be started even under critical conditions. Furthermore, such a product can have a use-value and the risk of environmental pollution is reduced to a minimum.*

Key words: galvanic sludge, slag, ash, zeolite, cathode glass.

INTRODUCTION

Galvanic sludge is declared as hazardous waste. If it is not processed or improperly disposed of, the easily mobile fraction of metal elutes with atmospheric precipitation and pollutes the environment by infiltration. In that case, the paper will present the characteristics of incorporated waste materials and the flow diagram of the inactivation of waste galvanic sludge.

Figure 1. *Ingredient of hazardous waste*

Stabilization of toxic metals from the technological process of galvanization will be performed by other waste industrial materials, such as waste slag from the technological process of iron production, waste ash from the thermal power plant, zeolite and waste cathode glass, Figure 1.

SLAG AS AN INGREDIENT OF SINTERED MATTER

The technological process of iron production creates a large amount of by-products in the form of waste slag, which is most often disposed of in landfills. In order to reduce the risk of environmental pollution, research on the possibilities of using slag for various purposes has been intensified. Slag can be used as an aggregate for filling and making embankments, filling roads, making lower layers of roads, making dams, as an aggregate for making concrete and asphalt, a raw material for making stone wool, as bedding under concrete blocks, as raw material for ceramics, etc. [1]. It is also used in agriculture as a substitute for limestone, i.e. to reduce soil acidity [2].

Figure 2. *Slag in road construction*

Slag is a complex system consisting of a number of components, most commonly of melting of various oxides with very high melting temperatures [3]. In relation to appearance, mode of cooling and mineralogy, slag is similar to magma. The type of slag that is formed during the technological process of iron production (crystal, granular, expanded) depends on the ore used, as well as the method of cooling [4]. The way the slag is cooled affects the appearance and granulation of the aggregate. Air-cooled slag is formed into a solid aggregate, while water-cooled slag is formed into a light fine-grained aggregate suitable for the preparation of mortar and concrete. Air-cooled slag will be used to stabilize the galvanic sludge due to its melting properties.

In air-cooled slag, the present CaO binds moisture from the surrounding, creating hydroxide, and reacting with CO_2 from the atmosphere, it turns into carbonate, which has a larger volume, which causes the slag to "swell". The same happens if free MgO is present which is converted to $MgCO_3$ in the same way. This transformation of free oxides into carbonates takes place during the "aging of slag", which usually takes place in landfills where the slag is exposed to atmospheric conditions with certain mechanical (swelling, cracking, crushing) and chemical (carbonization) changes. Carbonates have proved to be good glass melters and for this reason, this slag is used to obtain sintered glassy matter.

ASH AS AN INGREDIENT OF SINTERED MATTER

"Flying ash" will be used as an ingredient of the sintered material as a waste product of the coal combustion process in thermal power plants. The amount of ash deposited from thermal power plants is estimated to be several million tons per year. This is a huge economic and environmental problem of countries around the world, far ahead of other industrial wastes, such as phospho-gypsum, fluoro-gypsum and various types of industrial sludge [5].

Figure 3. *Ash dump*

The chemical composition of the ash and the share of the glassy phase contribute to its use in the production of glass-ceramic materials.

According to the American standard ASTM C618, ash produced in the process of coal combustion is classified into two groups: type F and type C. Type F (acidic) is formed during the combustion of anthracite and bituminous coal with low calcium oxide content (<7%) and with increased content of silicon dioxide, aluminum oxide and iron oxide. Type C (alkaline) is formed during the combustion of lignite and contains a larger amount of calcium oxide (from 15 to 30%). Class C ash has self-binding properties. Class F ash has pozzolan characteristics, and due to its low calcium content (less than 10% CaO), it does not have self-binding properties [6].

The ash characteristics depend on the type of coal and the method of collecting ash from electrostatic precipitators. It is generally a fine-grained and powdery material. The color of the ash is usually gray and depends on the Fe_2O_3 content and the amount of incombustible coal residues in the ash. The ash particles are of different sizes, mostly spherical in shape. The ash particle size is 0.01 to 100 μm in diameter, with the largest grain size being about 20 mm [7].

The chemical composition of ash is complex, and as characteristic chemical compounds, it contains: SiO_2, Al_2O_3, Fe_2O_3 and CaO and to a lesser extent MgO, MnO, Na_2O, K_2O, SO_3, N, C. In some ashes, TiO_2 and Pb_2O_5 can be found to a lesser extent.

The mineral composition of "flying ash" in a broader sense includes the following components: inorganic components, crystal and amorphous, organic substances derived from coal and liquid, gaseous and gaseous-liquid inclusions in inorganic and organic components [8].

Trace elements Ag, As, V, Ba, Be, Cd, Cr, Cs, Su, Ga, Ge, Li, Mn, Mo, Nb, Ni, Pb, Rb can be detected in the ashes of lignite as well as bituminous coals, Sb, Sc, Sn, Sr, U, Tl, V, Y, Zn and Zr. Many of these elements are extremely toxic, while some can be useful, so they are extracted [9].

ZEOLITE AS AN INGREDIENT OF SINTERED MATTER

Zeolite is a natural mineral formed by mixing volcanic lava with alkaline groundwater. It consists of microporous crystals of aluminosilicate origin whose structure is composed of pores, interconnected by channels in which cations and water molecules are located.

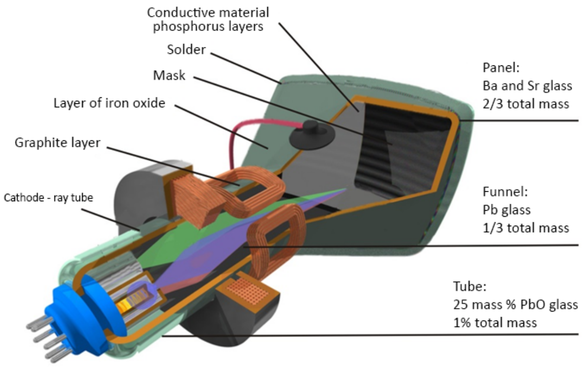
Zeolite has multiple applications in construction, medicine, wastewater treatment, etc. The addition of natural zeolites can improve the properties of concrete, various building materials and create new products. Mihajlov 's paper presents the results of the application of natural zeolites as components of ceramic masses for the production of ceramic tiles, new forms of porous ceramics [10]. Natural zeolites are used for making glazes, as well as for the production of refractory and thermal insulation materials. They are also used to make glass and glass products, such as hollow glass. Thermal treatment of zeolite, ie sintering, takes place in several phases: dehydration of the zeolite and increase of mobility of free ions, amorphization of the sample, crystallization of the new phase and phase transformation. A completely new phase that emerges is stable under certain thermodynamic conditions. When these conditions change, it is transformed into a new phase that is also stable in the new conditions [11].

CATHODE GLASS AS AN INGREDIENT OF SINTERED MATTER

The last waste material that will be used in the inactivation of toxic metals is cathode glass, which appears as a waste material when recycling monitors with a cathode ray tube, the so-called CRT monitor. The total annual production of a waste screen with a cathode ray tube reached 6.3 million tons, and more than half of that weight is cathode glass [12, 13]. In addition, China alone produced about 43.11 million tons of CRT glass in one year [14]. The amount of waste CRT glass will peak between 2015 and 2020 [15].

Depending on the part of the CRT monitor, silicate glass has a very complex chemical composition:

- front of the screen: barium-strontium oxide glass;
- the inner part of the bell: glass with lead oxides;
- combination of screen and bell - frit: easily soluble glass with lead oxides;
- neck: glass with an extremely high content of lead oxides.



Slika 4. *CRT monitor*

The cathode-ray tube of a CRT screen consists of two components: a conical glass and a screen glass. The supporting (conical) glass is coated on the inside with barium oxide and contains a large percentage of lead. The screen glass is of similar composition, large thickness with a photosensitive layer to create an image on the inside. It also contains a significant amount of lead to protect the user from possible radiation.

During the technological process of recycling such electronic waste, it is very important to separate hazardous and non-hazardous glass contained in CRT monitors, as well as safely remove fluorescent dust, which contains many carcinogenic substances, one of which is hexavalent chromium.

The selection of the composition of the initial materials used in the technological process of obtaining glass-ceramics by sintering is based on the knowledge of the crystallization properties. Since sintering is a physical process of reducing the distance between particles under the influence of high temperature, glass is the basic ingredient due to its specific crystallization properties. As a result of the technological sintering process, solid glass-ceramics of reduced dimensions and increased density are obtained, and the degree of sintering depends on the temperature, annealing time and pressure intensity in the furnace, and above all on the choice of raw materials.

DIAGRAM OF INACTIVATION OF WASTE GALVANIC SLUDGE FLOW

Glass-ceramic materials are solid inorganic polycrystalline materials obtained by directed crystallization of glass. Unlike traditional ceramics, where polycrystalline materials are used as starting materials, in glass-ceramics, crystalline phases are formed from the glass phase. This treatment and adequate choice of glass composition affects the structure and phase composition, and thus the properties of the material. It results in the development of a group of materials having properties that are better than other inorganic materials (glass, ceramics and metals) or have a combination of properties of these three groups of materials. For these reasons, they are used to a significant extent in the mechanical, electrochemical, construction, optical industry, medicine, etc.

In previous research, stabilization of toxic metals from galvanic sludge was performed by various chemical-technological processes, such as: obtaining clinker for cement production [16, 17], inertization of toxic metals of galvanic sludge in clay-based ceramics [18, 19], production of red ceramics using galvanic sludge and diatomite as raw material [20], inertization of galvanic sludge by incorporation into clay bricks [21], use of ash and sulfoaluminate cement in stabilization of toxic metals from galvanic sludge [22], incorporation of toxic metals from galvanic sludge and galvanic sludge glass-ceramic solution [23, 24].

This paper presents a flow diagram of the inactivation of toxic metals from waste galvanic sludge by transferring it into a sintered product, using waste industrial materials, such as: slag from the technological process of iron production, fly ash, cathode glass and natural zeolite material, Figure 5.

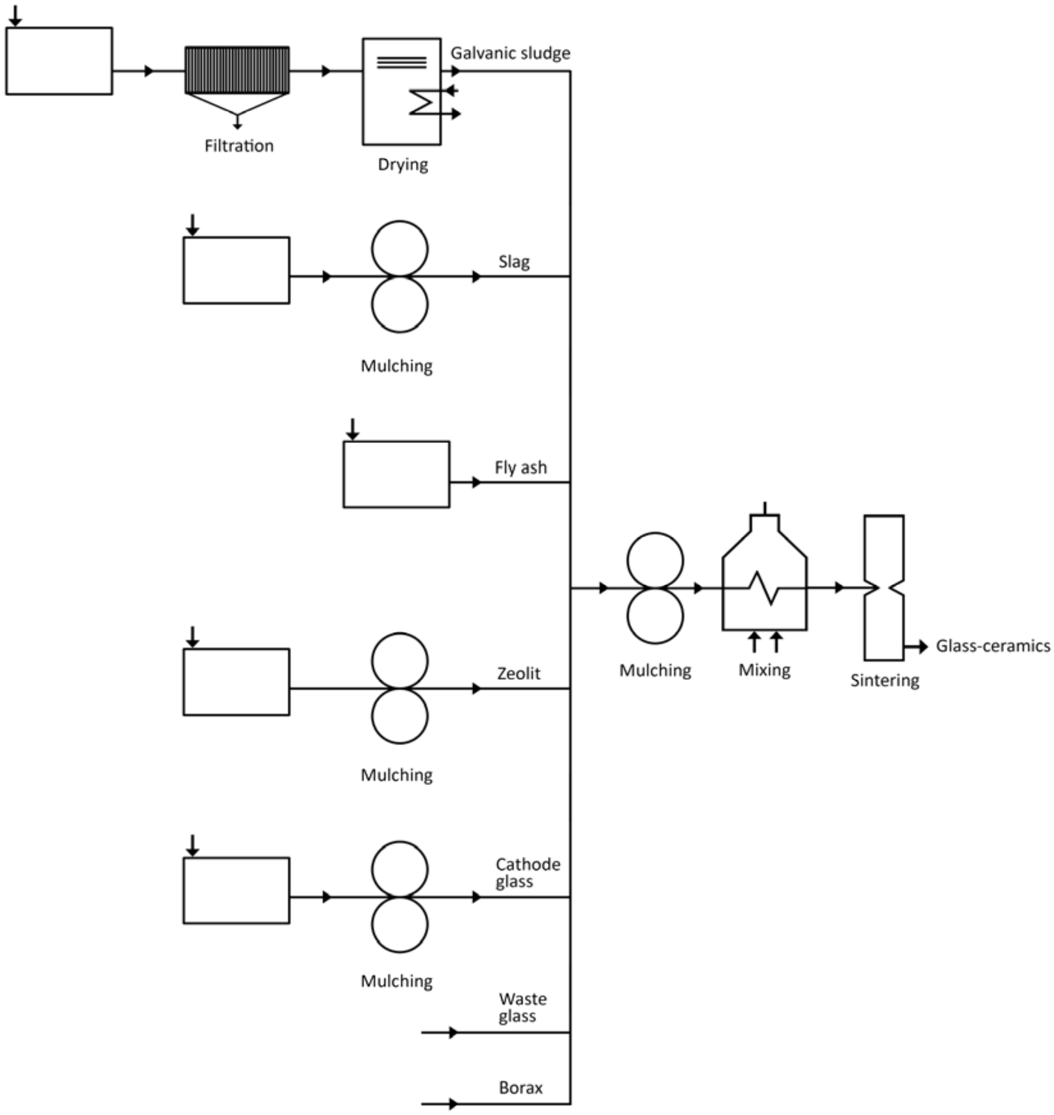


Figure 5. *Technological scheme of sintering glass-ceramics*

At the beginning of the sintering, the basic ingredients are prepared. First, the sludge is dried at 100°C, after which the slag, zeolite and cathode glass are crushed in a ball mill. When the raw materials are crushed, they are mixed until the mixture is homogenized. The homogenized mixture is placed in a melting crucible, which is subjected to high temperatures of 1200°C in an annealing furnace. The majority of the mixture is represented by hazardous waste materials: galvanic sludge, slag from the technological process of iron and steel production, flying ash and cathode glass. Auxiliary raw materials, waste glass due to their crystallization properties and borax (chemical formula: $Na_2B_4O_7$ x $10H_2O$) as a metal oxide solvent are also added. For phase changes to occur, the mixture must be completely liquid. Therefore, the crucible is kept in the oven for about 60 minutes, after which it is taken out of the oven with special tongs and the mixture is poured into preheated graphite molds or cooled spontaneously.

Testing the efficiency of this procedure is performed in different model systems, such as acidic or basic medium, high temperatures, the different granulometric composition of the solid solution, etc.

By incorporating toxic metals into the sintered product, chemically active substances, ie ions of toxic metals, are transformed by phase and chemical transformations into a stable structure of glass-ceramics in which these fractions cannot be started even in critical conditions.

The efficiency of the technological process of processing waste sludge into a stable structure of eco-sintered material was confirmed by an X-ray diffraction analysis (XRD). Based on the XRD spectrum, chemical-phase transformations with the binding of toxic metals (Al^{3+}, Cr^{3+}, Cu^{2+}, Cd^{2+}, Ni^{2+}, Pb^{2+}, Zn^{2+}) for the aluminosilicate phase in the form of solid solutions were confirmed, Figure 6.

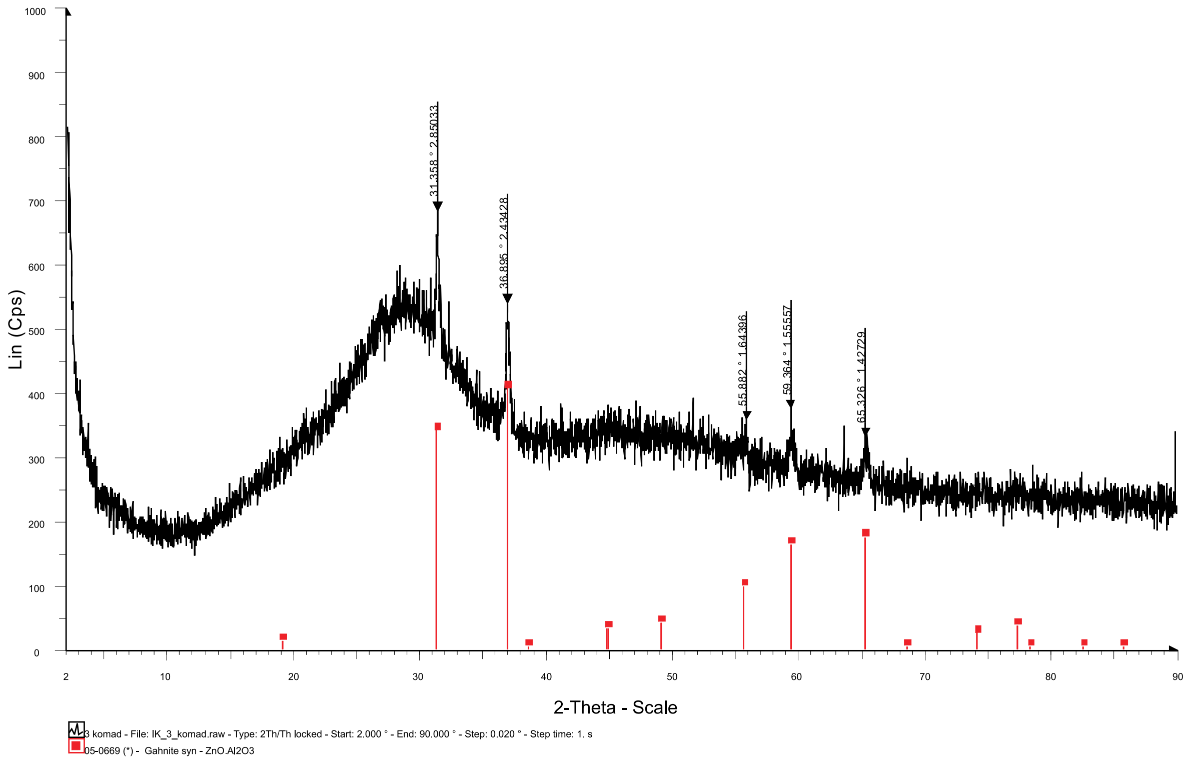


Figure 6. XRD spectrum of the glass-ceramics piece

CONCLUSION

Toxic metals found in industrial waste are one of the biggest problems of working and living environmental pollution. The state of the environment and the possible consequences of pollution indicate the imperative of developing procedures for minimizing toxic metals and their further processing and use. Accordingly, the paper presents the process of inactivation of toxic metals from the technological process of galvanization into a stable structure using slag, flying ash, cathode glass and zeolite as ingredients. In this way, the mobile fractions of toxic metals are permanently immobilized into a useful glass-ceramic product.

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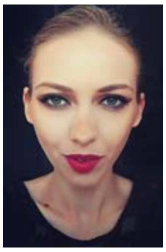
BIOGRAPHY of the first author



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INAKTIVACIJA TOKSIČNIH METALA IZ OTPADNOG GALVANSKOG MULJA DRUGIM OPASNIM OTPADOM

Ana Stojković, Miodrag Stanisavljević, Nenad Krstić, Dragan Đorđević, Ana Miltojević, Ivan Krstić

Rezime: *U radu je prikazan postupak inaktivacije toksičnih metala otpadnog galvanskog mulja drugim otpadnim materijama, kao što su otpadna šljaka iz tehnološkog procesa proizvodnje gvožđa, otpadni pepeo iz termoelektrane, zeolit i otpadno katodno staklo. Inaktivacija se izvodi procesom sinterovanja na visokim temperaturama. Dobijeni sinterovani proizvod je takve strukture da se toksični metali prisutni u njemu ne mogu pokrenuti ni pod kritičnim uslovima. Takođe, takav proizvod može imati upotrebnu vrednost, a rizik zagađenja životne sredine se svodi na minimum.*

Ključne reči: galvanski mulj, šljaka, pepeo, zeolit, katodno staklo.

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USING INDICATORS TO ASSESS THE CONSEQUENCES OF SERBIAN ENERGY SECTOR FUNCTIONING DURING COVID-19 STATE OF EMERGENCY

Abstract: *The emergency situation of global proportions caused by the COVID-19 virus has had an overall impact on the energy sector. The global economy is not at its full capacity, so there has been a decline in electricity consumption in all countries where population, to a greater or lesser extent, has been exposed to viral infection. Energy sectors record a 20% decline in electricity consumption, depending on the number of infected people and the level of economic activity. The implementation of indicators plays an important role in assessing the spread of infection, which occurs as a consequence of work activities related to electricity production. This paper emphasizes the significance of implementing indicators to determine the manner and the cause of virus transmission, with the aim to plan protection measures in the event of a new outbreak.*

Key words: COVID-19, energy sector, indicators, emergency situation

INTRODUCTION

The Electric Power Industry of Serbia recorded a decrease in consumption during the highest coronavirus activity, compared to the same period in previous years. The state of emergency [1,2], as a cause of disruption in industrial and energy systems, has had an impact on business and human health. For this reason, it is necessary to analyze possible consequences in a timely manner [3]. During the state of emergency, the industry operated at slightly reduced capacity; however, the reduction in energy consumption in Serbia turned out to be lower than in other European countries. It is considered that electro power systems in the Balkans [4] have performed well and have maintained significant stability in operation during COVID-19 age. At the period of the most severe pandemic in Italy, there was a decline in electricity consumption by 20% (according to the Anadolu Agency), while in France there was a drop of about 16% and in Spain about 8% [5, 6]. Northern Macedonia recorded a larger decline in energy production, compared to neighboring countries. The global oil industry is also experiencing changes [6]. Storage capacities have been almost full, which means that reduced traffic influenced the significant reduction in oil consumption and even a drop in prices globally. Temporarily closed oil fields stabilized the oil price; however, the costs have incurred due to the resumption of oil exploration activities. Interestingly, the drop in oil prices on the world market did not trigger the drop in fuel prices at gas stations. The cause of such disbalance is justified by the fact that fuel stocks were procured before the pandemic, at the time when the prices were higher. During this state of emergency, fuel consumption was low, so there was no possibility of buying oil at a lower price since storage spaces are full.

The need for coal has also been reduced, as a result of reduced electricity consumption. However, thermal power plants in Serbia [7] operated with the same capacity, which means that the planned exploitation remained at the same level. The impact of the state of emergency and lockdown on the decrease in energy consumption is not significant [8]. On the contrary, reduced traffic significantly contributed to reduced air pollutant emissions. In addition, the lockdown caused by the biological agent brought about more favorable conditions for the entire living world. Reduced fossil fuel consumption saved the environment from degradation.

THE NUMBER OF COVID-19 INFECTIONS IN SERBIA AS AN INDICATOR USED TO CONTROL STATE OF EMERGENCY

The number of people infected with the virus has varied significantly in different countries, so it means that without indicators we cannot make a real assessment of the situation. With the analysis of the number of people infected per population or the size of the state, i.e. with the use of indicators [9], we can obtain a clear insight into the problems that have arisen. An indicator, such as the number of deaths per total population of the country or per million inhabitants [9], is an item that can be comparatively analyzed. In that case, an indicator is a ratio between the number of deaths and the number of inhabitants [9]. For this purpose, we compared the situation in European countries, with special emphasis on the situation in Serbia.

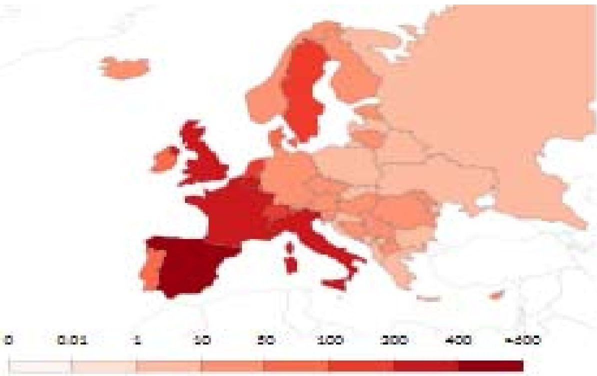

Figure 1. *Total confirmed COVID-19 deaths per million people in Europe [9]*

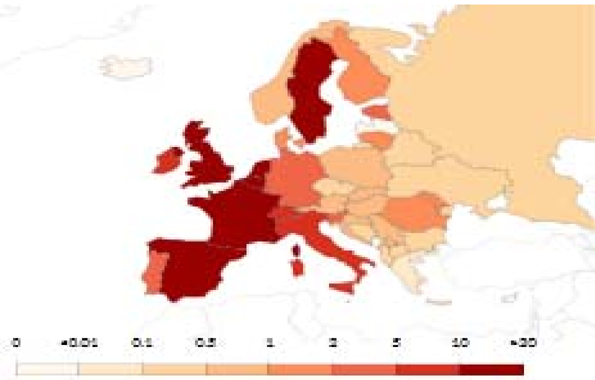

Figure 2. *Daily confirmed COVID-19 deaths per million people [9]*

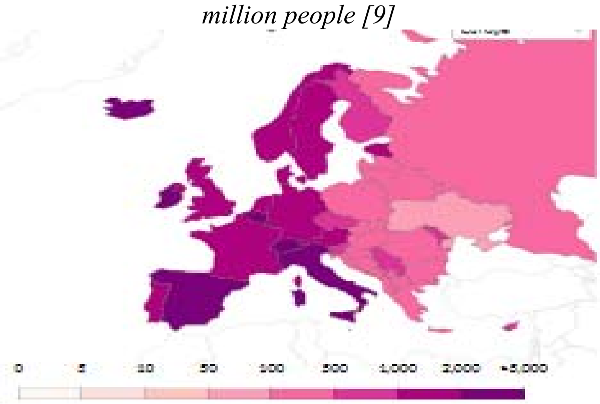

Figure 3. *Total confirmed COVID-19 cases per million people [9]*

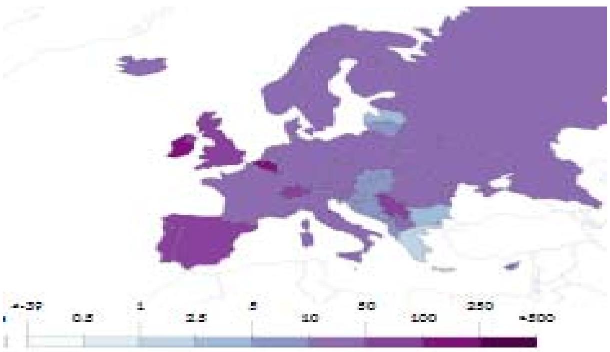

Figure 4. *Daily confirmed COVID-19 cases per million people [9]*

The analysis of the estimated number of deaths was done on April 16, 2020, when it was determined that the miners could influence the spread of the epidemics in Eastern Serbia. The number of COVID cases per million people, presented on the Our World in Data platform, [9] was obtained by dividing the population number (provided by the United Nations World Population Prospects) by the number of deaths published by the European Center for Disease Prevention and Control (ECDC) [9].

For Serbia, the value of the indicator was 14.55. Based on Figure 1, it can be concluded that the situation was similar in most countries in the region. The situation turned out to be more favorable in Croatia, Montenegro, Bulgaria and Greece. The daily number of deaths per million inhabitants is the ratio of deaths to the number of inhabitants, multiplied by one million [9]. The value of the indicator for Serbia was 0.73, which is significantly lower than in Romania, but higher than the indicator for Bosnia and Herzegovina, Montenegro, Bulgaria and Greece (Figure 2).

The indicator related to the number of confirmed COVID-19 cases in terms of the population size is presented in Figure 3. The value of the indicator for Serbia is 716.13, which is significantly higher than in the surrounding countries. Daily confirmed COVID-19 cases per million people are an indicator presented in Figure 4. The value of the indicator for the territory of Serbia is 59.96, which is significantly higher than in the surrounding countries. It should be borne in mind that the data used in the analysis are not fully comparable, because the diagnostic tests are not the same in terms of their characteristics and accuracy. However, those are the official data across the countries at the global level, and therefore, this is the only way to perform a comparative analysis.

SERBIAN ENERGY SECTOR FUNCTIONING DURING COVID-19 STATE OF EMERGENCY

The outbreak of the epidemic caused by the COVID-19 virus in Serbia was declared on March 19, 2020, when the significant level of risk for infection was confirmed on the territory of the state. Although a state of emergency slowed down the country's economy, the regular supply of electricity continued, and employees in this sector followed the prescribed measures. Serbia Electric Power Industry (srb. Elektroprivreda Srbije - EPS) continued transformation of the primary energy source of coal and hydro potential into electricity during these circumstances. The generation of electric power in thermal and hydropower plants was not interrupted, and coal exploitation continued despite the reserves available in coal warehouses. The distribution system also functioned as in the period before the state of emergency was declared. The installers performed their everyday activities smoothly, and therefore, a regular supply of consumers was ensured.

Social distancing measures and a slower rate of reduced electricity consumption. Serbia Electric Power Industry, as well as the energy sector of the surrounding countries, have provided an orderly supply of electricity. The employees in administration worked remotely from their homes. It is interesting to note that the energy sector in Slovenia organized fourteen-day shifts in the control center, in order to avoid problems with regular supplies.

The measures at the Krško Nuclear Power Plant in Slovenia involved taking employees' body temperature at the entrance. The employees in the energy production sector in Greece had restrictions on movement by which they were allowed to go only from home to work. They were not allowed to use public transport nor to have contact with their colleagues working in the second shift. It is interesting to note that there have been many requests by citizens to connect to the network of solar panel plants in Greece. On the contrary, China reduced the delivery of solar technology to other countries.

THE NUMBER OF MINERS INFECTED - AN INDICATOR OF THE ENERGY SECTOR IMPACT ON VIRUS SPREAD

Serbian energy sector operated at full capacity during the state of emergency [4], following the preventive protective measures. Surface exploitation of coal in the Mining Basins "Kolubara" and "Drmno" (near Kostolac) was carried out following hygiene procedures. Special attention was paid to the jobs in the excavators to avoid interruptions in coal excavation. However, in the Kolubara Mining Basin [4], coronavirus infection was confirmed in five workers, while one employee passed away due to coronavirus infection. Within the mining complex "Resavica", there are 9 mines with underground exploitation. In the "Rembas" mine in Resavica, one miner was positive [4], while the family members of two miners were infected. There are no reports of infected miners in the Vrška Čuka mine.

In the "Lubnica" mine, one miner was infected with the virus [4], and tests showed that they were positive for COVID-19. All of them, 309 miners were sent for testing. In the mine "Bogovina", two miners were infected with the virus, out of a total of 210 workers, or 122 workers [4] employed in pit exploitation. The first infected person was discovered on 15.04.2020 and immediately sent to isolation. They were given protective equipment, face masks and disinfectants [4] on 25.03.2020.

There were COVID 19 infected miners at the Soko and Lubnica mines which operated at reduced capacity. It is considered that the transmission of the infection occurred due to social distance issues, especially during the shift change (several times a day). On those occasions, more than a hundred miners pass by each other. The places associated with virus transmission are the bus for worker transportation and shared small premises. The cramped space of the locker rooms and bathrooms which are used after leaving the pit at the end of working hours are the places where infection can spread very easily.

In the brown coal mine "Soko", between Knjaževac and Sokobanja, only one in 300 miners was tested positive for COVID-19. The infection was discovered on 09.04. 2020. [4] in the period when the scope of work was reduced. The first measure was to send the workers from the municipality of Knjaževac, who worked in the same shift with the infected miner, on vacation. The bus was assumed to be the place of the virus spread. However, the virus continued to spread among the miners from Sokobanja and Aleksinac.

The mine was operating at the same capacity when infection was detected in 14 miners from Aleksinac, Knjaževac and Sokobanja. It was concluded that the infected miners had mild symptoms, and luckily, there were no deaths. Some were in home isolation, while others were hospitalized. The production in the mine stopped, except for the maintenance of the pit facilities. Figures 5, 6 and 7 show the number of infected citizens in Knjaževac, Sokobanja and Aleksinac, to present the overall impact of the COVID-19 virus spread in the "Soko" mine.

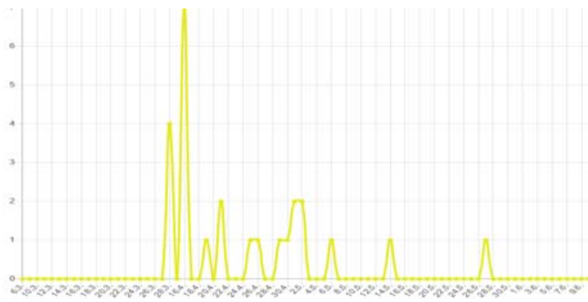

Figure 5. *The number of infected inhabitants of Knjaževac [10]*

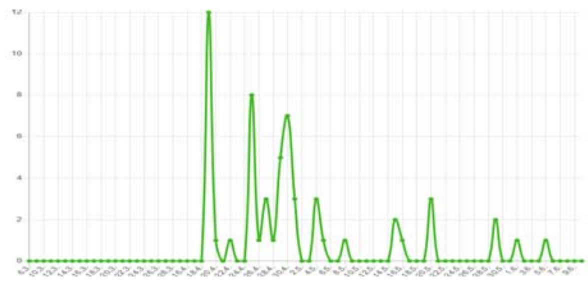

Figure 6. *The number of infected inhabitants of Sokobanja [10]*

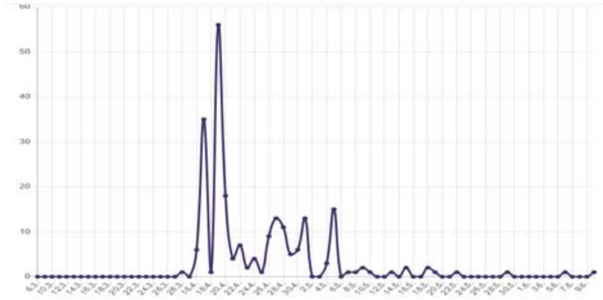

Figure 7. *The number of infected inhabitants of Aleksinac [10]*

Based on the graphs, it is clear that the spread of the virus among the miners in the "Soko" mine has had an impact on the number of infected citizens in the surrounding areas. In the period when the miners gradually became infected, the infection was transmitted to other inhabitants, more exactly to the people they had been in contact with. However, it can also be noticed that before the first infected miner in the "Soko" mine, an infection with the COVID-19 virus appeared in Knjaževac, on 28.03.2020. This indicates that the infected miner from Knjaževac was in contact with his colleagues and that there is a possibility that the infection was transmitted before the symptoms appeared; therefore, on 16.4.2020 the number of infected in Knjaževac (seven) increased, and the first cases in Sokobanja (twelve) appeared. Only a day later, on 17.04.2020, the symptoms began to manifest in Aleksinac, and the management of the "Soko" mine hired workers only for maintenance work. The workers were sent for examinations, and 25 miners were found positive for COVID-19 [4], mostly with mild or no symptoms.

THE PERCENT OF MINERS INFECTED - AN INDICATOR OF THE SITUATION IN THE MINES

The percentage of infected miners (Im) as an indicator of the situation compared to the total number of miners as an indicator of the impact of the state of emergency in the mines, points to the problems with the prescribed preventive measures.

The percentage of infected miners is calculated based on the following formula:

$$I_m[\%] = \frac{I_m}{T_m} \cdot 100 \qquad (1)$$

where:

I_m –the number of infected miners

T_m –total number of miners in the mine.

Table 1 presents a comparative analysis of the percentage of infected miners [4] in underground mines.

Table 1. *The percent of infected miners*

Mine	Im	Tm	Im [%]
Bogovina	2	210	0,95
Bogovina*	2	122	1,64
Lubnica	1	309	0,32
Soko	14	300	4,65

It can be seen that the highest percentage of infected was in the underground mine "Soko", which indicates the need for more rigorous preventive measures, and controls while wearing prescribed protective equipment. The number of confirmed COVID-19 cases in Serbia by date has been given based on the official database of Serbia. The graph below shows that the viral infection appeared in the "Soko" mine in the days with the highest number of positive COVID-19 cases.

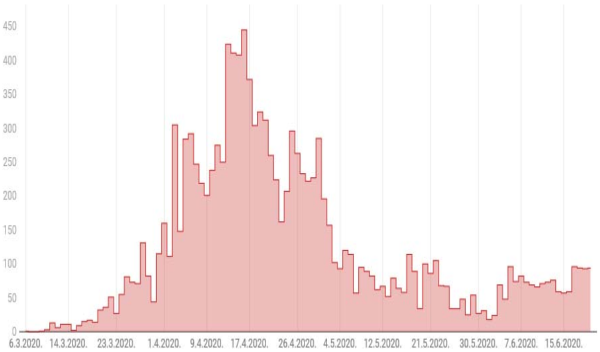

Figure 8. *The number of COVID-19 confirmed cases in Serbia [10]*

Figures 5 and 6 and 7 show that before the spread of the virus in the mine, there had been no registered cases in any of these three cities, although in Figure 8 we can see that the COVID-19 had been active in Serbia for more than a month. Nevertheless, the ratio of the infected miners and the infected citizens points to the great influence of direct indoor contacts between miners.

It should be borne in mind that workers from surrounding towns and areas are employed in this mining complex. This fact makes it a suitable location for infection spread since it is almost impossible to avoid direct contacts. With an insight into the real situation in the "Soko" mine and the surrounding towns, near Zajecar, and based on the indicators of the virus spread in the energy sector, we have got the impression that there is a need for more rigorous control of protective measures.

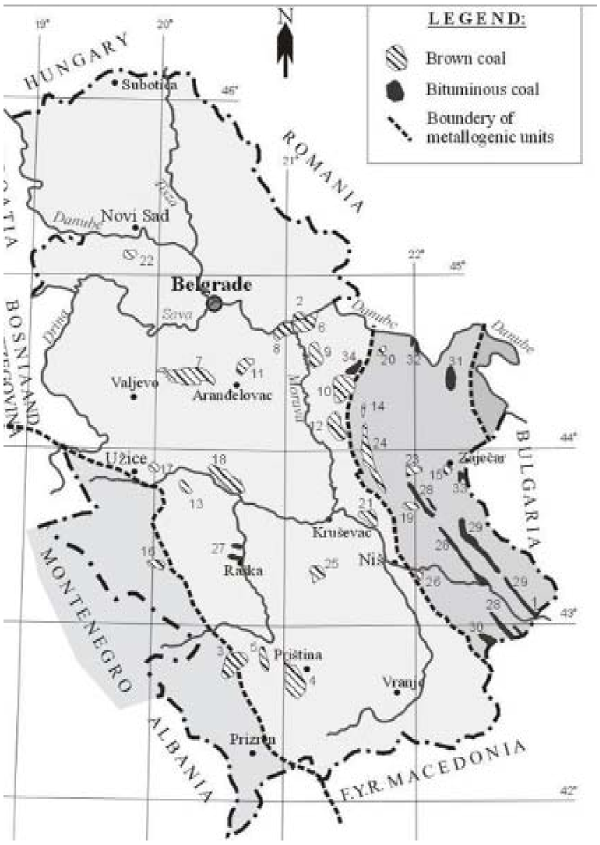

Figure 8. *Locations of mines in Serbia [11]*

ENERGY SECTOR FUNCTIONING AND THE DECREE ON THE ORGANIZATION OF WORK ACTIVITIES DURING THE EMERGENCY

Pursuant to Article 200, paragraph 6 of the Constitution of the Republic of Serbia, the Government of Serbia passed the Decree on the organization of work activities during the state of emergency, 05 number 110-2517/2020 in Belgrade, on 16.03.2020[12]. The Decree regulates the special manner and organization of work by employers on the territory of the Republic of Serbia during the state of emergency. Article 4 of the aforesaid regulation has been applied, having in mind the production in the mines, the technology of underground coal exploitation and the activities of ore extraction. It is prescribed that the employer, in case where it is not possible to organize remote work or work outside the premises, is obliged to provide all general, special hygiene measures to ensure safety and health of employees and other persons under the Law on the protection of population from infectious diseases. The employer is also obliged to provide sufficient protective equipment following special regulations for employees who are in direct contact or share the workspace with other persons.

The Decree expired on 06.05.2020, according to Article 2 of the Law on regulations validity issued by the Government and signed by the President, and finally confirmed by the National Assembly. The law was published in the "Official Gazette of RS", no. 65/2020 of 6.5.2020. In accordance with the prescribed recommendations, it is necessary to organize the energy sector, with special attention to protective measures in underground coal mining, where due to specific work conditions, it is not feasible to keep a 2-meter distance.

CONCLUSION

The analysis of the impact of the COVID-19 virus spread on the territory of Eastern Serbia, which occurred as a consequence of infection detected among miners from Knjaževac, showed that the mines with underground exploitation may influence the duration of the state of emergency.

By using the indicators to analyze the consequences of the COVID-19 virus in the energy sector, it was determined that the measures from Article 4 of the Decree on the organization of work activities during the state of emergency should be strictly followed in order to avoid the situation which happened in April 2020. It is necessary to control the implementation of preventive measures, but also to take into account the timely implementation of corrective measures. The decision to send the miners off the work to their home towns around the mine yielded the desired outcome because they spread the virus to their colleagues from other two towns during the incubation period. Also, one of the preventive measures was to order the whole shift of miners who worked with the infected miner to stay at home, but even this did not prevent the spread of the infection. It was concluded that in case of failure of preventive measures, the coil exploitation should stop immediately and all workers should be tested. This idea aimed to avoid consequences to the miners and their colleagues and inhabitants in the surrounding settlements, with the aim to maintain the stability of the energy sector and minimize the transmission of the virus.

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BIOGRAPHY of the first author

Jelena Malenović-Nikolić was born in Knjaževac, Serbia, in 1974. She received a diploma in environmental protection engineering and the Magister of technical sciences degree from the University of Nis, Faculty of Occupational Safety.

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PRIMENA INDIKATORA U PROCENI UTICAJA VANREDNE SITUACIJE IZAZVANE VIRUSOM COVID-19 NA FUNKCIONISANJE ENERGETSKOG SEKTORA SRBIJE

Jelena Malenović-Nikolić, Dejan Krstić, Darko Zigar

Rezime: *Vanredna situacija izazvana virusom COVID-19, svetskih razmetra, ima uticaj i na energetski sektor. Privreda na globalnom nivou ne funkcioniše punim kapacitetom tako da se beleži pad potrošnje električne energije u svim zemljama čiji su stanovnici, u manjem ili većem broju, izloženi virusnoj infekciji. Energetski sektori beleže pad potrošnje električne energije i do 20%, zavisno od broja inficiranih i nivoa privredne aktivnosti. Primena indikatora ima važnu ulogu u proceni širenja infekcije, koje nastaje i kao posledica radnih aktivnosti na obezbeđivanju potreba za električnom energijom. U radu se ističe značaj primene indikatora zbog lakšeg definisanja načina i uzroka prenošenja virusa, kako bi se planirale mere zaštite u slučaju da se ponovi prisustvo virusa.*

Ključne reči: COVID-19, energetski sektor, indikatori, vanredna situacija.

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HUMAN RESOURCE DEVELOPMENT AND ORGANIZATIONAL LEARNING IN OCCUPATIONAL AND ENVIRONMENTAL SAFETY

Abstract: *The presence and continuous generation of various risks and hazards in working and living environment have made safety and crisis management a strategic goal of modern organizations. Modern organizations are facing a great challenge - how to make organizations safe despite their increasing complexity, uncertainty and interdependence of risks in working and living environment. In this regard, starting from the elaboration of safety as a strategic goal of modern organizations, through the analysis of management and human resource development in the discourse of safety management, we paid special attention to organizational learning and basic assumptions of the development of an organization which learns in the modern business and safety environment.*

Key words: human resource development, organizational learning, occupational and environmental safety.

INSTEAD OF INTRODUCTION AND OCCUPATIONAL & ENVIRONMENTAL SAFETY AS A STRATEGIC GOAL OF MODERN ORGANIZATIONS

The diversity of safety risks, challenges and threats increased the interest in safety issues in contemporary business organizations. The success of business and the competitiveness of organizations are considered through their connection with occupational and environmental safety. Issues such as adverse environmental impacts, natural and other disasters and the like require new ways of anticipating risks and threats in a timely manner, appropriate measures to prevent them or to minimize and eliminate the consequences of possible accidents and emergencies. Thus, there is a number of concepts dealing with possible solutions in this field [1].

There is a growing number of authors who discuss safety management as a concept that involves a variety of activities aimed at eliminating various safety threats. The content of safety management involves the management of risks and hazards, crisis and emergency situations [2]. Safety and crisis management are increasingly becoming a strategic goal of contemporary organizations. Safety management brings both benefits and conflicts as organizations tend to observe safety activities as an unnecessary investment. Such views are closely related to organizations' tendency to view safety as a purely technically driven activity [3]. Occupational and environmental safety does not depend solely on technical or legal solutions. Legal regulations are necessary but not sufficient activity in an organization. Complying with legal regulations in an organization can give a false sense of the overall effectiveness of its safety program. Safety management that is limited to implementing technical or legal solutions can divert an organization from its strategy and practice that is best suited to a unique organizational context [3].

Many organizations have adopted a risk-based approach to safety. Risk management is a core business function [3]. Organizations must continually adapt to existing and potential risks in the working and living environment, i.e. they need to observe safety in the context of the bigger picture - either organizational or corporate sustainability [3, 4]. A resilient approach (sustainability) transforms the basic premise of safety - from the one that stops the accident so that it causes no damage - to the one that positions safety as a contributing factor to enhancing an organization's ability to adapt to new environmental risks and fulfill its mission.

A comprehensive human resource development strategy leads organizations to learning as a factor that can help them develop a safety culture and address safety and other issues. Many organizations choose to invest in individual and collective learning. The concept of a "learning organization" gained popularity with large organizations with their attempt to develop structures and systems that are much more adaptable to changes in the environment. Changes in the environment increase safety risks and business uncertainty by forcing companies to learn how to do things differently. Learning has a broad analytical value [5]. The concept of learning is extremely dynamic and its main objective is a continuous change of the nature of the organization and its preparation to address safety risks and opportunities from the environment through increasing organizational knowledge.

FROM TRADITIONAL TO LEARNING ORGANIZATION

In the business world, knowledge is an essential strategic resource for the development of individuals, organizations and society as a whole. Organizations are faced with rapid change and the need to adapt to changing circumstances. In this situation, the concept of organizational learning occupies an important place. This concept shows all the features of insufficiently developed and researched concepts in social sciences - the authors' inconsistency in defining the term, and the nature and process of organizational learning, fewer empirical papers, etc. [6].

In the literature, there are critical observations of the concept of organizational learning which indicate that the organization itself cannot learn, but the employees/people in that organization. Some authors argue that only individuals can learn and that knowledge cannot exist outside of individuals and their minds. Others argue that organizational learning is a social process that exists in an organization regardless of whether it exists in the individual minds of the members of the organization [7]. Organizational and individual learning are interrelated phenomena - even when an organization learns as a whole, that learning occurs through the individual activities of the organization members. The learning organization expects employees to learn, and it is its responsibility to make its members more independent and more willing to define actions that will contribute to creating added value for it [8]. Certainly, a learning organization is not the sum of what its individuals have learned. Learning needs to be shared and leveraged through organizational changes that respond to environmental changes. An organization does not exist to learn, but learns to exist. It is a constellation of people, means, methods and principles of work, values and norms of behaviour, whose main purpose is a unique and coherent action in the realization of its goals (occupational and environmental safety).

ORGANIZATIONAL LEARNING - CONCEPT, IMPORTANCE, CYCLE AND MODELS

Authors often observe organizational learning as a key process within an organization that should provide flexibility and better organizational performance [9]. Organizational learning exists when members of the organization act as agents of learning for the organization, responding to changes in the internal and external environment of the organization, and detecting and correcting errors in organizational theory applied within the organization [8]. Organizational learning can be seen as a change in the cognitive structures and behaviors of members of an organization that provides an uplift in the organization's ability to adapt to its environment [10]. The learning process leads to a change in employee knowledge that implies a change in their behavior. Behavioral change inevitably results from the change in cognitive structures in individuals as well as in collective cognitive structures in an organization [11]. The cognitive component of learning is a necessary but not sufficient condition to achieve organizational learning. It is necessary that the change of consciousness in people also causes a change in their individual behavior as well as in collective action, in order for it to have consequences for the organization [1, 11].

By analysing the nature of the organizational learning process, some authors emphasize its technical side - information processing, while others emphasize the social character of the process itself [7]. Organizational learning always involves some kind of social interaction of the members of the organization. It should be seen as a process that expands the scope of potential behaviours of the members of the organization as individuals but also of the organization as a whole is [12].

The purpose of organizational learning is for the organization to develop new competencies, especially those that enable it to gain a competitive advantage in the market, and which are based on modern standards of occupational and environmental safety. Learning new behaviours often entails prior “unlearning” of the existing behaviour, and this view of organizational learning is close to the perspective of organizational routines [13], as organizational learning can also be seen as a process of developing and applying new rules and routines in an organization. Routines accumulate the knowledge gained by members of an organization over time [11], and competitive advantage in the market is gained by developing superior routines over other market participants.

The importance of learning can be observed from various aspects. The managerial aspect is especially important for organizations, and learning has the following implications for managers:

1) it is a powerful process that can lead to both positive and negative results,
2) individuals who love learning become more flexible in a time of constant change and therefore better suited to accept organizational change,
3) there is an increasing awareness that a learning culture can affect the effectiveness of an organization [6].

According to Daft and Marcic, the learning process takes four stages. First, the person encounters a specific experience. This is followed by reflection and reflective observation, which further leads to the abstract conceptualization and ultimately to active experimentation. The experimentation results in new experiences and then the cycle repeats [14]. An individual, as a member of an organization in contact with existing organizational knowledge, conducts his/her critical review and testing. If it does not meet the current needs of the organization and the environment, its redefinition is performed. Knowledge upgraded by the process of cognitive thinking is tested in practice and transformed into concrete experience.

In numerous concepts of organizational learning, this process consists of acquiring, disseminating and using knowledge in the organization. According to one of these concepts, the process of organizational learning consists of five basic phases - identification of existing knowledge important for improving the competence of the organization, creation or generation of new knowledge in the organization, diffusion of existing and new knowledge in the organization, integration and modification of knowledge and its use [15].

Organizational learning has to be examined in close relation to organizational knowledge. It is a process by which an organization acquires, manipulates and uses knowledge. According to Nonaka, the two basic forms of knowledge are objective, and subjective knowledge [15]. In order to create organizational knowledge, it is necessary to convert one form of knowledge to another. The process of conversion through which individual knowledge is transformed into organizational is the process of organizational learning.

Agryris and Schon developed two models of organizational learning [8]. "Single-loop" learning addresses the changes that occur in the internal and external environment of organizations. It is a method of correcting errors with the aim of strengthening the elements of the existing system in the organization. The '"double-loop" learning model is the acquisition of knowledge that examines and changes the basic assumptions on which existing routines are built. In the "double-loop" learning, new, different innovative solutions to problems are created and values, norms, goals and strategies are modified at an individual level. According to Agryris and Schon, an ideal organization is capable of learning on the model of "double-loop learning" - that is, it does not adhere rigidly to previously set goals, norms, value systems, worldviews and its activities are not restrained by outdated rules, schemes and working methods [8]. Organizations with "double-loop learning" capabilities are also capable of "single-loop learning". Similarly, Edmonson and Moingeon classify organizational learning as "learning why" and "learning how "[16].

A LEARNING ORGANIZATION AS A CONDITION AND CONSEQUENCE OF ORGANIZATIONAL LEARNING

A learning organization can be considered an organization where people have the capacity to permanently develop their abilities in order to create the desired performance, where contemporary thinking patterns are applied, and where people are constantly taught how to learn together. Unlike organizational learning, the learning organization is at the same time a condition and consequence of that process [10]. The learning organization has the ability to refine and change its routines relatively easily and quickly, thereby building new competencies that will enable it to survive in a changing environment. Therefore, organizations must learn how to become learning organizations [17, 18]. Achieving a 'learning organization' requires a holistic and integrative approach to workplace learning due to the fact that organizational learning involves the integration of all factors of successful learning and all participants in learning and development [19].

Modern companies have recognized the strategic importance of organizational learning for enabling occupational and environmental safety [4]. Corporate environmental learning is becoming standard practice in many companies. They align their day-to-day activities with the corporate values of sustainability and environmental protection, so that environmental knowledge can expand instead of being isolated within the management. This creates green jobs that promote environmental protection and energy efficiency. Training for employees whose work can have a negative impact on the environment focuses on actual work processes and procedures in crisis situations [4].

CONCLUSION

In modern conditions many organizations seek to develop organizational learning and become learning organizations. The aspiration of organizations to become learning organizations represents a new approach in the management and development of human resources. For a traditional enterprise, changing to a learning organization is a major challenge [7]. The organization needs to create a climate where learning is accessible to all managers and in which senior managers have understood the need and importance of continuous training at all levels in the organization. Managers should encourage employees' 'openness' to new ideas, the honesty of dialogue and communication, team learning and teamwork, understanding of business operations and creating a collective vision of organizational development.

It would be utopian to overlook the constraints that exist in the creation of learning organizations [1]. These constraints relate to the purpose and structure of the organization itself, to individuals, especially with regard to self-directed learning, to the organization's decision-making about learning. Learning in organizations focuses on productivity. The balance between learning time and production time must be maintained. Some workers are satisfied with the jobs that are clearly defined and are not ready for constant consideration. Some jobs require hierarchy and centralized decision-making and this is in conflict with the initiative and participation of individuals. The organization is not an isolated entity but reflects the conditions and culture that aids or impedes learning. People cannot be expected to have autonomy and independence overnight.

Training and learning in occupational and environmental safety should adopt learning forms that are different from the conventional scholastic model.

Those are the forms that more closely match the ways in which knowledge is mobilized and shared. Programs based on active learning, interaction and employee participation can be used in this regard. New procedures need to be devised to share knowledge about occupational and environmental safety within and outside the organization. Understanding the overall cycle of occupational and environmental safety within an organization can help legislatures to formulate rules that are easier and more effective to implement. Legal requirements and rules are often viewed as coercion, even if they are intended to protect employees' rights. A better understanding of the deeply practical nature of the knowledge on occupational and environmental safety may result in greater critical awareness in the formation or adoption of appropriate regulations.

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RAZVOJ LJUDSKIH RESURSA I ORGANIZACIONO UČENJE U FUNKCIJI BEZBEDNOSTI RADNE I ŽIVOTNE SREDINE

Vesna Nikolić, Aleksandra Ilić Petković, Mirjana Galjak

Rezime: *Prisustvo i permanentno generisanje rizika i opasnosti različite prirode i karaktera u radnoj i životnoj sredini uticali su da se bezbednost i upravljanje kriznim situacijama, određuje i sve više postavlja kao strateški cilj savremenih organizacija. Savremene organizacije se nalaze pred velikim izazovom – kako da organizaciju učine bezbednom uprkos povećanju kompleksnosti, neizvesnosti i međuzavisnosti rizika u radnoj i životnoj sredini. S tim u vezi, u radu je polazeći od elaboriranja bezbednosti kao strateškog cilja savremenih organizacija, preko promišljanja menadžmenta i razvoja ljudskih resursa iz diskursa upravljanja bezbednošću posebno posmatrano organizaciono učenje i razmatrane osnovne pretpostavke razvoja organizacije koja uči u savremenom poslovnom i bezbednosnom ambijentu.*

Ključne reči: razvoj ljudskih resursa, organizaciono učenje, bezbednost radne i životne sredine.

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MODEL OF VIBRODIAGNOSTIC PROCEDURE FOR PREDICTIVE MAINTENANCE OF ROTARY MACHINES

Abstract: *The paper describes a model of vibrodiagnostic procedure for predictive maintenance of rotating machines, based on experimental tests of real objects. Systematic monitoring of the condition of rotating machines over a longer period of time allows the conclusion of potential irregularities in the operation of the industrial facilities, the detection of vibration sources and the degree of damage to individual components. This way, the conditions for making a vibration map and taking preventive measures for the maintenance of the industrial facilities are fulfilled.*

Keywords: technical maintenance, predictive maintenance, vibration, fault detection, rotary machines.

INTRODUCTION

Technical maintenance of machines represents a set of procedures and activities with the task of preventing the occurrence of failure or downtime, as well restoring the operation of the machine in the shortest possible time and with the least amount of losses in the given environmental conditions and work for an organization. In this way, maintenance becomes a process that enables the management of technical conditions and reliability during the entire life cycle of the technical system.

In the existing production conditions, when certain problems in the maintenance and repair of equipment are planned and predicted, there are three basic methods of technical maintenance in practice [1]:

- operation of the machine until its functional failure,
- intervention and repair based on expert judgment,
- intervention and repair based on the results of diagnostics and assessment of equipment condition.

From the economic point of view, only the last method is considered justified and efficient, and the success of its application is reflected in the following possibilities:

- reduction of the required maintenance time, number of repairs and the number of spare parts by at least two thirds in comparison to the previous two methods,
- reduced number of unexpected failures in a certain period,
- reduction of profit losses because of numerous delays due to unplanned maintenance activities.

The application of this method requires the necessary detailed diagnostics to detect all deficiencies and irregularities that affect the reduction of the life cycle of the equipment before the failure, so that there is time to plan and prepare the necessary maintenance activities.

Current practice indicates that successful diagnostics of mechanical and electrical equipment is possible in most cases using vibration signals [2], since:

- dynamic forces occur directly at the site of damage, so the machine itself is a vibrating body;
- vibrations contain a maximum of diagnostic information;
- diagnostics can be performed on-site, without disassembling and stopping the machine.

In this way, if the approach to the problem is correct, conventional methods such as temperature control, lubrication analysis, etc. are not necessary and do not have to be carried out, as they can be replaced by unique vibration analysis.

Detailed diagnostics of machines by means of vibrations does not only include the procedure of diagnostics and measurement, data processing with instruments for their analysis, but also includes two obligatory components:

- a database of measurement results over a long period for a large number of machines, with the possibility of access to each data and its subsequent analysis, and
- methods for making diagnostic conclusions.

The basis of a good approach to vibrodiagnostics is the understanding that vibrations themselves are not important but is important to know how the state of the machine changes, that is, how the internal forces in the machine change over time, accelerating damage to individual parts. In this case, changes in forces can be caused by direct changes in the work process or changes in the properties of machine parts.

PRACTICAL APPROACH TO DETECTION AND IDENTIFICATION OF VIBRATION SOURCES IN ROTARY MACHINES

In practice, there are two concepts regarding the prediction of the state of machine systems that are carried out using vibrations [3]:

1. Vibration monitoring, which includes the detection of changes in the state of vibration of the machine and analysis of the reasons for the changes, and
2. Vibration diagnostics (vibrodiagnostics), when the detection and identification of different types and severity of fails on the tested machines is performed.

The main difference between monitoring and diagnostics is that monitoring does not detect malfunctions and damage in their initial stage of development. The purpose of monitoring is the timely detection of serious faults, bearing in mind that long time before the failure, each small fault is only a part of the fault chain, where any fault in the chain that affects the vibration of the machine can be detected by relatively simple methods (techniques) of analysis of the vibration signal, measured at one or more control points on the machine. In line with this goal, vibration monitoring requires measurements at short intervals so that the rapid and sudden development of certain damages and malfunctions would not go unnoticed. Therefore, it is common to use permanent monitoring systems that perform measurements in a time interval of one or several seconds. One of the user requirements is to reduce the number of measuring channels of these systems, which primarily determines the price of the system. For this reason, the absence of multiple vibration transducers makes it impossible to detect the early stage of malfunction of those parts.

The goal of diagnostics is the detection of the beginning of malfunctions, observation and prediction of their development, and accordingly the development of a machine maintenance plan. However, the problem becomes far more complicated if it is necessary to organize maintenance based on the existing condition of the machine. In that case, it is important to detect all the faults from the very beginning. The fact is that there are no defects in rotary machines that can develop fast, except for hidden defects that occurred in the process of making parts and their assembly. Therefore, the basic features of vibration diagnostics can be expressed as follows [4]:

- It is necessary to perform vibration measurements of each machine part for which there is no specific method for detecting defects in the beginning;
- Diagnosis is more efficient to perform on high-frequency vibrations that can be excited by relatively small forces that develop in the early stage of malfunction.

To present the existing diagnostic methods for different parts of rotary machines, it is necessary to fulfill the main rule of quantitative diagnostics - the condition of the machine must be determined by the deviation of diagnostic parameters from their standard value. Two interrelated diagnostic problems arise from this rule - determination of optimal diagnostic parameters and determination of reference (authoritative) values for each of the parameters, which is a general problem in all branches and types of technical diagnostics.

Determining the reference condition of a machine without malfunction can be done in three ways [4]:

1. By measuring each diagnostic parameter of the same group of machines without malfunction, determining their mean value and setting the limits of their permissible deviations;
2. Observing deviations of the diagnostic parameter in the initial phase of operation of a certain machine, determining the course of that parameter changes and allowed deviations, after which the obtained values can be used as a reference for a given parameter in the future period of machine exploitation;
3. Carrying out certain measurements of the diagnostic parameter in the initial phase of work and their use during the next measurement.

PROGRAM FOR PREDICTIVE MAINTENANCE OF ROTARY MACHINES

To simplify the procedure of systematic monitoring of the condition of the machine in order to predict its maintenance, an algorithm (Fig. 1.) that defines the sequence of required operations was developed.

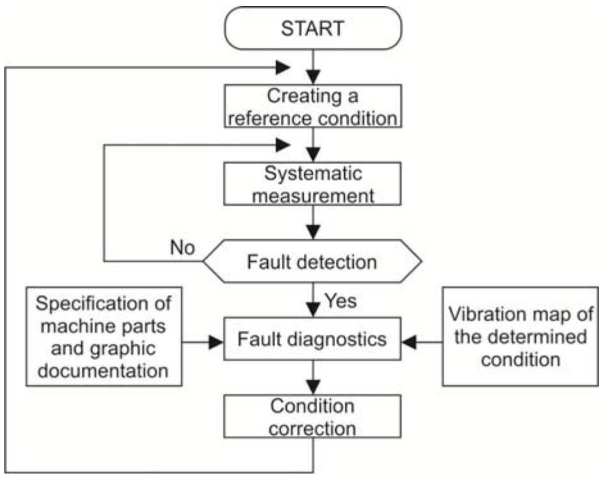


Figure 1. *Predictive maintenance algorithm [5]*

The initial step is the so-called zero measurements to define the reference condition for each measurement point when the machine is in good condition. Then, at defined time intervals (depending on the condition of the machine), new measurements are performed which are compared with the reference condition (reference total levels and reference spectra), and also deviations are registered. Smaller increases in vibration levels are used for setting a trend that indicates the moment when a malfunction may occur. Increases of the vibration levels in the range of 8-20 dB represent a warning about serious problems when the machine needs to be stopped and possibly repaired. After troubleshooting (repairing or replacing damaged machine parts), new reference spectra are created.

The program of predictive maintenance of mechanical equipment using vibrations assumes three logical steps: detection, analysis and correction [6].

Detection includes measuring and monitoring the flow (trend) of vibration levels at marked places on each machine covered by the program, based on the prescribed schedule. It is common for machines to be inspected monthly, although critical machines are inspected more frequently, or even continuously, with a permanently installed on-line vibration monitoring system, with the sole aim of detecting significant increases in machine vibration levels that generates a warning and point out the existence of a problem.

Measurement of vibration levels on machines can be done with a simple hand-held analyzer. The instrument contains a transducer that is set to the bearing housing or installed in it, with the task of converting the vibrations of the machine into the appropriate electrical signal that the instrument displays and loads as the vibration level. In order to obtain reliable and accurate information, the procedure and the way of taking data, that is, sampling of the vibration, are very important. Measured vibrations with such instruments can be recorded in the instrument database containing a sketch of the machine to help identify measurement locations and positions. The database also contains the possibility of recording and storing data in graphical form, especially suitable for insight into the entire history of machines, when each recorded increase in vibration levels is a reliable indicator and warning of the existence and development of the problem.

For maintenance programs that include a small number of machines and measurement points, manually operated instruments and systems are quite sufficient. However, programs involving hundreds, or even thousands of machines and measuring points generally require a computerized data collection system, not only to reduce the time taken to collect them, but also to process them. A typical system consists of software for a predictive maintenance program installed in the computer and appropriate instruments for collecting vibration data in the field. The majority of such systems, in addition to the possibility of collecting and monitoring the flow of total levels of machine vibration, provide the possibility of detailed analysis, necessary to identify specific damages and problems in the operation of machines. In this regard, the first step is to set up a maintenance program in the computer software, which includes [7]:

1. Listing of all machines included in the maintenance program;
2. Determining the exact locations on each machine where the vibration reading will be performed;
3. Determining the directions (horizontal, vertical and axial) in which the vibration reading will be performed;
4. Selection of vibration parameters to be measured at each location. In addition to vibration parameters, other parameters can be measured and monitored at the same locations, such as bearing temperature, rotational speed (RPM), pressure, flow, etc.;
5. Determining alarm or warning levels for each measurement;
6. Determining and adjusting details in the spectrum of data required for vibration analysis;
7. Organization of machines into groups suitable for work or organization of routes;
8. Determining the schedule of data collection for each group of machines.

Although the described process may seem rather tiring and time-consuming at first glance, most vibration prevention maintenance software allows for relatively easy use, with numerous advantages that simplify the maintenance program setup process. For example, the program can be set for more than a hundred pump generators in less than an hour. Determining measurement locations, alarm levels and analytical parameters requires special training and extensive staff experience.

Once the maintenance program is set up in the computer software, the next step is to collect the data. According to the previously determined schedule, a certain group of machines is selected and loaded from the computer software into the instrument for collecting vibration data. After taking over the instrument, the operator is directed to the field, accesses a certain area and starts the instrument. The instrument screen directly shows the specific machine, the measurement location and the direction of the measuring transducer. If the transducer is set to the appropriate measurement point, the operator simply presses the button on the instrument to start data collection. When the reading of the data at a given measurement point is completed, the operator presses the button to show the next scheduled measurement. This process is repeated until all measurements within the route have been performed.

After the process of collecting vibration data in the field, the operator returns to the computer and, following a few simple instructions, transfers the data from the instrument to the predictive maintenance software. Once data from the measurement instrument is downloaded, it is possible to determine in many forms of measurement reports which machines have a significant increase in vibration or exceeded the set alarm levels, indicating the development of the problems and malfunctions. The report is prepared in such a way that it contains information about specific machines, measurement points, vibration levels and changes in the condition (in percentage) in relation to the previous measurement in machines with observed problem development. Another form of report is a graphical trend of changing the condition of the machine, where it is possible to visually monitor how the measured vibration values change progressively over time and thus determine whether the increase in vibration is gradual or sudden. A sudden increase in vibration is generally considered to be potentially more serious than a gradual increase in vibration levels over time (e.g. over weeks or months).

Reports that contain alarms and trends are just some of the many different forms of reports that can be produced on a daily basis by modern computer software for predictive maintenance programs using vibration. Automated data collection and computerized systems for their processing are the basis of simple portable vibration measuring devices and data lists. Automated systems also allow the computer to choose the best solution, that is, to list and classify possible problems in the most successful and fastest way, so that the operator can read vibrations on several machines within the industrial plant with a data collection device in a very short period of time.

Although most general-purpose machines can be protected by periodic vibration checks, some machines are not suitable for the application of "manual monitoring" techniques. With high-performance machines, with essential performance characteristics for maintaining the technological process, such as steam and gas turbines, or centrifugal compressors and pumps with high rotational speeds, problems can arise very quickly, with little or no prior warning. Such machines require continuous monitoring.

When problems in the operation of machines are detected, either by periodic (manual) monitoring, or continuous monitoring, the next step is analysis - identification of certain characteristic problems in order to plan their solution (correction).

The purpose of vibration analysis is to very accurately identify specific problems in machines by detecting and establishing unique vibration characteristics. In most cases, data acquisition instruments and computer software for regular control and monitoring of vibration flow can be used to obtain detailed vibration characteristics, which are necessary for accurate determination of a specific problem. By systematic analysis of vibration, it is possible to identify more general and common problems that occur during the operation of different types of machines, such as: imbalance, misalignment, looseness, damaged bearings, resonance, eccentricity, wear of machine parts and equipment, problems with electricity in motors, problems with drive belts, various forms of material deformation, etc.

The analysis of vibration signals is carried out during the procedure of periodic monitoring of the condition of machine systems when periodic controls reveal a significant increase in the level of total vibrations. The analysis of vibration signals should be done at the beginning of the implementation of the maintenance program according to the condition so that the obtained results on the initial state of the technical system serve to monitor the trend of the overall level and individual frequency components of vibration.

The analysis procedure can be divided into two parts, where the first part is realized through two phases [8]:

1. data collection (preparation for measurement, vibration measurement itself and acquisition of measured data), and
2. identification of measurement results (comparison of registered data with reference data on the condition of system components).

The second phase of the analysis refers to the identification of dominant component sources registered in the time or frequency domain, applying the all previously acquired knowledge about the specific characteristics of the potential vibration picture of moving (usually rotating) machine parts. Frequency is a key parameter in all phases of the identification process, where for many rotating machine parts, (bearings and gears above all) in addition to the fundamental frequency and its higher harmonics, exact mathematical expressions define forced and natural frequencies. Those frequencies in the recorded spectra may correspond to individual machine parts.

If problems are detected and identified, the necessary measures for corrections and repairs can be planned in a suitable period of time, which together makes up the second part of the analysis. In the meantime, any special request or need for personnel (including the engagement of external capacities), spare parts and accessories must be organized in advance in order to reduce the downtime of the machine to an absolute minimum.

The program of predictive maintenance of machines (Fig. 2.) involves the selection and analysis of certain process parameters which, together with data on vibration activity, describe the working condition of the machine. Process parameters are measured during each vibration measurement, and the measured values are used to create machine operating classes.

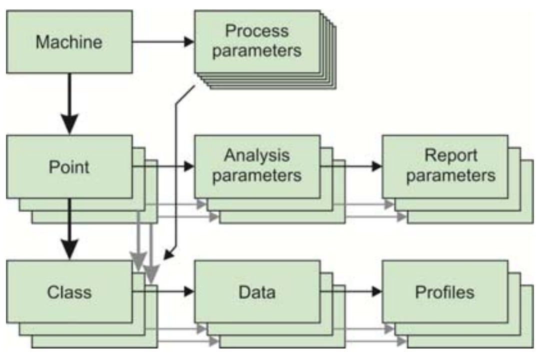
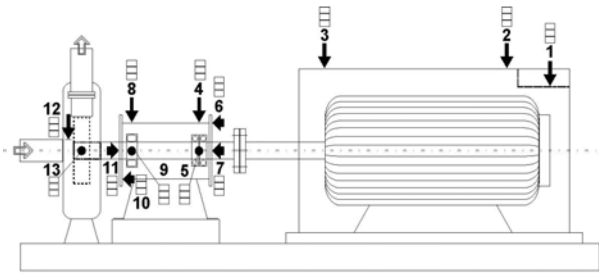


Figure 2. *Structure of the predictive maintenance program [3]*

The definition of measuring points is in line with the requirements and standard ISO 10816 [9]. The measurement is realized on the bearing assemblies, that is, on bearing housings or on other parts of the structure on which dynamic forces are significantly reflected

[10]. Typical measurement positions for the case of a radial centrifugal pump are shown in Figure 3. In order to define the state of vibration at each measuring position, it is necessary to perform the measurement in three mutually normal directions. In practice, it is common to measure in two radial directions and possibly in the axial direction, depending on the type of bearing.



LEGEND:

1. Fan-housing;
2. Electric motor housing - non-driving bearing position;
3. Electric motor housing - driving bearing position;
4. Pump ball bearing - vertical radial direction;
5. Pump ball bearing - horizontal radial direction;
6. Pump ball bearing - vertical axial direction;
7. Pump ball bearing - horizontal axial direction;
8. Pump roller bearing - vertical radial direction;
9. Pump roller bearing - horizontal radial direction;
10. Pump roller bearing - vertical axial direction;
11. Pump roller bearing - horizontal axial direction;
12. Pump impeller - vertical radial direction;
13. Pump impeller - horizontal radial direction;

Figure 3. *Distribution of measurement points for vibration monitoring on a centrifugal pump [11]*

One point on the machine can contain several measuring points if different analysis parameters are used for measurements, or vibration measurements are performed in different directions. If the operating condition of the machine affects the value of the vibration amplitudes, then the comparison of the spectra obtained by measurements under different operating conditions is not correct. Therefore, measurements performed under the same operating conditions are grouped into classes. Spectrum differences within one class of measurement reflect the development of the resulting damage, and not the changes caused by the operating mode of the machine. The classification of measurement points into measurement classes defines the reference spectrum of vibrations for the given measuring conditions, that is, the state of the tested element.

The term measurement point means one measuring position of the accelerometer. Hence the need to measure vibrations at several measurement points, since the effect of vibrations is not transmitted equally at all points, as well as the fact that vibrations in different directions are measured with separate accelerometers.

The term measuring class means a set of process parameters of a limited range in which the working condition of the machine does not change significantly.

The assessment of the condition of the machine is performed by comparing the obtained results with the severity zones for the group of machines to which the tested machine belongs, defined by the ISO 10816 standard (Fig. 4):

Zone 1 - "Good": Vibrations that are characteristic of new machines. The machine satisfies.
Zone 2 - "Satisfactory": Vibration machines in this zone can be operated for an unlimited period. The machine satisfies.
Zone 3 - "Unsatisfactory": Machines that have vibrations in this safety zone can work in limited operating loads, that is, in a very short period. The machine does not satisfy.
Zone 4 - "Unacceptable": Vibration in this zone can cause damage to the machine. The machine does not satisfy.

Severity zones 1 and 2 define the profile of reliable machine operation. Severity zone 3 defines the warning profile and implies the implementation of measures and activities to reduce vibrations through enhanced monitoring and limited operation. Severity zone 4 defines the alarm or danger profile and provides for the shutdown of the machine from further operation.

The boundaries of the safety zones of a certain class of machines depend on the size of the machine, the characteristics of the foundation of the machine and its purpose.

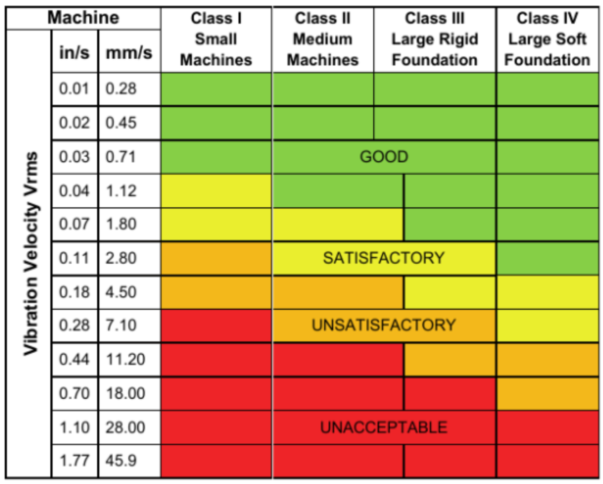


Figure 4. *Vibration Severity – ISO 10816-1*

Class I: Individual parts of engines and machines integrally connected to the machine in normal operation. Production electrical motors at a maximum of 15 kW are examples of machines in this category.
Class II: Medium-sized machines (typically electrical motors with 15 kW to 75 kW output) without special foundations, rigidly mounted engines or machines (up to 300 kW) on special foundations.

Class III: Large prime-movers and other large machines with rotating masses mounted on rigid and heavy foundations that are relatively stiff in the direction of the vibration measurements.

Class IV: Large prime-movers and other large machines with rotating masses mounted on foundations that are relatively soft in the direction of the vibration measurements (for example, turbo generator sets and gas turbines with outputs greater than 10 MW).

CONCLUSION

Conditional maintenance, or predictive maintenance, is the best choice for reducing the life cycle costs of a large number of industrial machines. The success of this maintenance strategy depends primarily on the possibility of sufficiently reliable fault detection. Implementing a predictive maintenance program increases process automation, reduces job losses due to production delays, reduces insurance prices (all insurance companies value the existence of predictive maintenance), raises production quality, reduces energy consumption (5%), reduces warehouse reserves and needs for stocking the equipment. The introduction of predictive maintenance carries with it risks, especially at the beginning of program implementation, and these are lack of management interest, untrained staff, initial errors and excessive equipment on which the test is applied.

The best results of maintenance of technical systems are achieved by a combination of predictive and proactive maintenance methods, which in addition to activities included in preventive maintenance also contains a phase of analysis of causes of failures which reveals the causes of frequent failures at individual machines. Based on this, their solution and removal can be carried out during the design and manufacture of certain elements.

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BIOGRAPHY

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MODEL VIBRODIJAGNOSTIČKOG POSTUPKA ZA PREDIKTIVNO ODRŽAVANJE ROTACIONIH MAŠINA

Darko Mihajlov, Momir Praščević, Marko Ličanin

Rezime: *Rad opisuje model vibrodijagnostičkog postupka za prediktivno održavanje rotacionih mašina, zasnovan na eksperimentalnim ispitivanjima realnih objekata. Sistematsko praćenje stanja rotacionih mašina u dužem vremenskom periodu dozvoljava zaključivanje o potencijalnim nepravilnostima u radu postrojenja, uočavanje izvora nastanka vibracija i stepena oštećenja pojedinih sastavnih delova. Na taj način su ispunjeni uslovi za izradu vibracione karte i preduzimanje preventivnih mera za održavanje postrojenja.*

Ključne reči: tehničko održavanje, prediktivno održavanje, vibracije, detekcija otkaza, rotacione mašine.

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CHEMICAL RISK ASSESSMENT METHODOLOGY

Abstract: *The basic source of hazard in chemical industry is plants with hazardous substances. Exposure to hazardous substances may cause harm to humans, animals and/or the environment. Also, they are a great threat in case of inadequate treatment as well as during production, manipulation, storage, transport, utilization, or even in case of hazard or an accident. In this paper, a definition of a chemical accident has been given, followed by descriptions of accident phases and the zones of accident. Managing and assessing risks related to chemical accidents is a complex process that requires a systematic approach during risk identification, control and reduction.*

Key words: hazardous substances, chemical accidents, risk, risk assessment.

INTRODUCTION

Inadequate treatment of hazardous substances can lead to chemical mishaps or accidents.

An accident, a mishap, or a disaster is an emergency event or a series of events that occur as a consequence of uncontrolled releases, spilling, or spreading of hazardous substances in production, utilization, transport, storage, and cause damage to humans and the environment.

The cause of accidents (mishaps or disasters) related to chemical laboratories, chemical industry and companies using hazardous substances in production, storage or transport are most often: employees mistakes (due to ignorance or being irresponsible), accidents arising from conditions that are difficult to control, or natural disasters [1].

For example, the production of paints and varnish is a very complex and risky process since paint pigments of organic or non-organic origin get synthesized, and it contains polymers and solvents mostly used as a foundation for paints and varnish. The mentioned substances possess a higher or a lower level of toxicity and most of them have a characteristic of easy vaporescence which can influence their release, during the production process and/or during an accident. Therefore, they can represent a risk for human health and the environment.

It can be said that the technological process in the chemical industry is considered a risk. In other words, risk is a potential problem. It is present in all spheres of work within an organization, thus it is necessary to manage it. According to the terminology of the International Organization for Standardization - ISO [2], the risk is "A combination of the probability of an event and its consequences", and in some situations, the risk is "a deviation from the expected" [3]. Organizations face various forms of risk, so there is a need to develop the management system for risk monitoring and recommendations on how to treat the consequences of a risky event.

THE PHASES OF CHEMICAL ACCIDENTS

Stages of accident involve the time before the occurrence of an accident, the initiation, duration, accident development, termination and the time after the accident. It is essential to be familiar with the stages of an accident in order to adequately respond and to undertake activities to eliminate the negative consequences of an accident. In literature, there are four phases of an accident. It is considered that the classification which comprises four phases of an accident development is rather incomplete and inadequate, that is, it does not provide necessary temporal and spatial information about the accident. By the same criterion, a classification can involve seven phases of an accident in a facility [4]:

- Phase I - the time before the occurrence,
- Phase II - the time of the occurrence,
- Phase III - the time of the accident duration within the facility (production, storage, transport),
- Phase IV - the time of the accident duration outside the facility,
- Phase V- the termination of the accident,
- Phase VI - the time immediately after the accident, and
- Phase VII - the time after the accident.

In the first phase, all necessary measures should be taken to prevent the appearance of the accident. Knowing the time of the accident occurrence is significant in order to be prepared for the third phase and to be able to determine the priorities in saving lives and material goods. In the third phase, it is necessary to save employee lives and undertake technical and technological measures to prevent the accident occurrence outside the facility. The fourth phase is focused on providing conditions for saving the population, flora, fauna, economy and, most importantly, humans. In the fifth phase, the territory affected by the accident is determined. This phase also involves the preparations for the sixth phase. In the sixth phase, immediately after the accident, the first aid is given (food, accommodation and medical help) and the evacuation is organized with the aim to save people. The seventh phase comprises taking suitable measures for the localization, remediation, and elimination of consequences of the accident.

Temporal and spatial distribution of an accident depends on several factors: physical-chemical characteristics of the substance, temperature, meteorological and hydrological conditions, topographic characteristics of the locality, etc. The dynamics of the accident and the level of remediation depend on the type and the mass (quantity) of the discharge, characteristics of the substance, characteristics of the relief, and climatic conditions of the terrain, as well as on the preparedness and technical competence. Experiments have shown that bursting of reservoirs with hazardous matters in a solid or liquid state, lead only to the local impact in the place of the accident, or the close surroundings. Steam and gasses of hazardous substances can spread even to dozens of kilometres, which noticeably increases the proportions of hazard [4].

CHEMICAL ACCIDENT RISK

Chemical-industrial complexes are very compound systems that comprise various equipment, managing-controlling devices, and operating procedures necessary for the regular production and processing. Industrial plants from this field use a large number of various hazardous matters which can be in the form of raw materials and/or finished products. The presence of hazardous matters in industrial plants, warehouses, means of transport, or during activities poses a risk of occurrence of a chemical accident. Hazard can be defined as a physical event, a process or phenomenon which can cause damage. According to the genesis, it can be geological, hydrometeorological, or biological, and it can differ by its magnitude or intensity, frequency, duration, space it affects, the speed of its occurrence, spreading, and the reversible period (UNISDR, 2004).

Satisfying all the requirements and standards by the legislation in order to prevent the potential hazard does not fully secure the occurrence of a chemical accident. However, for the chemical accidents to appear two conditions must be fulfilled - the necessary and sufficient conditions. The necessary activity implies the existence of a hazard and its activity at the potential development of the unwanted event, while the sufficient condition relates to the unfavourable outcome of hazard activity involving all risk factors. The necessary condition is always present in the system of hazardous substances and its degree of action varies depending on the risk factors which are in function of the sum of magnitude or intensity, frequency, duration, the speed of appearance, the reversible period of action and the surface of the space comprised by the hazard. There are hazards probability categories which can change in space and time. If, in certain circumstances, the hazard is manifested through a combination of events H_1, H_2,...,H_n; afterward, the probability can be expressed through an equation (1) of total probability [4]:

$$P = \sum_i P \frac{G}{H_i} \cdot P(H_i) \tag{1}$$

where the following are: $P(G/H_i)$ – the conditional probability of danger, G - danger; $P(H_i)$ – the probability of the i-event, H_i – i-event, P - probability.

The sufficient condition, the appearance of the chemical accident depends on four basic groups of risk factors: characteristics of the substance used in industrial production, means of work, human factor and the management.

In chemical industry, the products can have certain characteristics (toxicity, flammability, explosivity, etc.) based on which they are classified into the group of hazardous substances. At certain conditions, the above characteristics may pose risks for both people and the environment. The level of hazard from the toxic activity of substances is conditioned by its toxic potential, while the hazard from fire and explosion is conditioned by the energy potential [4].

In conditions of fast and sudden manifestation of the highly toxic potential of substances, we speak about toxic accident. The release of energy in substances can lead to the existing hazard which, as a consequence, may turn into a fire and/or an explosion. The accident may involve a combination of activities of a substance ac: toxic - fire – explosive actions. For this reason, various combined accidents may occur, for example: fire that releases the emission of toxic substances when the flammable substance is toxic at the same time or when a non-toxic substance or its compound turns into a toxic substance in conditions of combustion. Mutual connection and conditionality between various kinds of chemical hazards create combined chemical accidents and risk for a man and the environment to a greater or lesser extent [4].

When a chemical accident is a technical-technological accident, which is a condition for risk occurrence, the risk can be defined as a function of the probability of occurrence and consequence of a specific hazardous event, occurrence, a process which happens or can happen and which causes a hazard for life, people and the environment. Although the attempts to give a unique definition of risk are suitable in all scientific disciplines did not lead to the wanted goal. There have been various definitions across the scientific disciplines [4]. The Law on Emergencies (“The Official Gazette of the Republic of Serbia“ No. 111/2009, 92/2011 and 93/2012) defines the technical-technological accident as a sudden and uncontrolled event which is a consequence of the lack of management control of means of work, handling hazardous matters in production, transport, storage, and logistics, and whose aftermaths can jeopardize the safety of people, goods and the ecosystem. This definition relates to the static and dynamic conditions and that it comprises all the technological processes during the manipulation of hazardous matters [5].

CHEMICAL ACCIDENTS HAZARD ZONES

As it has been already stated, there is an ever-present risk of accidents during the processes of production, transport, and storage of hazardous substances. Therefore, the places of accident occurrence can be the following:

- production and technological plants where hazardous substances are involved;
- warehouses, stockrooms, and facilities where hazardous matters are deposited and kept;
- landfills, and
- means and communications by which hazardous matters are transported.

In case of an accident in facilities with hazardous substances, we distinguish the following:

- *The hotspot of the accident* represents an imagined space where there is a spill of the hazardous substance and the aerial space above that ground where the primary cloud with hazardous substances is being formed. In the term meaning, the accident hotspot suits the *primarily affected region* (PAR), which is formed at chemical impacts.

- *The primary cloud* is the cloud of steam of the hazardous substance which appeared during dehermetization (or an explosion) of a reservoir with the hazardous substance, by transforming the hazardous substance from the liquid to the steam phase. With the simple dehermetization of the reservoir with hazardous matters (without the effect of explosion or a sudden increase in temperature in the reservoir), the primary cloud is formed only by that hazardous substance whose boiling temperature is lower than the temperature of the environment.

- *The secondary cloud* is a cloud of steam of hazardous matter which appeared because of the evaporation of a spilled hazardous matter into the protective pool or on the surrounding ground (Figure 1) [5].

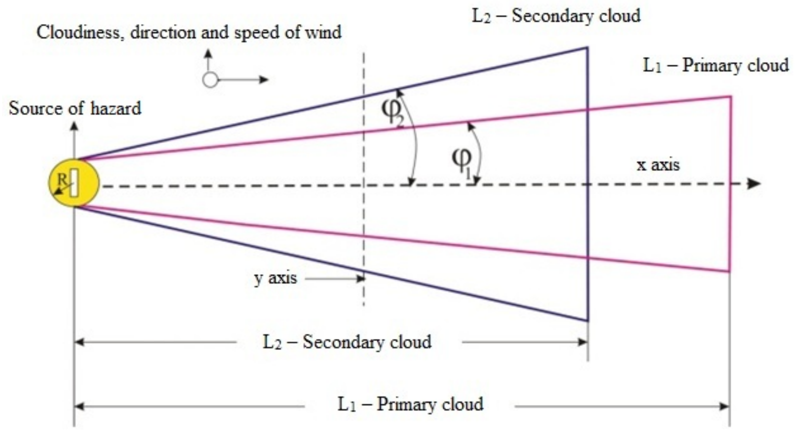

Figure 1. *The main elements of a chemical accident*

The main elements of the description of a chemical accident, φ1andφ2–half of the angle of the spreading sector of the primary, i.e. the secondary cloud; the x-axis -the wind direction or the direction of spreading of the cloud (the wind direction is defined in degrees or the sides of the world where the wind "blows" from, and the direction of steam spreading is defined by degrees or the sides of the world toward which the cloud of contamination is moving); they-axis–the direction vertical on the wind direction (used in determining the width of the hotspot and the primary and the secondary contamination cloud).

After proper risk analysis and assessment, it is possible to determine the hazard zones after the accident for each new case. The main zones are the following:

- *The first zone* is the zone in which the accident occurred and where providing first aid to the endangered population implies the efficient application of protective means;

- *The second zone* can be defined in 10-30 minutes interval from the moment of the accident occurrence, and how much time it takes for the intensive spread of toxic substances. The space covered depends on the accident range, the kind of hazardous substance, and conditions in that area (meteorological, topographic, etc.). In this zone, it is possible to carry out certain measures in order to reduce the break-through of toxic substances in the facilities, with the simultaneous evacuation of the endangered population.

- *The third zone* is determined by the territory on which the chemical substance appears after 30 minutes. This zone is considered as a real hazard zone of chemical accident. In this zone, the measures for population protection, evacuation, and other procedures are defined by protection plans [4].

THE STAGES OF CHEMICAL ACCIDENT DEVELOPMENT

Regardless of the kind or the character, all accidental situations pass four stages of development: occurrence, initiation, culmination, and the end of an accident.

In the stage of **occurrence,** there are preconditions for the future accidental situation: there are many disadvantages in processes, technological failures and omissions as well as shortcomings in production; there is a burden to both the equipment and the employees, extreme physical conditions of the production appear (such as high and low temperatures, high-pressure shocks), various chemical substances are stored changes (flammable, explosive, corrosive, highly reactive, powdery substances), all followed by the negative anthropogenic influences on the environment.

In the stage of **initiation**, technological breakdowns appear due to the change of process parameters (pressure, temperature, concentrations of hazardous matters, the speed of reaction, and the consumption of substances), unfavourable or extreme weather conditions, natural disasters, diversions. The initiation of the accident happens due to deviation from the normal process or the uncontrolled coincidence due to which the system becomes unstable. Accidents in warehouses and technological processes are a consequence of defects in the equipment: errors during design, building and equipment assembly; errors in equipment exploitation; malfunctions in the technological process. The accidents during transport happen due to bad conditions of railway tracks, poor-quality of overhaul works, the defects on a transport vehicle; crashes, collisions; corrosion of pipelines, etc.

The stage of **culmination** is followed by the release of a large quantity of mass and energy. An insignificant initial event usually starts up a mechanism of chain events, with multiple increases in the initial power and the size of the event. As a consequence of accidents in warehouses and technological processes, fires, explosions, and emissions of hazardous substances are transmitted into the environment occur. In transport accidents, the accidents which may happen are falling off from tank rails, fires, explosions, and emissions of hazardous substances into the environment.

The stage denoting **the end of an accident** starts from the moment of elimination of the source of hazard and it lasts until the total elimination of consequences of the emergency. The duration of this stage depends on the type, intensity, and size of the consequences and can be measured even in decades (for example, the Chernobyl disaster). It comprises measures of chemical protection applied in the localization and liquidation of the source of pollution [4].

CLASSIFICATION AND CATEGORIZATION OF CHEMICAL ACCIDENTS

Chemical accidents are conditioned by the existence of an accidental event which is an opportunity for exposure to chemical substances. The understanding of the nature of a chemical event and the choice of criteria for the categorization and classification of a chemical accident requires consideration and knowledge of characteristics of hazardous matters.

Categorization of chemical accidents represents a systematized approach to all relevant techniques (methods, rulebooks, practical experience, software, etc.).

Classification of chemical accidents implies their alignment in groups with identical or very similar characteristics. Categorization of chemical accidents is carried out based on the results of their classification and it is significant for a unique system of risk assessment. It means that every chemical accident is characterized by a certain group of parameters that do not have the same influence on the outcome of the accident (consequence).

The most general division of chemical accidents is according to their origin. They can be:

- natural and
- artificial (anthropogenic)

The classification of chemical accidents according to the place of their appearance comprises:

- production (fixed) plants for production and processing of hazardous matters,
- transportation means for the transport of hazardous matters,
- warehouses with hazardous matters (industrial, distributive and other),
- waste landfills which have characteristics of hazardous waste,
- households in everyday use (for example, propane-butane, hydrochloric acid, etc.)

Depending on the scope of the geographical prevalence of the contaminated zone, chemical accidents can be local, regional, national and global.

According to the consequences with fatal outcome, chemical accidents are divided into:

- Technological disasters ($\geq$ 25 casualties),
- Large chemical accidents ($\geq$ 5 casualties) and
- Significant chemical accidents ($\geq$ 3casualties).

Basic processes which can appear after the initiation of a chemical accident comprise:

- explosions,
- fires and
- spilling (leaking) of hazardous matters [6].

RISK ASSESSMENT FROM A CHEMICAL ACCIDENT

Technogenic risk is conditioned by the development of hazard which appears in accidents or breakdowns in the technosphere, and it comprises emissions of hazardous matters from industry in working and living environment, fires, contamination with radioactive substances as well as contamination with toxic substances during their transport and storage.

Based on the aforesaid, it arises that qualitative-quantitative assessment of the technogenic risk should be used to determine the risk in utilization, handling, transport, and storage of hazardous substances, if it is concluded that on a certain location (for example the industrial zone or on traffic routes) certain ecological elements will be exposed to hazardous substances, which will, as a consequence lead to the degradation of the environment.

The purpose of qualitative-quantitative risk assessment is to provide a report of the risk within the plant and evaluate the level of acceptable risk, as well as to inform the competent institutions and the public about the increased risk at the spot or in the close vicinity.

During qualitative ad quantitative risk assessment, the starting point is to present the risk as a quantified size of the occurring or expected side effects on people, things, or certain elements of the environment, which are the consequence of certain accidents. So, the risk (R) is viewed as the frequency function of the activity of stressors and the occurrence of side effects with the assessment of the level of consequences, the equation (2) [7].

$$R = f(F, G) \tag{2}$$

where: R–is the numeric representation of the risk related to the accidental event; F–the frequency of the activity of stressors and the appearance of side effects; G–the level of consequences on the corresponding element.

The risk assessment can be carried out by the application of suitable methods and techniques used to define the nature and degree of risk from a potential accident, the state of hazard and the consequences which can cause damage, losses and jeopardize people, the environment and material goods.

The analysis of hazard develops through three phases, and they are: identification and analysis of consequences, measures of preventive activities, and measures of the response to the accident and remediation plans for the consequences of the accident. Production and technological plants with hazardous substances used in production are the most important places where these measures should be applied, followed by warehouses, stock rooms, and other facilities where such substances are stored, as well as the means of their transportation.

Here we have tried to define the notion of "endangered space", which is an area where we could expect to find

Accident risk assessment is the activity used to identify hazards, carry out the analysis, and determine the levels of risk from uncontrolled events in industrial plants and installations, facilities and warehouses. It represents an assessment of the probability of whether a certain hazard shall turn into risk [8].

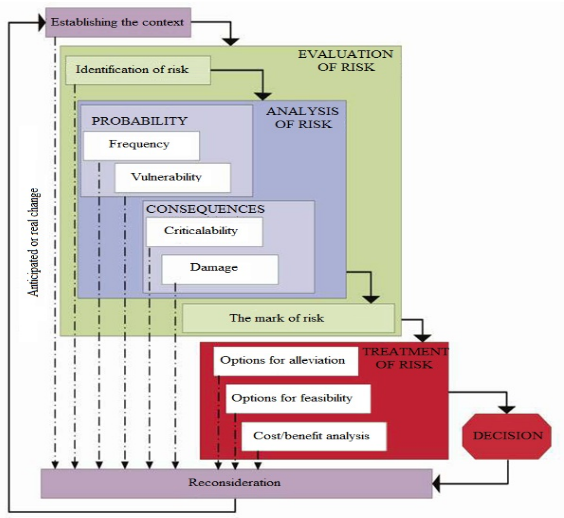

Figure 2. *Graphical presentation of risk assessment methodology*

The process of an accident risk assessment is broken into three phases: the preparation phase, development of a risk assessment program, and the implementation phase. In the first phase, an action plan should be made and it should contain data on the organizational structure in the facility, the branch of industry, data on persons responsible for risk assessment and data about the members of the risk assessment team, decisions and conclusions on the use of the information important for the assessment, details on resources needed for carrying out this process, cooperation and coordination between the persons who perform the assessment, the director, employed and all other relevant participants, the ways of documenting all the decisions, measures and plans in the assessment process and the ways of informing and reporting. The second phase is the phase of carrying out a risk assessment program. The third phase is the phase for the implementation of decisions, solutions and measures which were taken in the process of chemical risk assessment [8].

hazardous substances during an accident. Apart from this, we must take into consideration the assessment of possible chemical accidents occurred within individual technological processes and systems. That is why it is extremely important to provide all the data about the plant where a potential accident can occur [9].

The analysis of consequences is done by assuming the possible effects of hazardous substances on people, property, and the environment in the case of an accident. To successfully manage preventive measures and suppress the harmful activity of hazardous chemical substances, one must get acquainted with regularities as well as with unfavourable activities which can create harmful effects. The analysis of consequences uses data on the characteristics of chemicals and their maximum allowable concentrations (MAC) [10].

Preventive measures represent the implementation of more complex procedures intended to develop safe conditions in the whole technological system, establishing safety in production by which it is possible to prevent the occurrence of an accident.

Response to an accident is in charge of the services of The Ministry of Internal Affairs (Emergency Management Department), then the specialized ABCD (Atomic Biological Chemical Defence) units of the Army of the Republic of Serbia, state authorities, health services, fire protection services, communal services, units of civil protection, units for remediation, specialized laboratories, information support centres, hydrometeorological services, transport services and other relevant specialized organizations, institutions, and associations. The main goal of the remediation is the recovery of the injured, prevention of further pollution, and returning the living and working environment to the initial state.

MANAGING RISKS

The goal of risk management in the environment is to get an insight into the state of the environment and to reach the level of preparedness for all the subjects in preventing occurrence, processes, and events which jeopardize the life and health of people, and to evaluate the suggestions for further system development in managing environmental risks.

Figure 3. *Managing accidental risks*

There are various definitions of risk management [11]:

- Managing risk is an aspect of managing quality which has a supporting role in accomplishing the demanded quality of the system. The primary goal of managing quality is an implementation of the strategic management plan of which provides the requested system quality, while the goal of managing risk is maintaining the system quality even in the case of possible realizations of risky events. Managing risk should provide the continual existence of the system.
- Risk management implies managing which achieves a suitable balance between the creation of possibilities for profit and minimization of losses.
- Risk management is an approach that is based on the identification and control of those fields and events which are potential causes of unwanted changes in the system.
- Managing risk from an accident implies a group of measures and prevention procedures, readiness, response to the accident and remediations for reducing the probability of its occurrence and possible consequences, and has a goal to create conditions under which the risk from plants and work of hazardous installations is acceptable on a certain space.
- Managing risk is an organized process of identifying and measuring risk, choices, development, and application of options for treatment and following of risk.

In scientific and expert public there are common cases when in managing risk the risk itself is emphasized together with its quantitative identification, while in the methodological approach in the process control and a suitable response for its monitoring of state almost none of the significance is given.

Misunderstanding of goals in the process of risk management is often mystified and connected to the complex models for the quantitative risk assessment. It points out that the phenomenon of risk management should not be viewed as an independent category, but as a practical mechanism for realization of functions anticipated by suitable strategies.

THE METHODS USED IN RISK ASSESSMENT

Production, logistic, and transport activities with hazardous substances can be exposed to high risk from the occurrence of accidents having in mind the significant number of causes which influence the nature of hazard. Risk assessment at the exposure to certain hazardous substances requires an analytical approach in identifying potential hazards and consequences of their harmful events, especially for human health. Although qualitative methods had a significant contribution to risk assessment in the past, not diminishing their importance, it should be mentioned that in the past few years the main point of risk assessment has moved towards quantitative methods, see Figure 4 [6].

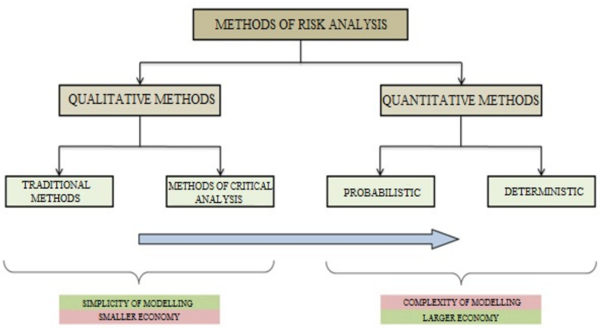

Figure 4. *Methods of risk assessment*

Risk assessment should also encompass special methods of knowledge by which we could discover structural, functional, causal and genetic dependencies, mutual conditionality, identicality or similarity of more appearances (chemical accidents, hazardous matters, chemical injuries, damages of material goods, etc.).

In this field, there is a larger number of generally accepted methods: "What If" Study, Checklist Study, Job Safety Analysis, Safety Function Analysis, Hazard and Operability Study (HAZOP), Event Tree Analysis, Fault Tree Analysis, etc. [12].

There are actual methodologies for the assessment of ecological risk in a technical-technological accident, such as: REHRA Rapid Environmental and Health Risk Assessment, US EPA ecological risk assessment methodology, APELL methodology - Awareness and preparedness for emergencies at the local level, EIA methodology of environmental impact assessment, Methodologies within standards - ISO 31000:2009 and ISO 31010:2009, LCA methodology of life cycle assessment, etc.

CONCLUSION

Due to the increased awareness about the consequences of possible chemical accidents, and a hazard to people and the environment, there has been a rise in the awareness of the need for their assessment and management. The companies which operate within the systems with hazardous substances are usually of a closed type, and they strictly keep information about all the accidents and those that were almost prevented, because they are an indicator of the state within such a system.

In those circumstances, the risk assessment comes down to the expert analysis performed by employees who use conventional techniques and methods. The risk assessment carried out in such a way is not reliable enough, because it is more quantitative and it mostly depends on the experience of the assessor.

This approach is not possible for a wider circle of researchers, therefore, the risk assessment within the system of hazardous substances exists in the frame of traditional methods. Contemporary business environments go beyond these and develop preconditions in which risk of an accident is increased, despite all investments in the modernization of plants that operate with hazardous substances. Certain processes in industry are characterized as hazardous, and the risk is perceived in terms of the usage of hazardous and harmful substances in such systems. The most common cause of the occurrence of chemical accidents are errors arising from human factors and poor and outdated technology which is still being used.

This is the point at which the need for the assessment and management of such risk arises. The main goal of risk management from a chemical accident is to achieve system safety and protect people, property, and the environment. The foundation for successful risk management is to perform risk assessment and analysis so that all the risks would be identified on time and all the consequences recognized.

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BIOGRAPHY of the first author

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METODOLOGIJA PROCENE HEMIJSKOG UDESA

Danijela Stojadinović, Amelija Đorđević, Jasmina Radosavljević

Rezime: *Osnovni izvor opasnosti u hemijskoj industriji su postrojenja sa opasnim supstancama. Opasne supstance su one supstance koje mogu izazvati štetne pojave kod eksponiranog čoveka, životinja i/ili životnu sredinu, pri neodgovarajućem postupanju sa njima, u procesu proizvodnje, manipulacije, njihovog skladištenja, transporta, upotrebe, hazarda ili udesa. U radu je data definicija hemijskog udesa, opisane su faze udesa kao i njihove zone pri formiranju rizika nastalog usled hemijskog akcidenta. Procena i upravljanje rizicima koji su uslovljeni hemijskim udesnim događajima predstavlja složen proces, koji zahteva sistemski pristup prilikom identifikacije, kontrole i redukcije rizika.*

Ključne reči: opasne supstance, hemijski udesi, rizik, procena rizika.

BOOK REVIEW / PRIKAZ KNJIGE

METODE I REZULTATI ISTRAŽIVANJA ŠTETNOG DEJSTVA ELEKTROMAGNETNIH ZRAČENJA U ŽIVOTNOJ SREDINI

Dejan Krstić, Dušan Sokolović

Obim rukopisa obuhvata 281 stranu B5 formata. Struktura rukopisa koncipirana je kroz 14 poglavlja koja od kojih su tri uvodno teorijska sa pregledom novih naučnih znanja iz elektromagnetike, dozimetrije nejonizujućih zračenja i numeričkih metoda proračuna i ostalih poglavlja u kojima su izloženi rezultati istraživanja autora o dejstvu elektromagnetnih zračenja mobilnih telefona u oblasti inženjerstva zaštite životne sredine i zaštite na radu kao i u oblasti medicinskih nauka.

Kvalitetno i razumljivo izložena poglavlja nose sledeće naslove:

1. Elektromagnetna polja i fizika živog
2. Dozimetrija nejonizujućeg zračenja
3. Metode istraživanja efekata dejstva elektromagnetnih zračenja
4. Istraživanje dejstva mobilnih telefona na modelu glave
5. Istraživanje dejstva mobilnih telefona na oči
6. Istraživanje dejstva mobilnih telefona na zube
7. Istraživanje dejstva sistema mobilne telefonije pri profesionalnoj izloženosti servisera na predajnim sistemima
8. Istraživanje mogućnosti zaštite servisera mobilne telefonije upotrebom provodnih ekrana
9. Efekti magnetnog polja na živi svet
10. Istraživanja dejstva magnetnih polja i anomalijskih magnetnih polja na stanovništvo
11. Efekti mobilnih telekomunikacionih sistema na promenu biohemijsko/metaboličkih puteva u živim sistemima
12. Biohemijski aspekti efekata mobilnih telekomunikacionih sistema na pojedina tkiva i organe u životnoj sredini
13. Protektivni efekti različitih supstanci u prevenciji mogućih toksičnih efekata elektromagnetnog polja

Autori su strukturisali tekst na sistematičan i naučan način, poglavlja obradili pregledno i jasno sa potrebnim brojem ilustracija, slika, tabela i formula. Problematika rukopisa je obrađena detaljno sa savremenim podacima iz prikupljene bogate literature (preko 400 referenci) i sa (preko 60 sopstvenih referenci) i na taj način dali state of art u oblasti, a pregledom rezultata do kojih su došli tokom dugogodišnjeg istraživanja pružili informacije potrebne istraživačima i naučnicima.

Problemi proračuna prostiranja elektromagnetnih talasa od izvora do objekta, apsorpcije energije u materiji, fizičkih mehanizma dejstva na materiju i efekata na biološka tkiva su izloženi naučno zasnovanim pristupom koji obuhvata teorijske i praktične aspekte ovog složenog i za proučavanje zahtevnog energetskog procesa. Opisana je teorija proučavanja elektromagnetnih talasa i polja, teorija numeričkih metoda proračuna komponenata polja i dozimetrijskih veličina kao i metodologija istraživanja bioloških efekata elektromagnetnih zračenja.

Autori su sve celine obradili razumljivo, pregledno i jasno dajući svakoj savremeni naučni pristup. Prezentovana materija je obrađena detaljno sa pregledom rezultata do kojih su došli autori, komentarima i zaključcima. Autori su prikazali metodologiju istraživanja bioloških efekata zračenja koja je prihvaćena u naučnoj javnosti kroz radove u renomiranim svetskim časopisima. Posebno treba istaći rezultate simulacije komponenata elektromagnetnih talasa, prodrlog polja, apsorbovane energije, SARa i indukovanih struja. Značajni su naučni dometi u oblasti proračuna elektromagnetnih zračenja u žive organizme a posebno u modelu čoveka i u pojedinim izloženim delovima i organima, izvedenim eksperimentima na životinjama i zaključcima mehanizma delovanja za fizičkog, biohemijskog i medicinskog aspekta.

Svako pojedinačno poglavlje kroz inženjerski pristup proračunima i kroz medicinsko biohemijski pristup eksperimentima in vivo i in vitro daje svoj odgovor na pitanje koliko je elektromagnetno zračenje tehničkih urešaja, a posebno elektromagnetno zračenja mobilnih telefona štetno po zdravlje ljudi.

Multidisciplinarnim pristupom autori, iako iz različitih oblasti pristupaju problemu zračenja, iskazuju rezultate koji su validirani u međunarodnim časopisima i prikazani kroz autocitate u rukopisu. Prikazani su rezultati proračuna dejstva elektromagnetnih zračenja mobilnih telefona na modelu glave, zuba, očiju i celokupnog tela u uslovima ekspozicije stanovništva i profesionalno izloženih lica. Takođe prikazani su i rezultati biohemijskih i medicinskih istraživanja dejstva na elemente bioloških sistema, organe i čitavo telo.

Oblast zaštite na radu je obogaćena praktičnim istraživanjem ekraniranja za servisere na telekomunikacionim emisionim sistemima, čime se njima obezbeđuju zdraviji radni uslovi sa manjim poljima.

Praktičan doprinos monografije se ogleda kroz predlaganje tehničkih načina zaštite pri profesionalnom izlaganje u blizini emisionih stanica mobilne telefonije.

Još jedan doprinos monografije se ogleda i kroz otkrivanje načina smanjivanja štetnih efekata zračenja biomedicinskim sredstvima kao što je melatonin, za koji su autori dokazali da može biti protektor i indikator elektromagnetnih zračenja. Značajni su i izneti dokazi da rezonantna BDORT metoda može koristiti u dijagnostici štetnog dejstva elektromagnetnog zračenja.

Ova publikacija obiluje značajnim informacijama koje su sistematično izložene i koje će koristiti naučnim istraživačima u razjašnjenju fenomena prenosa energije elektromagnetnih talasa i uticaja elektromagnetnih zračenja na žive organizme.

Može se zaključiti da monografija pod nazivom „Metode i rezultati istraživanja štetnog dejstva elektromagnetnih zračenja u životnoj sredini“, prikazuje: rezultate dugogodišnjih eksperimentalnih istraživanja autora, rezultate teorijskih istraživanja uticaja elektromagnetnih zračenja u ovoj širokoj i multidisciplinarnoj oblasti (sa 68 autocitata i sa preko 30 autocitata u publikacijama iz kategorije M20 i M50), analizu citirane naučne literature, metode i sredstva za smanjenje štetnih efekata elektromagnetnih zračenja. Ova publikacija iskazuje samostalan, sveobuhvatan i originalan pristup razmatranju efekata elektromagnetnih zračenja.

Stručnoj javnosti su naučne monografije i naučnih knjige iz ove oblasti potrebne jer ih posebno nema dovoljno na srpskom jeziku, a potrebne su za edukaciju lekara i inženjera, kao i za naučno-istraživački rad, a ova monografija ispunjava sve te zahteve. Studenti poslediplomskih i doktorskih studija na tehničkim i medicinskim fakultetima dobiju korisnu knjigu sa savremenim znanjima i potrebnim informacijama, a čitaocu ova monografija pruža podatke o dejstvu elektromagnetnih polja, promišljanja i zaključke autora i svojim dometom svrstava je u grupu neophodne literature za studente doktorskih studija i istraživače iz oblasti zaštite od štetnih efekata tehnički generisanih elektromagnetnih polja.

BOOK REVIEW / PRIKAZ KNJIGE

„PRIRUČNIK ZA PRAKTIČAN RAD POVJERENIKA RADNIKA ZA ZAŠTITU NA RADU“

Cvetan Kovač, Ana Šijaković, Ivana Krišto, Hrvoje Kovač

U *„Priručniku za praktičan rad povjerenika radnika za zaštitu na radu“* autora Cvetana Kovača, Ane Šijaković, Ivane Krišto i Hrvoja Kovača (izdavač

Nezavisni sindikat radnika u proizvodnji hrane i pića, Kutjevo, Hrvatska, 2018.) nalaze se originalni sadržaji o ulozi i značaju poverenika radnika za zaštitu na radu (predstavnika radnika, prim.aut.) i praktične smernice za njegov rad i delovanje u sistemu zaštite na radu.

Sam priručnik je nastao kao rezultat rada na projektu „Zaštita na radu-prilika i izazov u socijalnom dijalogu“ čiji je nosilac Nezavisni sindikat radnika u proizvodnji hrane i pića (SRPHP) iz Kutjeva. Projekat je realizovan tokom 2018. i 2019. godine u Republici Hrvatskoj.

„Publikacija za radničke predstavnike“ ispunjava sve neophodne preduslove dobrog priručnog štiva. Sastoji se iz 20 delova sa „Izvatkom iz kataloga zakona i propisa“. Svi delovi su analitičke jedinice tekstualne celine koja postupno i razumljivo uvode čitaoca u problematiku zaštite na radu. U priručniku su obuhvaćeni i smisaono i sadržajno povezani sledeći delovi: *Sigurnosna kultura; Kolektivno pregovaranje za bolje uvjete života i rada; Uloga i značaj povjerenika radnika za zaštitu na radu; Timski rad; Načela jasne komunikacije; Zakon o zaštiti na radu; Obaveze poslodavca u provođenju zaštite na radu; Odgovornost za štetu na radu i u vezi s radom; Osposobljavanje za rad na siguran način; Odbor za zaštitu na radu; Obaveze i prava radnika; Povjerenik radnika za zaštitu na radu; Povjerenik u radu odbora za zaštitu na radu; Procjena rizika (s uključenom check listom) i Izvadak iz kataloga zakona i propisa*.

U stručnom smislu, priručnik može da bude od koristi kako poverenicima radnika za zaštitu na radu tako i članovima sindikata, svim radnicima i poslodavcima i drugim brojnim subjektima koji su neposredno ili posredno u vezi sa delovanjem poverenika radnika zaštie na radu

U uvodnom delu publikacije autori upoznaju čitaoca sa osnovnim načelima i odredbama zakonske regulative iz oblasti zaštite na radu. Polazeći od pitanja „(...) *kako u stvarnosti ostvariti uspešno provođenje tog osnovnog ljudskog prava“* autori daju odgovor sa aspekta poverenika radnika za zaštitu na radu. Dalje, u svakom delu Priručnika, a posebno u delovima koji se odnose na *„Kolektivno pregovaranje za bolje uvjete života i rada“, „Ulogu i značaj povjerenika radnika za zaštitu na radu“,* autori ukazuju na poziciju predstavnika radnika za zaštitu na radu u sistemu zaštite na radu naglašavajući značaj *„redovite i dvosmjerne komunikacije“*, informisanje i uvažavanje mišljenja.

Autori su utemeljili Priručnik na pozitivnim pravnim propisima i relevantnoj praksi. Uložili su veliki trud i pokazali da su vrsni poznavatelji odnosa u sistemu zaštite na radu. Pišu pristupačno, nenametljivo i s merom, naglašavajući značajnosti o mestu i funkcijama poverenika radnika za zaštitu na radu koje nemaju drugi subjekti. „Postavljaju“ ga na pravo mjesto kako kada radi samostalno, tako i u timu, što je još karakterističnije i zahtevnije.

Tako složenu i aktuelnu „građu“ autori su rasporedili da se može koristiti i razumeti od početka do kraja te da bude od praktične koristi onima koji su u prilici da se u odnosima prava sigurnosti i zaštite zdravlja na radu nalaze i „snalaze“. Polazeći od toga da se bez permanentnog učenja i informisanja ne može očekivati uspeh u socijalnom dijalogu, kolektivnom pregovaranju i različitim oblicima radničke participacije, neosporna je vrednost ove publikacije. To se posebno odnosi na zahteve u sigurnosti i zaštiti zdravlja na radu i primeni brojnih propisa u pravu zaštite na radu.

Konvencija MOR-a 135 (1971), Direktiva EU 2002/14/EC i Zakon o radu Republike Hrvatske naglašavaju odnosno izričito određuju da se poverenik bira u skladu s nacionalnim zakonodavstvom. Time je njegova uloga jača, uvažavanje veće i status sigurniji, što je uostalom osnova za radnopravnu zaštitu poverenika. Zakon o radu i Zakon o zaštiti na radu Republike Hrvatske uređuju radnopravnu zaštitu poverenika u skladu s univerzalnim i regionalnim (heteronomnim) propisima koji su na snazi u ovoj državi.

Poverenik je predstavnik radnika. Pored prava i obaveza koje ima kao i svaki drugi radnik u radnom odnosu, poverenik ima i posebna prava i obaveze, ali i posebnu zaštitu po tom osnovu i svojstvu. Poverenik zaslužuje delotvornu zaštitu od svakog, za njega, štetnog postupka.

Koliku važnost i ulogu poverenika radnika za zaštitu na radu daje zakonodavstvo Republike Hrvatske, svedoči posebna glava VI Zakona o zaštiti na radu *„VI. Povjerenik radnika za zaštitu na radu"* u odredbama člana 70 – 72, koje uređuju: izbor poverenika, prava i obaveze poverenika i zaštitu delovanja.

Odredbe su precizne „prave zakonske" jer ne ostavljaju dilemu o mestu i ulozi poverenika u zaštiti na radu. To se odnosi na: izbor poverenika koga mogu birati radnici između sebe (a to znači i ne moraju) na način propisan u članu 70. Zakona o zaštiti na radu a „ako je prema pisanim kriterijumima kod poslodavca izabrano više povjerenika, oni između sebe biraju svoga koordinatora" (član 70. st. 4.).

U odredbama člana 71. Zakona o zaštiti na radu Republike Hrvatske utvrđeno je da je poverenik obavezan „štititi interese radnika na području zaštite na radu te pratiti primjenu pravila, mjera, postupaka i aktivnosti zaštite na radu". U tom smislu prema stavu 2. toga člana „ima pravo" utvrđeno u 15 (petnaest) tačaka, s tim da se taj „popis" može proširiti kolektivnim ugovorom i sporazumom sklopljenim između poslodavca i radničkog veća.

Da bi poverenik mogao realizirati određena mu prava i obaveze, u odredbama članka 72. Zakona o zaštiti na radu propisana je njegova zaštita delovanja, koja se sastoji u obavezama poslodavca da povereniku osigura „uvjete za nesmetano obnašanje dužnosti"; zaštita od otkaza ugovora o radu i pravo na naknadu plaće za najmanje tri sata dnevno..." U drugim odredbama to je još detaljnije uređeno. Poslodavac čini prekršaj ako ne poštuje odredbe o zaštiti poverenika (članak 95. st. 1. t. 5 u vezi s člankom 72. Zakona o zaštiti na radu).

Poverenik je deo mehanizma u kome direktno i/ili indirektno deluju brojni subjekti: poslodavci, radnici, sindikat(i), radnička veća, ovlaštenici poslodavca, stručnjaci za zaštitu na radu, osobe ovlaštene za obavljanje poslova zaštite na radu, službe za zaštitu na radu, odbori za zaštitu na radu, posebno osetljive grupe radnika, izabrani specijalisti medicine rada, tela nadzora i drugi.

Njegova prava i obaveze su uređene heteronomnim i autonomnim normama u propisima različitog prostornog i vremenskog delovanja. To zahteva od poverenika da bude dobar i uzoran radnik, da poseduje stručne i druge radne sposobnosti, veštine i radne navike, poseban odnos prema radnicima, poslodavcu i njegovim sredstvima, radnoj okolini i celokupnoj delatnosti koju poslodavac obavlja. Polazeći od toga, autori ispravno zaključuju da poverenik mora stalno da uči, usavršava znanja, da prati savremene trendove zaštite na radu, poznaje propise, kontinuirano prati dokumentaciju poslodavca, sarađuje sa svim radnicima, ali i nadležnim inspekcijskim organima i drugim subjektima u sistemu zaštite na radu.

Prof. dr Marinko Učur
Prof. dr Vesna Nikolić


SEIBL TRADE
Odabir renomiranih svetskih proizvođača izdvaja Seibl Trade od drugih kompanija i čini osnovu za bolju produktivnost i zaštitu na radnom mestu
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Pulsafe obezbeđuje moderan i ergonomski dizajn za svaku vrstu primene koja zahteva zaštitu očiju i lica.
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Zahtevi zaštite na radu u industrijama mogu biti različiti i individualni koliko i same industrije. Iz tog razloga Centurion je i dizajnirao fleksibilnu liniju specijalizovanih zaštitnih šlemova.
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Willson i Fernez obezbeđuju rešenje za sva radna okruženja kompletnom gamom panorama–gas maski, polumaski, respiratora sadovodom vazduha, filtera i opreme za jednokratnu upotrebu.
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Bilsom antifoni i Howard Leight čepovi za uši su sinonim za tehnološke inovacije, fleksibilnost i nenadmašnu udobnost uz maksimalnu zaštitu.
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Perfect Fit ima najopsežniju ponudu zaštite za ruke: sečene i prošivene rukavice od kože ili tehničkog tekstila, pletene i premazane rukavice.
BACOU
Bacou, vodeća kompanija u razvoju jedinstvenih i inovativnih koncepata, nudi širok izbor ultra udobne obuće prilagođene delatnostima i inspirisane poslednjim modnim trendovima uz kombinaciju bezbednosti, udobnosti i stila.
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TWW
Mutexil i TWW odeća je dizajnirana da pruži radnicima moderan izgled koji odgovara današnjim standardima udobnosti i lakoće korišćenja i predstavlja savršen spoj stila, higijene i zaštite.
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Miller kao sinonim za bezbednost
Kao globalni lider na polju opreme za zaštitu od pada, Bacou–Dalloz već više od pedeset godina razvija rešenja kako bi učinio bezbednijim rad na visini.
Miller, kao najinovativnije priznato svetsko ime u zaštiti od pada, nudi širok izbor proizvoda koji poboljšavaju zaštitu, udobnost i performanse korisnika, i ohrabruju ga da koristi opremu 100% vremena u toku rada.
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TERMOVIZIJSKE KAMERE
Instrumenti za termovizijsku dijagnostiku

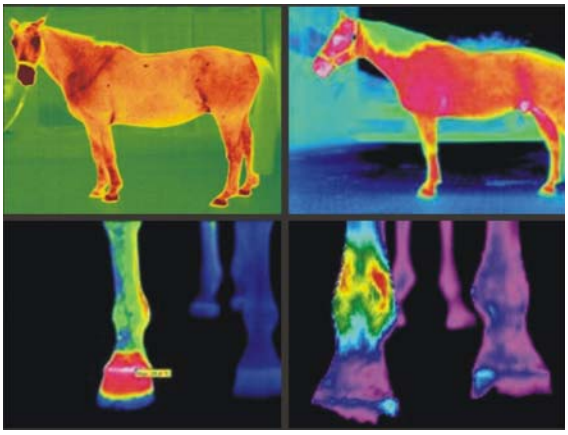
Termovizijska dijagnostika se koristi u tehničke i medicinske svrhe, a posebno je našla primenu u zaštiti i bezbednosnim sistemima. Termovizijske kamere omogućavaju da ljudsko oko sagleda ono što ne može da vidi. Svako telo emituje određenu količinu energije koja može da se registruje kamerom za termoviziju.
Na osnovu rezultata snimanja ili posmatranja kroz objektiv kamere, registruje se infracrveno ili toplotno zračenje i najnižeg stepena, a omogućava se izuzetno precizno merenje temperature bez ikakvog kontakta sa objektom čije se fizičke karakteristike mere. Na osnovu rezultata dobijenih testiranjem moguće je napraviti preciznu evaluaciju mehaničkih, termičkih, električnih i bioloških procesa. Informacije o struji, voltaži, otporu i energiji su dragoceni za adekvatno postavljanje električnih instalacija i njihovo puštanje u rad.
Kineska kompanija Wuhan Guide Infrared, koju na našem tržištu zastupa "Aleksandar Inženjering", godinama unapređuje tehnologiju registrovanja termalne, odnosno infracrvene energije. Termovizijske kamere "Wuhan Guide Infrared" su tehnološki superiorni proizvodi, visokih performansi i za životnu sredinu neškodljivi.

Za industriju
TP8 serija

EasIR Serija i EasIR-9

EasIR Serija je nova infracrvena kamera proizvođača Guide, koja pomera granice infracrvenog snimanja svojim odličnim karakteristikama i niskom cenom. Dizajnirana je za rad pod teškim radnim uslovima i za korisnike, koji ne moraju biti visoko obučeni, EasiR Serija je otporna na udarce i robus tna i pod najtežim radnim uslovima.

Za medicinu
Termovizijske kamere vrlo lako i precizno detektuju detektuju temperatune razlike pojedinih delova površine tela čoveka i životinja i mogu se koristiti u mnogim medicinskih granama kao u epidemiologiji, virusologiji, reumatologiji, hirurgiji, dijagnostici kancera, metaboličkih bolesti, vaskularnih promena, stomatologiji, kao i za otkrivanje različitih bolesti i pre nego što su doživeli punu kliničku sliku pa je značajna njena uloga u ranom otkrivanju i prevenciji.



Za zaštitu od požara, zaštitu radne i životne sredine
Protivpožarna ručna termička kamera IR1190 je opremljena sa detektorom ultravisoke rezolucije, što joj omogućuje prikazivanje slike besprekorne jasnoće, a time se pomaže vatrogascima da vide kroz oblake dima i da identifikuju moguće žrtve pre nego što do dođe do povrede, ili smrti

Napredna tehnologija infracrvenog merenja temperature vam pomaže da odredite tačan izvor vatre, a time da donesete tačnu i blagovremenu odluku, koja neće biti ugrožena od strane nepreciznosti merenja detektora. Na raspolaganju je i bežični prenos video informacija, kojim se može ostvariti slanje žive slike iz prve ruke u komandni centar, gde se onda mogu doneti brze i precizne odluke.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Шуме су одувек сматране националним благом сваке земље и једним од услова опстанка, па су чуване, неговане и обнављане, имајући у виду да су пожари највећи непријатељи шума, који могу да изазову пустош и еколошку штету, која је много већа од вредности изгореле дрвне масе


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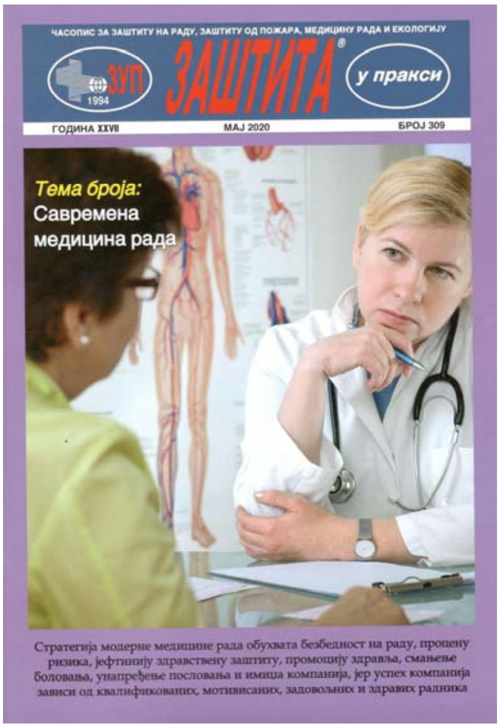
Тема броја:
Заштита од пожара
у условима ванредног стања
Систем заштите од пожара у условима ванредног стања је сложен и зависи од врсте опасности, интензитета опасности по људе, материјална добра или животну средину, а у условима епидемије само један заражени радник ватрогасне јединице може да угрози рад целокупне јединице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медицина рада
Стратегија модерне медицине рада обухвата безбедност на раду, процену ризика, јефтинију здравствену заштиту, промоцију здравља, смањење боловања, унапређење пословања и имиџа компанија, јер успех компанија зависи од квалификованих, мотивисаних, задовољних и здравих радника


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Тема броја:
Како сачувати здравље у условима
пандемије COVID-19
Свет рада је озбиљно погођен током пандемије COVID-19, те сви делови друштва, укључујући предузећа, послодавце и социјалне партнере, морају испунити своју улогу у циљу заштите радника, њихових породица и друштва у целини, применом мера које доноси струка и надлежни државни органи

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