8th International Professional and Scientific Conference

BOOK OF PROCEEDINGS

KARLOVAC UNIVERSITY OF APPLIED SCIENCES

ISSN 2975-3139

8th International Professional and Scientific Conference
"Occupational Safety and Health"
BOOK OF PROCEEDINGS

Karlovac University Of Applied Sciences

ISSN 2975-3139

Publisher: KARLOVAC UNIVERSITY OF APPLIED SCIENCES

For publisher: Ivan ŠTEDUL

Editor: Snježana KIRIN, Ivan ŠTEDUL, Marija BUBAŠ,

Graphics editor: Studio HS internet d.o.o.

8th International Professional and Scientific Conference
"OCCUPATIONAL SAFETY AND HEALTH"
September 21-24, 2022 • Zadar • Croatia

BOOK OF PROCEEDINGS

Karlovac, 2022.

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Foreword

This Book of Proceedings contains papers written for the 8th International Professional and Scientific Conference *Occupational Safety and Health* which was held 21-24 September 2022 in Zadar, Croatia. The Conference is organised by the Karlovac University of Applied Sciences in cooperation with Instituto Politécnico de Beja (Portugal), University of Niš, Faculty of Occupational Safety (Serbia) and International Slavic University G.R. Derzhavin (North Macedonia).

Exactly 16 years has passed since the first Conference was held in 2006. During these 16 years, each Conference, as well as this eighth one, gathered scientists and experts from Croatia and the world as well as occupational health specialists, representatives of chambers, unions and various companies, confirming the Conference's significance and serious approach to issues related to occupational safety and health.

This Book of Proceedings includes a total of 118 papers classified into invited papers (5) and 9 theme sections: Occupational Safety (9), Public Health (16), Technical-Technological Protection Factors (18), Ergonomics (16), Ecology (13), Personal Protective Equipment (7), Protection from Fire and Explosion (7), Social and Legal Aspects (17), Multidisciplinary Aspects (10). The papers, written by 235 authors, offer a diversified methodological and thematic approach which results from the particularity of individual scientific areas in the field of occupational safety and health.

The authors presented their papers orally or through poster sections, and two round tables were held in conjunction with the *Conference: Amendments to the Labour Act* and *Covid, Postcovid, Burnout and Mental Health.*

Finally, we would like to thank the sponsors of the Conference, supporters, authors and reviewers for their valuable contribution and elaborate work as well the Professional and Scientific Committee, Organisational Committee and all other participants who helped in organising this eighth Conference with their dedicated and responsible engagement.

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INVITED PAPERS

SUSTAINABILITY AND CIRCULARITY: CONTEMPORARY CHALLENGES CALLING FOR ENVIRONMENTAL PARADIGM SHIFT

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Abstract:

This abridged review of some of the principal anthropogenic challenges of our times, that pose various risks for human health and the environment, was composed in attempt to spark regional academic dialogue on the subject and to call for a new awareness. Some illustrative examples of contemporary technologies and issues that pose challenges to proclaimed concepts of sustainability and circular economy (i.e. nanomaterials, microplastics, electromagnetic radiation and climate change) are chosen from entire spectrum of modern environmental concerns. The current manner in which industrial societies process and use material and energy is not in accordance with proclaimed sustainability goals. A systematic, life cycle based assessment of the environmental risks of emerging technologies is needed since the progress of mankind more than ever relies on a web of interactions between the nature, man-made systems and the society.

Keywords: *Sustainability, Circular Economy, Nanotechnology, Microplastics, Climate Change*

1. INTRODUCTION

The transition to a sustainable and circular economy with fewer detrimental effects on the environment shall require new global and local economic policies in the near future, along with improved strategic analyses and management. The consequences of the currently prevailing model of production / consumption to the environment are perceivable and serious: depleted reserves of limited resources, pollution of environmental compartments, climate change and reduction of biodiversity. The necessity of change in character of consumption and production has been perceived in the most developed economies of the world, directions of action have been determined, goals set, and strategies for promotion circular economy institutionalized. From the standpoint of social benefit, it is primarily required to exclude from further sales, and then from further use, products and technologies that excessively consume energy and other resources, contain hazardous substances or release harmful emissions and effluents. The next logical

step is to establish the framework to support and promote the creation of energy efficient and environmentally friendly products and technologies. The properties of materials used, the possibilities of their secondary use/recycling and long term effects on the environment are considered integrally, via a systemic approach [1]. Significant parameters include energy consumption at the exploitation phase, environmental implications of the production processes and serviceable structures of durable consumer goods.

Sustainable development rely on three well known pillars (economic, societal and environmental), while novel technologies inevitably tackle three important aspects that decide on their wide applicability and future developments (i.e. safety issues, legislative support and public acceptance). Risk assessments and uncertainties are subject to scientific researches since both decision makers and consumers expect to derive conclusions according to the latest findings. Legislators strive to design contemporary regulations, while users are trying to learn how to make informed choice on the market based on trade-offs between advantages and consequences that new technologies bring about.

2. RESEARCH METHODOLOGY

This desktop-research based study combines publicly available data on the subject and several research that in-depth describe particular environmental issues and consequences of applying described technologies. Core trends and conclusions were derived from analysis-synthesis of scientific findings on various, sustainability related themes and disposed in the review with intention to highlight emerging threats to development of a stable, circular model of economy. General trend analysis was applied to reveal industry-related issues that should be tackled in order to prevent and hinder consequences of emerging and fast spreading technologies. While the most of the data analyzed reflect global trends, every single health, safety and/or environment related challenge mentioned might be scaled down to the regional or national level. While the threats mentioned are global phenomena, their detrimental effects are predominantly noticeable locally.

3. CONTEMPORARY CHALENGES AND TREATS TO ENVIRONMENTAL SAFETY

There is an ongoing debate what are principal anthropogenic challenges of our times that pose particular risks for human health and the environment. The following few are chosen arbitrary among the most pronounced ones, in attempt to call for a new awareness. The illustrative examples of contemporary technologies and issues that pose challenges to proclaimed concepts of sustainability and circular economy are chosen from entire spectrum of modern environmental concerns. There will inevitably be unintended consequences and new risks as technology advances. A

trade-off between knowing the impact of a given technology and the ease of influencing its social and innovation trajectories is widely known as The Collingridge dilemma: "When change is easy, the need for it cannot be foreseen; when the need for change is apparent, change has become expensive, difficult and time consuming." Because of the impossibility of foreseeing all consequences, interventions should be open to adjustment or “reversible, corrigible and flexible” [2]. Therefore, the concept of Life Cycle Thinking entails a holistic approach to the product, process or service under consideration and comprise inventory of all the inputs, outputs and impacts at each stage of the life cycle – raw materials extraction, material production, manufacturing, distribution, use and end-of-life treatment.

3.1. Overconsumption and resource depletion

Demand for resources is increasing worldwide, due to population growth and steadily improving living standard in developing world. World Business Council for Sustainable Development announced that by the year 2030, in the developing countries of today there will be 3 times more people capable to pursue ‘middle class’ consumption habits as we know them in contemporary developed world [3]. All predictions are that resource demand will continue to grow, given the underlying trends and population projections. A decade ago, it was argued that global demand for energy and water was expected to rise by 40 % over the next twenty years, if no major policy changes are implemented [4]. It is yet to be confirmed that this statement was grounded, but there are all reasons to expect the values predicted.

Urban centers absorb large amounts of materials extracted from natural deposits, due to overpopulation and urban sprawl. Increasing urban population causes huge growth in various sectors of economy such as housing, transportation, infrastructure, and consumption of industrial products. Cities were envisioned as future deposits of mineral resources years ago [5], while extraction of these resources hidden in urban settlements, named urban mining, is now considered to be the backbone of the concept of circular economy. Urban deposits consist of materials accumulated in society, contained in products and infrastructure [6].

The quality of life, being a broad category, also depends on environmental impacts of omnipresent industrial products, services and processes, all of which should be designed in a sustainable manner by environmentally conscious engineers and decision makers. It has been proven many times that preserving the environment equals investing in the future. Therefore, environmentally conscious, prosperous companies and their decision makers should be actively engaged in raising public awareness on environmental issues. Unless modern consumers are educated to make informed choice on the market, and to understand the complex, interconnected environmental and developmental issues that face the modern societies, sustainability concept would hardly prevail.

3.2. Nanotechnology

Nanomaterials are an illustrative example of contemporary technologies that are steadily being used in numerous innovative approaches, such as renewable energy sources of increased efficiency, water and soil remediation methods, remote sensing and pollution detection techniques, targeted drug delivery, antibacterial protection, and many more. Those materials are being applied in so many products because of their large surface-to volume ratio and specific features that make them extremely reactive [7]. There is a wide range of applications for nanomaterials: electronics (thin batteries) [8], energy (solar panels) [9], medical equipment (imaging) [10], cosmetics (sunscreens) [11], and others.

Nano based products are supposed to deliver a lot of benefits to mankind, and there is a proven potential for advancements in environmental protection by decreasing energy consumption and the use of raw materials, thus reducing waste and greenhouse gas (GHG) emissions. For instance, nano-coatings are dirt repellent, which contribute to reducing water pollution and consumption. Nanocomposites increase the durability of structural components and at the same time reduce the weight of vehicles, thus decreasing their fuel consumption. However, some authors sent an early warning that potential of nanotechnology to support sustainable development is somewhat debatable [12], because the related environmental impacts from manufacturing such materials may overrule benefits of using nano based items. It is confirmed that nanomaterial manufacturing usually requires vast amounts of energy, as well as substantial amounts of water, and environmentally damaging chemicals [13]. It was estimated that anthropogenic nanomaterials already represent a significant portion of the industrial material flow, and it is high time for appreciation of their environmental impacts. However, still there are numerous uncertainties and lack of information on nanomaterials manufacturing and emission rates, as it was noticed more than decade ago [14]. Keller and colleagues [15], tried to estimate the global life cycle emissions of ENM (during the production, usage, and disposal phases) for ten most produced ENMs by mass, and it was estimated that 63–91% of over 260,000-309,000 metric tons of global ENM production (in 2010) ended up in landfills, while the rest was released into soils (8–28%), water (0.4–7%), and the atmosphere (0.1–1.5%).

Carbon nanotubes, as well as nano fractions of ZnO and TiO_2 were found to exhibit cytotoxicity to mice [16], nanosilver and quantum dots seem to be toxic as well [17] while fullerene was found toxic to both fish and humans [18]. The size of nanoparticles can have major toxicological effects since they could possibly enter human cells [19]. Apparently, nanoparticles might be harmful because of reactions at a cellular level, because of their similarity in shape and size to asbestos [20]. The mechanisms of nanotoxicity are debated, but growing evidence indicates that nanomaterials are getting into aquatic systems where algae, bacteria and fish and are exposed to them, as well as, consequently, human population.

Nevertheless, toxicity is only one among drawbacks of nanomaterials. Production process to obtain nanomaterials still requires great amounts of energy, water and environmentally problematic solvents. It was published that the total

energy demand for one kilogram of carbon nanotubes is between 0.1 to 1TJ of energy, which ranks them among the most energy intensive materials known so far [21].

Very serious problem is the fact that in most of the countries worldwide the content of nanomaterials in everyday products remain unnoticed. The first European inventory of nano-claimed consumer goods was created in 2009 by the European Consumers Organization [22], followed by the Danish Ecological Council that in 2012 formed so called Nanodatabase a searchable, updatable inventory of products with nano-content in the EU market [23]. Every product in the Nanodatabase was given a short description of the nano-content, and a color code that represent occupational and environmental exposure, as well as hazards for humans and the environment.

Nanoparticles should be designed or chosen from multitude so that they don't pose a risk for the environment or human health. Modifying the structure of a nanomaterial it is possible to change the mode of their interaction with the physical or biological surrounding, in terms of their reactivity, and toxicity. Various ENMs might be improved by environmentally responsible lifecycle engineering [24]. Further research are needed to understand how the ENM structure influences their properties and behavior, so that environmentally benign functionalities might prevail.

3.3. Plastics in the Environment

Plastics is among the most abundant man-made materials, preceded only by concrete and steel [25]. It is estimated that about 70 % of the total amount of plastics produced have become waste, of which 84 % has been disposed of in landfills or elsewhere in the environment [26]. One of the fundamental challenges for applying the concept of circular economy is the persistent plastic pollution that cause economic and environmental costs to society. These issues require a comprehensive, systemic change in which R&D supported by policymaking has a crucial role.

There is no commonly accepted definition of plastic waste. The term plastic comprises all synthetic polymers including the major commodities of a kind such as PET, PE, PP, PS, or PVC [27]. According to the Dutch National Institute for Public Health and the Environment, environmental plastics are solid, insoluble and non-degradable materials that contain synthetic polymers, and that are found in natural environments without fulfilling an intended function [28]. Plastics in the environment is often classified by size: nanoplastics (< 1 μm), microplastics (< 5 mm), mesoplastics (< 2.5 cm), macroplastics (< 1 m), and megaplastics (> 1 m) [29]. A research on plastic waste indicated that rivers transport between 0.41 and 4 million tonnes of plastics yearly to the oceans, whereof ten rivers in Africa and Asia transport 88-95 % [30].

Plastic pollution should be observed by a life-cycle approach. In production phase and transportation, plastics can be lost due to improper handling. Some studies indicate that plastic emissions due to spills from manufacturing can be substantial

[31]. During the use phase, plastic-based products and materials can be released into the environment accidentally or after usage, such as microplastics that originates from wash-off cosmetics. Significant quantities come from littering due to inefficient collection or inadequate disposal [32], while degradation and wear during use (e.g. synthetic fibres from clothing) can also generate plastic fragments [33]. However, the distribution and impacts of plastics in the environment are yet to be understood, while knowledge of the degradation of plastics in different environments remains limited [34].

The annual release of microplastics into EU environment is estimated between 75 000 and 300 000 tonnes. However, terrestrial and atmospheric transport or deposition of microplastics in the environment is still subject of scientific investigations. A study report an atmospheric fallout of 29-280 particles per m2 daily, resulting in an annual deposition of 6-17 tonnes of fibres in an EU metropolitan area [35]. Microplastics were also found in beach sediments in 13 European countries with concentrations spanning from 72 to 1512 items per kg with higher levels found in the Eastern Mediterranean and Baltic [36].

Macroplastics, microplastics and nanoplastics, physically and chemically interact with biota. While external exposure to macroplastics is often easily observable, ingestion of microplastics can be demonstrated only experimentally for different species. Ingestion can result in reduced mobility, reduced energy intake, injuries, and associated infections [37]. It seems that ingestion does not represent a toxicological hazard per se, but it is assumed that ingested microplastics may reduce the food intake and in extreme cases block the digestive system. However, it seems that nanoplastics may pass biological barriers and enter tissues or cells. A study on Blue mussels confirmed that microplastics were translocated to tissues causing inflammatory response [38]. European Food Safety Authority (EFSA) concluded that it is currently not possible to evaluate the human health risk of nanoplastics and microplastics [39]. However, a study in mice, revealed that microplastics of 5 and 20 µm were distributed in tissues inducing metabolic changes or oxidative stress [40].

It has been estimated that 95 % of the material value in plastic packaging sector is lost annually due to a typical short use cycle [41]. The loss is explained by the low global recycling rates (14 %) and value loss during the collection, sorting and recycling processes, where merely 5 % of plastic packaging material value being retained. While PET is probably the most effectively recycled plastic material, only 7 % is recycled bottle-to-bottle. The same study indicates that merely 2 % of plastic packaging is being recycled in a closed loop that retains adequate quality, 40 % is landfilled and 32 % leaks into the environment.

There are significant knowledge gaps on the human and environmental health impacts of microplastics and nanoplastics, which hinder effective risk assessment and management [42]. The information is needed on the types of exposure sources and routes, hazard characterisation, as well as levels of exposure for humans and the environment [39]. One of the major challenges is the heterogenity of physico-chemical properties of plastics, since the key properties driving the toxicity (such as size range or shape) are still under investigation. It is also unknown which habitats

or species are the most vulnerable, since the impacts of plastics on them could be different to findings from research on animal models.

Bio-based feedstock has the potential as a renewable platform for plastics. However, to realize the full potential of prospective bio-refineries and to valorize the variety of biological feedstock Europe wide, systems thinking is needed. Material innovation is of utmost importance, but a circular economy concept requires new approaches, novel business models, and improved product designs. Ecodesign and product-service systems have the potential to alter the current linear production and consumption paradigm through reuse at various levels of the waste hierarchy. However, most design innovation are still focused on introducing a new materials, instead of taking the systemic approach toward a circular pathway in the background structure. Improvements are usually driven by technical innovations, including automated sorting, and innovative chemical recycling methods aimed to obtain virgin-grade plastics. Also, the use of compostable materials could allow organic recycling of bio-waste. Nevertheless, all the recycling options are confronted with challenges in terms of economic viability, technology availability, necessary infrastructure, regulations, and environmental issues. It has been noticed that the performance and added value of all after-use solutions predominantly depend on the design and material choice of plastic products available on the market – a conclusion that underlines the importance of design for environment. However, in circular economy framework, business model redesign is of crucial importance to prevent plastic products from becoming waste at the first place.

3.4. Electromagnetic Radiation in Working and Natural Environment

The exponential increase in number of telecommunication devices, cell phones and related infrastructure worldwide has caused increase in sources of electromagnetic fields in urban areas and the environment alike. Several recent studies were devoted to the effects of electromagnetic radiation of telecommunication devices to human and environmental health. Although most of these studies were conducted on models under controlled, laboratory conditions [43] [44], current evidence strongly indicates that both humans and insects may be adversely affected by emitters of electromagnetic radiation.

Stankovic et al. [43] performed the numerical analysis of Specific Absorption Rate (SAR) and temperature distribution within a child head model exposed to cell phone radiation at the frequency of 900MHz, and shown various biological tissues under exposure to the electromagnetic radiation. They confirmed that the maximum absorption of electromagnetic energy was in the surface layers of the model, although the value was greater than the maximum allowed one, as defined by standards. Temperature expectedly decreased with the distance from radiation source, however more slowly than SAR values. It was also concluded that electric field strength from a mobile phone was higher than specified by standards for the maximum allowable exposure limits.

Jovanovic [44] investigated the electric field distribution and the amount of absorbed energy within teeth, in the presence of orthodontic brace exposed to the electromagnetic radiation from mobile phone. According to the results reported, the maximum value of electric field was 4.5 times higher in the presence of orthodontic brace than without it. It was concluded that the increase in the amount of absorbed energy in the presence of orthodontic brace is not negligible.

Lázaro et al. [45] studied the effects of EMR on wild pollinators, such as wild bees and wasps, by measuring EMR at various distances from telecommunication antennas on Greek islands of eastern Mediterranean, and combining values obtained with data on insect abundance. It has been found that all pollinators were affected by EMR one way or another. As EMR harmfully affected the abundance and navigation of these species that perform crucially important ecosystem services in their natural habitats, the concerns were raised that the phenomenon could also have far reaching ecological and economic consequences on plant biodiversity and production of crops.

While exposure to electromagnetic radiation seems to be both increasing and unavoidable in the foreseeable future, there is a scientifically grounded expectation that research based technology advancement might mitigate risks by increasing energy efficiency, adjusting frequency range and power outputs of devices to acceptable levels.

3.5. Climate Change and GHG Emissions

The effects of climate change are potentially far reaching and go well beyond obvious environmental disturbances. Climate-related issues pose social, economic and health risks for entire communities. Climate change is among principal issues recognized in the framework of disaster risk reduction (DRR), and therefore it should not be neglected when planning risk mitigation measures [46]. It is attributed mainly to man-made greenhouse gases (GHG) emissions, so technology optimists expect that so called green development might revers the trends observed. However, it is quite clear by now that only comprehensive societal changes supported by appropriate legislation, different consumption patterns, as well as mitigation and adaptation measures might provide desired results when combined with emerging technologies. Climate-related hazards have been studied for almost a decade now [47]. Previously, climate related problems were recognized as a, so called, creeping environmental change that trigger certain level of crisis only when a critical threshold has been exceeded [48]. Therefore, it is considered that still there is a lag, although very uncertain, for managing climate change risks-related activities. However, negligence or postponed action of decision makers at various levels (operative or strategic) can have possibly severe and costly consequences [49]. For instance, climate-related disasters such as rising temperatures and disturbances in the precipitation patterns are becoming more frequent and damaging in the South East Europe and Balkans. It has been noticed that the region is being confronted with more frequent droughts and floods that jeopardize crucial sectors of economy, such as energy, agriculture, forestry and tourism [50]. Trend analyses indicate that

the entire region, since the middle of the XX century, experienced increased values of average annual temperatures, with more intensive heatwaves and interchangeable deficit and extreme increase in rainfall [51].

The climate change analyses for South East Europe - Balkans, according to the Representative Concentration Pathways (RCPs) described in IPCC Assessment Report Five (AR5), anticipated continuation of the previously observed temperature rise trends [51]. The finding from IPCC Assessment Report Six (AR6) are yet to be analyzed for the region, but there are all reasons to expect similar development. RPCs predicted 4 principal developments based on different assumptions about energy sources and consumption, land occupancy, economic and population growth. They depicted potential paths for the carbon-dioxide emissions and consequential atmospheric concentration over the century. The RCP scenarios comprised: (1) high emissions scenario (RCP8.5) based on energy-intensive society, continuous GHG emissions, population growth, and a slowed technology development; (2) two different intermediate scenarios (RCP4.5/RCP6) that envisage moderate population and growth rate, improved reforestation, diversified energy sources, and stabilized GHG emissions by mid XXI century; and (3) mitigation scenario (RCP2.6), the most optimistic in terms of energy intensity and consequences [52]. For AR6, new input sets, so called Shared Socio-Economic Pathways (SSPs) were used. Five SSP scenarios (i.e. SSP1–1.9, SSP1–2.6, SSP2–4.5, 11SSP3– 7.0, and SSP5–8.5) were selected [53]. The SSPs were nicknamed after societal effects they describe: SSP1 - Sustainability (Taking the Green Road); SSP2 - Middle of the road, SSP3: Regional rivalry (A Rocky Road); SSP4 - Inequality (A Road Divided); SSP5 - Fossil-Fueled Development (Taking the Highway) [54]

Various climate change scenarios are being regularly applied in assessments of socio-economic vulnerability at various spatial levels. In general, most of the relevant projections predict rise of the temperature and more frequent or longer drought periods in the future. Consequently, it is expected more wildfires and similar events to occur. Climate change will cause obstacles in services and structure of natural ecosystems, their capacities to sequestrate carbon and produce biomass, and thus their ability to mitigate their effects. There are studies that anticipate number of wildfires in the Balkans to increase more than threefold as the consequence [55]. Obviously, afforestation and conservation of existing forests should be the main strategies in attempt to increase capacities for bio-sequestration of carbon-dioxide. However, there are great expectations that carbon footprint accounting and related product and process redesign would contribute to decrease in anthropogenic greenhouse emissions. Meanwhile, adaptive capacity of communities and local / regional economies must be strengthen through various strategies and comprehensive measures.

4. CONCLUSION

Sustainability and circularity are a shared responsibility of designers and consumers alike. Every responsible industry should demonstrate concern that extends beyond manufacturing products, all the way to the natural environment and further to sustainable development related issues. Modern engineers should possess knowledge rather than just skills, to become an effective part of the industrial shift toward sustainability and circular economy. Technology related skills are clearly important, but they must be accompanied with awareness of ethical and environmental issues. On other hand, contemporary environmental management should go well beyond pollution prevention, site remediation, waste treatment and simply applying procedures prescribed by standards. There is a need for appropriate design that will result in well-thought-out technologies and related products that operate in an environmentally friendly manner. The ability to predict and understand environmental impact of a technology is the key to success. The highest degree of creativity and innovative ability, combined with technological expertise, is required to continue this process of change toward reducing, recycling, and reusing. A strategy for achieving environmental friendliness of products is necessary in order to meet ever stringent legislative requirements, maintain competitive advantage on the market, and mitigate pollution and resource depletion.

REFERENCES

[1] Glisovic, S.: *Sustainable Design and the Environment*, (in Serbian) Faculty of Occupational Safety, ISBN 978-86-6093-075-2, Nis (2017).
[2] Collingridge, D.: *The Social Control of Technology*, Palgrave Macmillan, ISBN 978-0312731687, London (1981)
[3] Carreño S. F.; Harel T.; Macario C. Vision 2050: The new agenda for business. World Business Council for Sustainable Development *Available from* https://www.wbcsd.org/contentwbc/download/1766/22050/1 *Accessed:* 2021-05-14.
[4] EU Commission. *Roadmap to a resource efficient Europe*. *Available from* https://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm *Accessed:* 2021-06-12.
[5] Jacobs, J.:*The death and life of great American cities*, R. House, ISBN 978-0679741954, New York (1961)
[6] Medkova K.: Urban Mines – The Mines of Circular Economy, *Proceedings of the Conference Smart Cities in Smart Regions*, Anna Aalto & Laura Montonen (Eds.), p.p. 2342-7507, ISBN 978-951-827-264-2, Lahti, May 2016, University of Applied Sciences, Lahti (2016)
[7] Felekis T.A. & Katsaros N.: Environment and nanotechnology: a promising challenge. *Journal of Environmental Protection and Ecology* 10 (2009) No 4, pp. 1146–1154, ISSN 13115065

[8] Hu Y, & Sun X.: Flexible rechargeable lithium ion batteries: advances and challenges in materials and process technologies. *Journal of Materials Chemistry A,* 2 (2014) No. 28, pp 10712-10738, ISSN 2050-7496
[9] Kim T.K.: Tandem structured spectrally selective coating layer of copper oxide nanowires combined with cobalt oxide nanoparticles, *Nano Energy*, 11 (2015), pp. 247-259, ISSN: 2211-2855
[10] Lehner R, Wang X, Marsch S, Hunziker P.: Intelligent nanomaterials for medicine: Carrier platforms and targeting strategies in the context of clinical application. *Nanomedicine: Nanotechnology, Biology and Medicine,* 9 (2013), pp 742-757, ISSN 1549-9634
[11] Yoshida T, Yoshioka Y, Tsutsumi Y. The Safety Assessment of Nanomaterials for Development of Nano-cosmetics. *Yakugaku Zasshi,* 132 (2012) 11, pp. 1231-123, ISSN 0031-6903
[12] Nentwich M, and Greßler S.: Nano and the environment - part I: Potential environmental benefits and sustainability effects. NanoTrust - Dossier No. 026, *Available from* http://epub.oeaw.ac.at/ita/nanotrustdossiers/dossier026en.pdf *Accessed:* 2022-05-12.
[13] Dhingra R, Naidu S, Upreti G, Sawhney R.: Sustainable Nanotechnology: Through Green Methods and Life-Cycle Thinking. *Sustainability,* 2 (2010), pp. 3323-3338, ISSN 2071-1050
[14] Hendren, C.O.; Mesnard, X.; Droge, J.; Wiesner, M.R.: Estimating Production Data for Five Engineered Nanomaterials as a Basis for Exposure Assessment. *Environmental Science and Technology,* 45 (2011), pp. 2562–2569, ISSN 0013-936X
[15] Keller AA, McFerran S, Lazareva A.: Global lifecycle releases of engineered nanomaterials. *Journal of Nanoparticle Research,* 15 (2013), pp. 1692-1699, ISSN 1388-0764
[16] Xia T.; Kovochich M.; Liong K.: Comparison of the Mechanism of Toxicity of zinc oxide and cerium oxide nanoparticles based on dissolution and oxidative stress properties. *ACS Nano,* 2 (2012) No. 10, pp. 2121-2134, ISSN: 1936-0851
[17] Benn TM, Westerhoff P. Nanoparticle Silver Released into Water from Commercially Available Sock Fabrics. *Environmental Science and Technology,* 42 (2008) 11, pp. 4133 - 4145, ISSN 0013-936X
[18] Wiesner MR, Hotze EM, Brant JA, Espinasse B Nanomaterials as possible contaminants: the fullerene example. *Water Science and Technology* 57 (2008) 3, pp. 305-310, ISSN 0273-1223
[19] Krug HF, Wick P.: Nanotoxicology: an interdisciplinary challenge. *Angewandte Chemie International Edition,* 50 (2011) 6, pp. 1260–1278, ISSN 1433-7851
[20] Musee N, Brent AC, Ashton PJ. A South African research agenda to investigate the potential environmental, health and safety risks of nanotechnology, *South African Journal of Science,* 106 (2010) No. 159, pp. 22-28, eISSN 1996-7489
[21] Gutowski T.G.; Liow J.H.; Sekulic D.P.: Minimum Exergy Requirements for the Manufacturing of Carbon Nanotubes, *Proceedings of the 2010 IEEE International Symposium on Sustainable Systems and Technologies*, pp 1-6, doi: 10.1109/ISSST.2010.5507687, May 2010, IEEE, Washington D.C. (2010)

[22] Hansen, S. F.; Heggelund L. R.; Besora P. R.; Mackevica A.; Boldrin A. & Baun A. Nanoproducts – what is actually available to European consumers?. *Environmental Science: Nano*, 3 (2016) 1, pp. 169-180, ISSN 2051-8161
[23] Hansen S. F.; Lone Mikkelsen L.; Jørgensen C.: The Nanodatabase, The Danish Consumer Council, *Available from* http://nanodb.dk. *Accessed:* 2021-08-14
[24] Glisovic S.: Life Cycle Modelling, In *Life Cycle Analysis of Nanoparticles: Risk, Assessment, and Sustainability*. Vaseashta, A. (Ed.), DEStech Publications, ISBN 978-1-60595-023-5, Lancaster, PA, (2015), pp. 55-95.
[25] Plastics Europe. *Plastics – the Facts 2017*. *Available from* https://plasticseurope.org/wp-content/uploads/2021/10/2017-Plastics-the-facts.pdf *Accessed:* 2021-09-12
[26] Geyer, R., Jambeck, J. R. & Law, K. L.: Plastics. Production, use and fate of all plastics ever made. *Science Advances* 3 (2017), pp. 1-5, eISSN 2375-2548
[27] ISO 472. Plastics - Vocabulary. Vol. 472 (2013).
[28] Verschoor, A. J. *Towards a definition of microplastics - Considerations for the specification of physico-chemical properties*. National Institute for Public Health and the Environment, (2015) pp 41-42, *Available from Available from* https://www.rivm.nl/bibliotheek/rapporten/2015-0116.pdf, *Accessed:* 2021-10-05
[29] Kershaw, P.J., and Rochman, C.M., Sources, fate and effects of microplastics in the marine environment: part two of a global assessment. Gesamp (2016) No. 93, *Available from* http://gesamp.org *Accessed:* 2022-07-27.
[30] Schmidt, C., Krauth, T. & Wagner, S.: Export of plastic debris by rivers into the sea. *Environmental Science and Technology*, 51 (2017) 21, ISSN 0013-936X
[31] Karlsson, T. M., Arneborg, L., Brostrom, G., Almroth, B. C., Gipperth, L. & Hassellov, M.: The unaccountability case of plastic pellet pollution. *Marine Pollution Bulletin* 129 (2018), pp. 52-60, ISSN 0025-326X
[32] Wagner, T. P. & Broaddus, N.: The generation and cost of litter resulting from the curbside collection of recycling. *Waste Management*, 50 (2016), pp. 3-9, ISSN 0956-053X
[33] Wagner, S., Huffer, T., Klockner, P., Wehrhahn, M., Hofmann, T. & Reemtsma, T.: Tire wear particles in the aquatic environment - A review on generation, analysis, occurrence, fate and effects. *Water Resources*, 139 (2018), pp. 83-100, ISSN 0043-1354
[34] Jahnke, A., Arp, H. P., Escher, B. I., Gewert, B., Gorokhova, E., Kuhnel, D., MacLeod, M.: Reducing uncertainty and confronting ignorance about the possible impacts of weathering plastic in the marine environment, *Environmental Science and Technology Letters*, 4 (2017) 3, pp. 85-90, ISSN 2328-8930
[35] Dris, R., Gasperi, J., Saad, M., Mirande, C. & Tassin, B.: Synthetic fibers in atmospheric fallout: A source of microplastics in the environment, *Marine Pollution Bulletin*, (2016) 104, (1-2), 290-3, ISSN 0025-326X
[36] Lots, F. A., Behrens, P., Vijver, M. G., Horton, A. A. & Bosker, T. A large-scale investigation of microplastic contamination: Abundance and characteristics of microplastics in European beach sediment. *Marine Pollution Bulletin*, 123 (2017) 1-2, pp. 219-231, ISSN 0025-326X

[37] Kuhn, S., Bravo Rebolledo, E. L. & van Franeker, J. A.: Deleterious effects of litter on marine life. *Marine Anthropogenic Litter*, (2015), pp. 75-116, ISSN 978-3-319-37653-0
[38] von Moos, N., Burkhardt-Holm, P. & Kohler, A. Uptake and effects of microplastics on cells and tissue of the blue mussel Mytilus edulis L. after an experimental exposure. *Environ Science and Technology*, 46 (2012) 20, 11327-35. ISSN 0013-936X
[39] European Food Safety Authority CONTAM Panel, Statement on the presence of microplastics and nanoplastics in food, with particular focus on seafood. *EFSA Journal*, 14 (2016) 6, pp. 30-41, ISSN1831-4732
[40] Deng, Y., Zhang, Y., Lemos, B. & Ren, H. Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure. *Scientific Reports*, 7 (2017), pp. 46687-4699, ISSN 2045-2322
[41] Ellen MacArthur Foundation. New Plastics Economy. *Available from* https://newplasticseconomy.org *Accessed:* 2022-07-27.
[42] Rist, C., Almroth, B., Hartmann, N. B. & Karlsson, T. M.: A critical perspective on early communications concerning human health aspects of microplastics. *Science of Total Environment*, (2018) 626, 720-726, ISSN 0048-9697
[43] Stanković V., Jovanović D., Krstić D., Marković V., Cvetković N.: Temperature distribution and specific absorption rate inside a child's head, *International Journal of Heat and Mass Transfer*, 104 (2017), pp. 559-565, ISSN: 0017-9310
[44] Jovanović D., Krasić D., Stanković V., Cvetković N., Vučković D.: Electric Field and SAR Distribution in the Vicinity of Orthodontic Brace Exposed to the Cell Phone Radiation, *ACES Journal*, 34 (2019) 12, pp. 1904-1914, ISSN 1054-4887.
[45] Lázaro, A., Chroni, A., Tscheulin, T.: Electromagnetic radiation of mobile telecommunication antennas affects the abundance and composition of wild pollinators. *Journal of Insect Conservation* 20 (2016), pp. 315–324, ISSN 1366-638X
[46] Bendito, A. & Barrios E.: Convergent agency: Encouraging transdisciplinary approaches for effective climate change adaptation and disaster risk reduction. *International Journal of Disaster Risk Science,* 7 (2016) 4, pp. 430–435. ISSN 20950055
[47] Kelman, I., Gaillard J.C. & Mercer J.: Climate change's role in disaster risk reduction's future: Beyond vulnerability and resilience, *International Journal of Disaster Risk Science* 6 (2015) 1, pp. 21–27, ISSN 20950055
[48] Glantz, M.H.: Creeping environmental problems. The World & I, *Available from* www.ilankelman.org/glantz/Glantz1994TWAI.pdf *Accessed:* 2021-05-01.
[49] Dittricha, R.; Butler A.; Ball T.; Wreford, A. & Moran D.: Making real options analysis more accessible for climate change adaptation. An application to afforestation as a flood management measure in the Scottish Borders. *Journal of Environmental Management* 245 (2019), pp. 338–347, ISSN: 0301-4797
[50] Hughes G.: *Climate change in the West Balkans*. ENVSEC and Zoi Environment Network. ISBN: 978-2-940490-06-6, Chatelaine, Switzerland: (2012)

[51] Bozanic, D. & Mitrovic, Đ.: Study on the socio-economic aspects of climate change in the Republic of Serbia, UNDP, *Available from* https://www.undp.org/sites/g/files/zskgke326/files/migration/rs/Draft-Study-on-Socio-economic-aspects-of-climate-change-in-Serbia.pdf *Accessed:* 2022-05-05
[52] van Vuuren: The representative concentration pathways: An overview. *Climatic Change* 109 (2011) 1–2, pp. 5–31, ISSN 0165-0009
[53] Pörtner, H.O. et al: Climate Change 2022: Impacts, Adaptation, and Vulnerability. *Contribution of WG II to the Sixth Assessment Report of the IPCC*. Cambridge University Press.
[54] Riahi, K.: The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview, *Global Environmental Change*. 42 (2017), pp. 153–168, ISSN 0959-3780
[55] Khabarov, N.; Krasovskii A.; Obersteiner M.; Swart R.; Dosio A.; San-Miguel-Ayanz J.; Durrant T.; Camia A. & Migliavacca M.: Forest fires and adaptation options in Europe. *Regional Environmental Change* 16 (2016) 1, pp. 21–30, ISSN 1436-3798

WORK CHARACTERISTICS IN GARMENT MANUFACTURING AND ANALYSIS OF WORKLOAD

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Abstract: *In the technological processes of garment manufacturing, workers are often stressed and tiered out by working in unfavourable working postures involving repetitive work tasks requiring a high degree of motor coordination of the body, hands and legs, as well as by forced postures of the body and head resulting from the unfavourable dimensions of the working space, unfavourable working methods and unfavourable conditions of the working environment. The paper provides a summary of the characteristics of work in clothing production processes, the causes of worker workload as well as the consequences that come up as a result of the workload, and how they affect worker health and work productivity. Moreover, the methods for determining and analysing the workload of workers in garment production and the results of the investigations carried out in real production systems are presented.*

Keywords *clothing production processes, work characteristics, workload, methods for workload analysis*

1. INTRODUCTION

Production processes in the garment industry are seen as small production series of garments with a large number of sizes, colours and patterns, and the difficulties in organising work indicate the need for workers who must have the necessary knowledge and skills to carry out demanding technological operations. In the technological processes of garment production, work is organised on the basis of a large number of technological production operations that depend on the type of garment, the use of appropriate machines and tools and interphase transport.

In the processes of garment production, the technological process of sewing is the most important phase and at the same time accounts on average for up to 70 % of the total production time of garment, while the technological processes of cutting and finishing the garment are significantly less represented at around 30 % [1].

Work in garment manufacturing processes is very complex and requires a high level of responsibility in terms of quality, accurate and appropriately timed execution of work tasks, as well as significant psychophysical commitment from workers.

Work in the technological process of cutting is carried out in a standing posture and the worker uses the trunk and upper limbs to handle the material and/or the machine during the technological cutting operations. The work requires coordinated use of the upper and lower limbs and a high degree of visual concentration. During work, there is often a conditionally unfavourable body and head posture due to standing and loading of the hands and fingers [2]. In the sewing process, the work is performed in a sitting posture and during sewing the worker uses the trunk and upper limbs to perform machine-hand and auxiliary hand suboperations and the feet to achieve the required sewing speed of the sewing machine in machine-hand sewing suboperations. In the technological processes of finishing, the work is carried out on some places in a sitting posture and in other places in a standing posture. Work in a standing posture is carried out in the technological operations of final garment ironing, where the worker handles the product while pressing the pedal with the foot to activate the ironing machine, followed by automatic ironing [3].

At all stages of the garment manufacturing process, the worker handles the workpiece, which is characterised by extreme flexibility, requiring exceptional motor skills on the part of the worker, manifested in the mobility of the fingers, hands and arms, as well as a good sense of tactile sensitivity.

For successful work and the achievement of high productivity in the processes of garment production, it is necessary to achieve harmony between the man-machine-environment relationship, which is achieved through the best design of the workplace according to ergonomic laws and through the development of a favourable working method with connected time norms that enable a favourable structure of technological operation and reduce the psychophysical stress on workers.

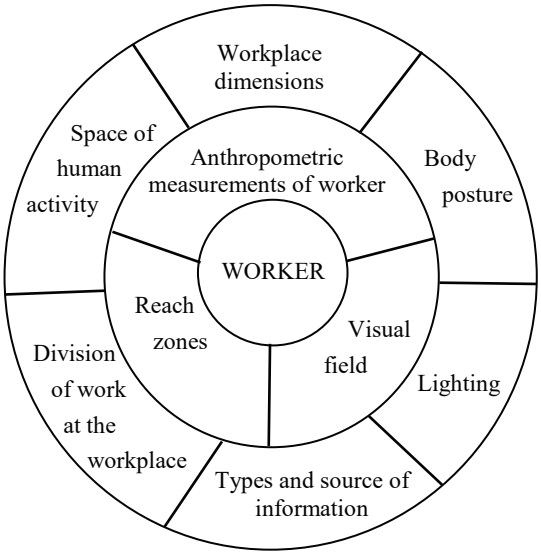


Figure 1: Interaction of the man-machine-environment system [4]

For the proper design of the workplace in the man-machine-environment system and an efficient execution of work, the overall system must be adapted to the human being, as he or she is an integral part of the system because of the execution of the work task and personal abilities (Fig. 1) [4]. When designing a workplace, the anthropometric measurements of the worker and the working reach and visual zones are important. The body posture at work, the dimensions of the workplace, the division of labour and the parameters of the working environment (temperature, humidity, particles in the air, noise, lighting, vibrations, etc.) are also important.

2. ERGONOMIC ANALYSIS OF WORK IN GARMENT MANUFACTURING PROCESSES

In the technological process of cutting the workers work in a standing posture with increased flexion of trunk and head with an angle of curvature of the lumbar part of the spine between 15° and 30° and an angle of curvature of the head greater than 30°. In the technological process of sewing, the work is carried out in a sitting posture, with the worker using the trunk and upper limbs to handle the workpieces during sewing and the feet to regulate the sewing machine stitch speed. This work requires a repetitive and coordinated use of the body, upper and lower limbs and a high degree of visual concentration. This often leads to a conditional forced posture of the body (>15°) and head (>30°), the occurrence of non-physiological sitting, isometric loading of the lower limbs and considerable loading of the wrists and

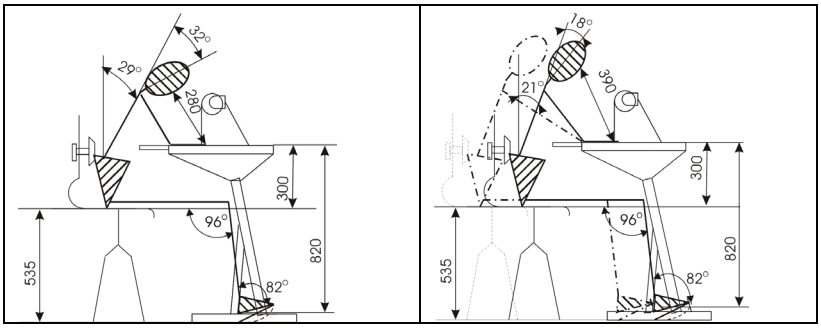
hands [5-7]. In the technological process of finishing, where the work is carried out in a standing posture, there are forced postures of the body and the head when carrying out technological ironing operations, load on the hands due to the repeated handling of the workpiece and load on the legs due to the activation of the machine by pressing the foot on the pedal of the machine. The values of the angle of curvature of the cervical and lumbar parts of the spine are different for each worker, which indicates that they depend on the type and method of performing the technological operation as well as the duration of work during working hours.

In garment manufacturing processes, work can be described as a combination of static and dynamic muscular work, with the static part consisting of standing in the technological processes of cutting and finishing as well as sitting in the technological process of sewing. Static position standing and sitting are associated with a permanent load on certain muscle groups of the back and neck and lead to fatigue. While working in a sitting or standing posture, the worker's upper and lower limbs perform dynamic work. Due to the dynamics and the necessary coordination of the movements as well as the constant repetition of technological operations in very short intervals, in which the same muscle groups are always used (unilateral dynamic work), there is a considerable load on the upper limbs (arms, hands, fingers). Due to the lack of time for muscle recovery, fatigue occurs, which can be prevented by taking a break or changing the work activity [8]. Long-term static loads, which occur due to the constant use of the same muscle groups, lead to damage to joints, ligaments and tendons (tendinitis, tenosynovitis), inflammation of the joints between tendons and bones (epicondylitis), and in more severe cases, joint degeneration (arthrosis) can occur. Current research indicates that, in addition to the above-mentioned conditions, carpal tunnel syndrome, which is an inflammation of the tendons of the wrist RSI (Repetitive Strain Injury), occurs frequently. All the mentioned diseases of the muscular system are the result of injuries due to repetitive movements and are called cumulative trauma disorders (CTDs).

As a result of long-term non-physiological body posture of the body during work, i.e. improper sitting, the abdominal muscles weaken, the spine is distorted, and the digestive system and breathing are disturbed. A distortion of the spine can occur in the sagittal plane (kyphosis and lordosis) or in the frontal plane (scoliosis) or in both the sagittal and frontal planes (kyphoscoliosis) and can lead to injuries to the intervertebral discs and the cervical vertebrae. The resulting injuries manifest as muscle spasms in the shoulders and neck, pain and limited mobility of the cervical spine (cervical syndrome) and pain in the arms (cervical brachial syndrome) [9, 10].

In the processes of garment production, technological operations require a high frequency of movements in short time intervals. Load and fatigue in the production system cause changes in the rhythm of work and lead to spontaneous interruptions in work activities. In addition, there is a disorder of the worker's psychomotor dexterity, which leads to weakening of movement coordination and the occurrence of excessive movements when performing technological operations. Load and fatigue manifest themselves in reduced accuracy, precision and reduced quality of technological operations, so that there is a qualitative and quantitative reduction in productivity.

The most common load on workers in the cutting and finishing processes happens due to the disproportion between the height of the work surface and the worker's height. In the technological process of sewing, the worker's workload is caused by the disproportion between the size and height of the work surface and the height of the seat, the height of the backrest and the position of the pedal in relation to the worker's height. Figure 2 shows a correctly and an incorrectly designed workplace in the technological process of sewing with the corresponding angles of the kinematic chains



a) b)

Figure 2: Presentation of the workplace: a) unfavourably designed; b) favourably designed

The aim of workplace design is adapting working methods and means of work in such a way as to reduce the workload and fatigue of workers when carrying out the work process. Workplace design is based on the adaptation of the workplace to the worker's body dimensions with the related reach zones and the necessary focus of vision and arrangement of visual fields (Figure 3). All of these enables smooth execution of technological operations in a working posture that requires less energy consumption of the body and the structure of the technological operation enables a natural and steady work rhythm with normal breathing and rhythmic relaxation of the chest and abdominal muscles [11].

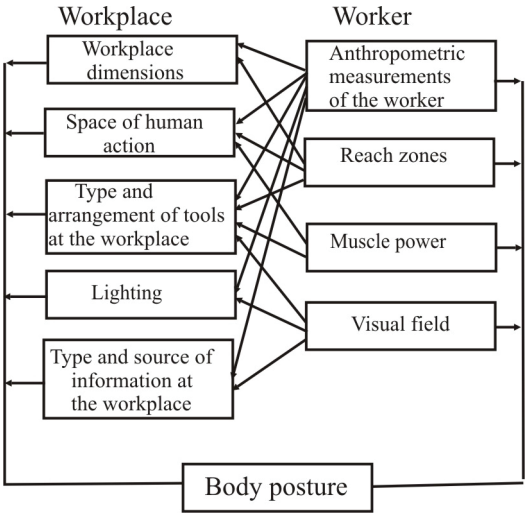


Figure 3: Interaction between the workplace and the worker on the body posture at work

Reduction of workload and effective performance of the work task is achieved [8]:

- if the shape and dimensions of the workplace are adapted to the worker's body and the mobility of the muscular system

- designed so that the worker works in a working posture that requires minimal static and dynamic load and uses lower-level muscle groups,

- equipped with means of work adapted to the physiological and psychological characteristics of the worker's body.

The working posture should allow good mobility of the extremities, an ergonomically favourable arrangement of the working and visual zones and a stable equilibrium state when carrying out technological operations.

3. WORKING CONDITIONS IN CLOTHING PRODUCTION PROCESSES

In the technological processes of clothing production, the worker is exposed to working environment conditions determined by temperature, relative humidity, air pollution (the presence of particles and/or unpleasant odors in the air) and the intensity of light, noise and vibrations.

In the working environment, the minimum requirements for carrying out the work should be met, namely:

- lighting (depending on the type of work),

- the floors in the production facilities should be even and smooth (not slippery) and have a moderate temperature,
- safety protective devices should be within easy reach of workers (fire extinguisher),
- the air in the production facilities should be cleaned by various exchangers or by ventilation,
- sanitary facilities should be located at a certain distance from the production facilities.

In production facilities, the conditions of the working microclimate are regulated by the Occupational Safety and Health Ordinance for workplaces [12] and the Law on protection at work [13].

The optimal working surrounding conditions are [14]:

- air temperature (should be adapted to the type of work and the season): 20-24 °C,
- temperature of surrounding objects and surfaces (should be the same as air temperature): max. 2-3°C higher than air temperature,
- fresh air supply must not be less than 30 m^3h^{-1},
- air flow: up to 0.2 ms^{-1} in winter and 0.5 ms^{-1} in summer,
- relative humidity between 40 and 60% RH.

The sensitivity of workers to noise depends on the characteristics of the noise, the individual characteristics of the exposed person (condition of the hearing organs, age, individual sensitivity to noise) and on the duration, type and method of exposure (the position of the person in relation to the noise source, the presence or absence of noise during the rest period taken during working hours and in leisure time) [15].

Noise at the workplace in the production process makes linguistic communication impossible, distracts workers from the work object, causes psychological tension, restlessness and, if prolonged, can lead to fatigue, general irritability and hearing damage, reducing productivity and increasing the number of errors at work [16].

Noise in the technological process of sewing should not exceed 80 dB(A) according to the Rulebook on the Protection of Workers from Exposure to Noise at Work [17], the Law on Protection from Noise [18] and HRN EN ISO 9612: Determination of occupational noise exposure 19].

In the technological processes of garment manufacturing, noise reduction can be achieved through organizational and technical measures (regular maintenance and servicing of equipment, selection of machines and equipment that cause less noise) [20].

Optimal lighting for the technological process of sewing depends primarily on the visual complexity and difficulty of the visual task as well as the state of the workers' visual apparatus. Poor lighting of the workspace and workplace and very bright shine in the field of vision leads to the appearance of visual tiredness, which makes itself visible as painful irritation of the eyes, double visual images, headache, reduced possibility of accommodation, decrease in visual sharpness, sensitivity to contrasts and speed of perception.

As a result of visual fatigue, there is a decrease in productivity, quality of work, an increase in the number of work errors, the number of work accidents and visual problems in general.

Proper lighting of the workrooms and the workplace itself means accomplishing or gaining with effort the strength, distribution and type of lighting that allows work tasks to be completed comfortably and successfully. In the technological sewing processes according to the Rulebook on protection at work for workplaces [12] and the standard HRN EN 12464-1 2012 - Light and Lighting - Lighting of workplaces – Part 1: Indoor workplaces [21], lighting at the workplace should be between 750 up to 1000 lx, with a visual comfort (sense of satisfaction) that contributes to productivity, the possibility of performing work tasks over a long period of time and safety.

In the clothing industry, production facilities are illuminated with general or central lighting, and additional lighting fixtures are often installed in workplaces due to the performance of precise work (sewing). If garments are sewn from lighter fabrics, the lighting should be at least 500 lx, for darker fabrics 1000 lx [14].

4. METHODS FOR WORKLOAD ANALYSIS

Ergonomic research has identified the importance of identifying and preventing unfavourable working postures, movements and workloads of workers when performing work tasks. Therefore, methods to study and analyse body posture and movements at work have been developed to reduce the load on workers when performing work tasks [10, 22-24].

There are various workload analyses, which can be divided into [25]:

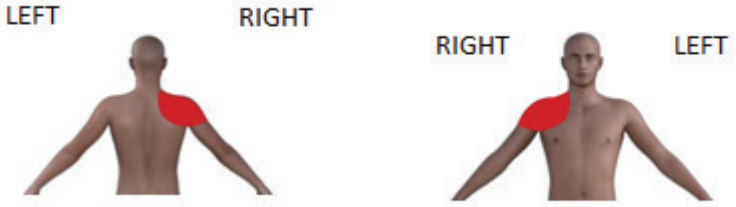
a) Methods for analysing workload using a questionnaire filled in by the worker (NIOSH *(The National Institute for Occupational Safety and Health Method)* method.

b) Methods for analysing the work process by observation and by means of questionnaires (OADM method) (*Evaluative Analysis of the Workplace*), PLIBEL method (*A Method Assigned for Identification of Ergonomics Hazards*) and DMQ (*The Dutch Musculoskeletal Questionnaire*).

c) Methods for workload analysis through the analysis of working postures and movements OWAS (*Ovaco Working Posture Analysis System*), MODAPTS (*Modular Arrangement of Predetermined Time Standards*), RULA (*Rapid Upper Limb Assessment*), REBA (*Rapid Entire Body Assessment*), QEC (*Quick Exposure Check*).

d) Methods for workload analysis using computer systems for work process simulation (SAMMIE, RAMSIS, 3DSSPP/AutoCAD, APOLIN, CAAA, COMBIMAN, ERGOSpace, JACK, SAFEWORK, ANYBODY, eM-Workplace, ERGOPlan).

The NIOSH (*The National Institute for Occupational Safety and Health Method*) method uses a questionnaire consisting of a body map divided by body segments (Fig. 4) in order to specify a certain discomfort or occurrence of pain as a result of an unfavourable working posture. The worker is assigned the task of assessing individual body parts, after which the severity of the individual condition is determined based on duration, frequency and intensity.



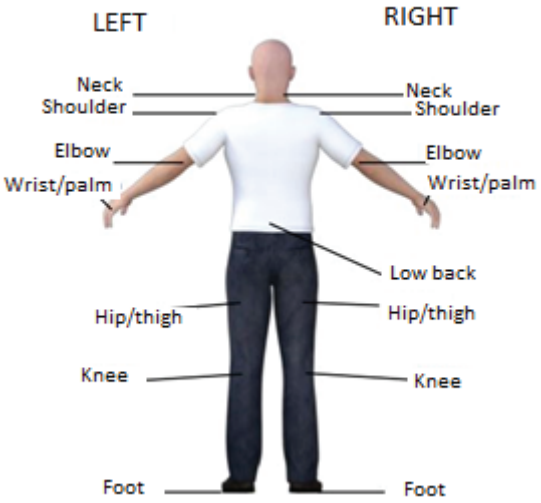
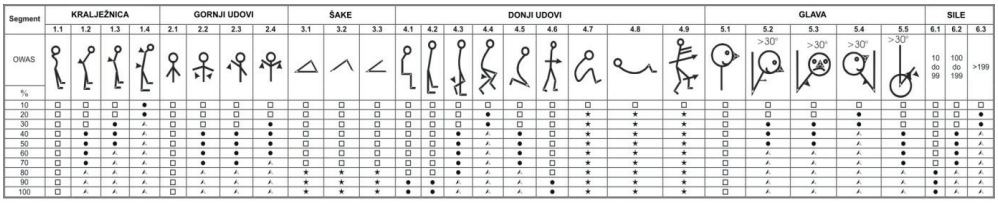


Figure 4: Illustration of the questionnaire according to NIOSH [22]

The PLIBEL (*A Method Assigned for Identification of Ergonomics Hazards*) method consists of a questionnaire that is divided into the upper part of the body (shoulder, neck, back), arms, legs, hips, knees and lumbar spine. The procedure consists of interviewing the worker, and when the load on a certain part of the body is observed, questions from the questionnaire are answered in more detail, while data on the duration of the load, environment and organizational factors are recorded.

The DMQ (*The Dutch Musculoskeletal Questionnaire*) method consists of 225 questions covering gender, age, working hours, workload, body posture, work organization and lifestyle outside working hours. After completing the questionnaire, the answers are evaluated in terms of static and dynamic load, repetitive work, ergonomic working conditions, vibrations and body stress due to load transfer.

The OWAS method (*Ovaco Working Analysing System*) is based on determining the position of the back (spine), arms and legs. The combination of the basic postures of the individual parts of the body determines the types of working postures when performing a particular work activity. According to J. Sušnik [26], the OWAS method contains four spinal positions (lumbar and dorsal), four upper arm positions, three hand positions, seven leg positions, two body movement positions, five head tilt positions and three mass transfer positions (Fig. 5). Individual body parts studied are defined by a graphic symbol, a label and a detailed description of that body part.



Legend:

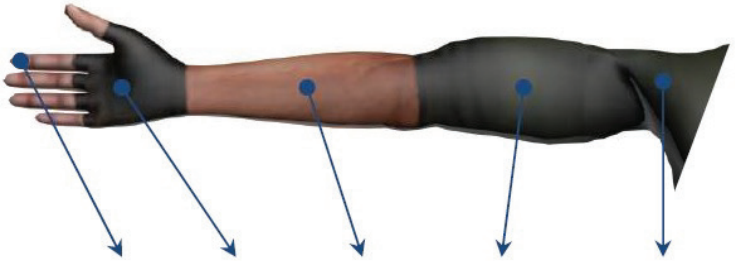
- ☐ redesign of the workplace is not necessary
- ● redesign of the workplace is necessary in the foreseeable future
- redesign of the workplace is necessary soon
- * redesign of the workplace is necessary immediately

Figure 5: Overview table for scoring body postures according to the OWAS method [26]

The REBA method (*Rapid Entire Body Assessment*) uses a matrix of 144 different body postures to identify unfavourable working postures during the work process, which are added up after observation and the necessary interventions at the workplace are determined with regard to the workload.

The QEC (*Quick Exposure Check)* method includes examining the worker's movements and posture while performing the work task and having the worker fill out part of the questionnaire. On the basis of the obtained results, scoring is performed by body segment (back, shoulders, arms, neck, hands) and a score of the total load is obtained, i.e. the level of risk (low, moderate, high, very high), which forms the basis of assessing the need to redesign the workplace and methods of work.

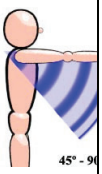
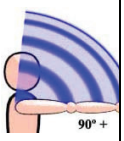
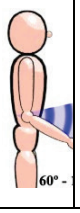
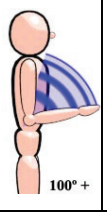
The MODAPTS (*Modular Arrangement of Predetermined Time Standards*) method is used to analyse the movements and workloads of the worker when completing a specific work job with the aim of simplifying the work and designing a good working method in production systems where repetitive work is present during the performance of a work operation and enables the identification and prevention of possible ergonomic risk factors at the workplace [27]. When analysing the body posture according to the MODAPTS method, the work task is divided into movements according to the movement classes of the MODAPTS matrix, within which the so-called MOD value is determined in terms of frequency and type of movement. This allows watching or making a statement of awkward movements, which is important information for the design of appropriate working methods.



Parts of the arm	Fingers	Hand	Forearm	Upper arm	Whole arm
MOD	1	2	3	4	5
Movement length	2.5 cm	5.0 cm	15 cm	30 cm	45 cm

Figure 6: Illustration of the basic movements according to the MODAPTS method

The RULA (*Rapid Upper Limb Assessment*) method is used to determine the degree of worker exposure to unfavorable working postures that can lead to musculoskeletal disorders. The RULA method is used to watch and assess the biomechanical positions of the whole body, i.e. the arms (upper arm, forearm, hand, Fig. 7), neck, trunk and legs, the repeatability of the work of the arms and body, and the load on the body during mass transfer. The analysis of workplaces using the RULA method provides data on body parts that are extremely loaded when performing a technological operation. Taking into account the score obtained (1-7+), the level of workload and the need to redesign the workplace to reduce workers' fatigue and workload is determined.

Arm – upper arm						-shoulders raised [+1] -upper arm extended [+1] - arm resting [-1]
	+1	+2	+2	+3	+4	additional positions
Arm – forearm						

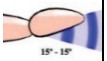
	+1	+2	+2	+1	
rm – hand					
	+1	+2	+3	+3	+1/ additional positions
Hand rotation			Hand load: - without load (load less than 20 N [0] - low load (20 N – 100 N [+1] - static load (20-100 N)/ repetitive intervals (20-100 N)/ intermittent load (>100 N[+2] - static load (100 N)/repetitive intervals (100 N)/high load (> 100 N [+3])		
	+1	+2			
Arm muscle work: - arm position is mostly static (duration longer than 1 min) [+1] - arm work is repetitive [+1]					

Figure 7: Illustration of the working arm positions according to the RULA method [10]

The computer system ERGOPlan, Delta company, is used for work analysis and ergonomic design of workplaces in the garment industry and enables virtual simulation of the continuous flow of the entire production process with the help of modules for workplace design, ergonomic analysis of the workplace, elaboration of the structure of execution of technological operations, analysis of execution time and cost analysis [28].

5. RESULTS OF THE METHODS USED TO ANALYSE WORKLOAD IN GARMENT PRODUCTION PROCESSES

As part of the research on work methods, an analysis of the workload of workers at three different workplaces in a real production process is presented using the OWAS, RULA and REBA methods.

For the analysis of workload during the technological operation of sewing the side seam of the trousers, the OWAS method was used, collecting 825 notes on

individual postures per body parts. For the investigated technological operation of sewing, the duration of the shift with the prescribed rest period was 450 minutes.

Based on the notes, the percentage and duration of the individual working postures in the effective daily working time were calculated and compared with the overview table for the assessment of body posture. Figure 8 shows the permissible percentage of representation of a particular working posture within the effective daily working hours and the results obtained by analysing the worker load while performing a technological operation. The results obtained using the OWAS method are shown in Table 1.

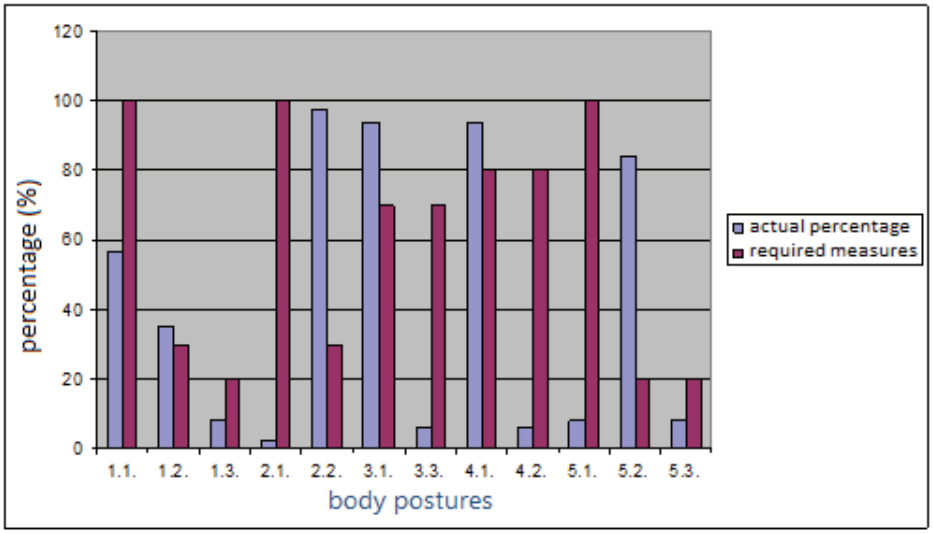


Figure 8 Histogram of the measurements according to the OWAS method at the workplace when sewing the side seam of the trousers

Table 1: Unfavourable working postures and their amount of time according to the OWAS method

Joint system	Reached angle or position	Effective time [%]	Effective time [min]
forward flexion of the spine (1.2.)	> 15°	35.1	158.0
forward flexion of the head (5.2.)	>30°	84.1	378.9
upper arm (2.2.)	away from the body	97.6	439.2
hands and fingers (3.1.)	fine work	93.6	421.2

sitting (4.1.)	changing the front and back postures	100.0	450.0

According to the OWAS technique results (Tab. 1), the head is in a forward-flexion posture with an angle greater than 30° for 84.1% of working hours, while the spine is in a forward-flexion posture with an angle greater than 15° for 35.1% of working hours (158 min) (378.9 min). A higher load is placed on the worker due to the defined position of the head and spine, which results in an uncomfortable working posture and increases the stress on the cervical and lumbar regions of the spine. The worker spends 97.6% of time (439.2 minutes) at the sewing machine with upper arms turned away from body (posture 2.2), which puts a load on elbows and shoulders. For fine and precise movements of taking, grasping, and guiding the workpiece (position 3.1), fingers are used 93.6% of the time at work (421.2 min).
The need for a redesign of the current workplace is demonstrated by unfavourable working postures (1.2; 2.2; 3.1; 4.1 and 5.2) and their significantly increased proportion of time during the work process (Table 1).

The analysis of the worker's workload for the technological operation of sewing sleeves on a T-shirt using technological suboperations was carried out using the RULA method and the results are shown in Table 2. Table 2 gives an overview of the working postures, the curvature angles of the back and neck of the spine, the necessary head and eye rotation as well as the movement angles of the upper and lower arm for the right and left hand.

Table 2: Angles of curvature of the back (T) and cervical spine (C), required head and eye rotation (E), angles of movement of the upper arm (F) and forearm (W)

Technological suboperation	Working posture	Angles of curvature of the back (T), the neck (C), rotation of the head and eye (E)	Angles of upper arm movements [°] (F)		Angles of forearm movements [°] (W)	
			Right arm	Left arm	Right arm	Left arm
taking the T-shirt	medium	17/33/32	30	45	100	110
taking the sleeve	medium	11/42/34	10	20	55	50
putting together	forward	22/36/33	30	45	95	90
positioning	forward	24/35/32	35	45	95	95
machine-hand sewing	forward	25/41/31	10	30	90	90
machine cutting off the thread	medium	16/39/28	20	25	90	100
laying off	backward	T, C to the rest, E head rotations 50°	10	20	80	85

The technological operation of sewing in sleeves is carried out in a short period of time, with certain sub-operations and movements being repeated regularly during working hours, resulting in a certain physical load on the worker.

When performing the technological operation of sewing in sleeves, the worker changes working postures depending on the demands and required precision of the individual technological suboperation. Taking the T-shirt and taking the sleeve is performed in the medium posture, while putting together, positioning and machine-hand sewing is performed in the forward posture that requires additional precision of work. The technological suboperation of the machine cutting of the thread is performed in the medium posture, while the laying off the workpiece in the backward posture (up to the backrest) with a rotation of the head up to 50°. The technological suboperation of sewing machine thread cutting is performed in the medium posture, while the laying off the workpiece is carried out in the backward posture (up to the backrest) with a rotation of the head up to 50°. The angle of curvature of the back part of the spine in technological subperations ranges from 11° to 25°. The angle of curvature of the neck part of the spine is between 33° and 42°, depending on the technological sub-operation. The angles of the upper arm and forearm of the right and left arm depend on the required set of movements when performing a particular technological suboperation. When working at the sewing machine, the worker works with the upper arms turned away from the body, which causes considerable load on the arms. In addition, due to the repetitive execution and precise work of technological suboperations, putting together, positioning and machine-hand sewing impose a considerable load on the hand and fingers.

The analysis of workers' workload for the technological operation of sewing in sleeves on a children's T-shirt using the RULA method for seven characteristic working postures, which also include work according to technological sub-operation, is presented in Table 3.

Table 3: Presentation of the scores achieved according to technological suboperations

Technological suboperation /load	**Taking a T-shirt**		**Taking sleeves**		**Putting together**		**Positioning**		**Machine -hand sewing**		**Machine thread cutting**		**Laying off**	
Arm (right/left)	D	L	D	L	D	L	D	L	D	L	D	L	D	L
Arm	6	6	4	4	5	5	5	5	5	6	5	5	4	4
Body	5			6	5		5		5		4		5	
Total	6		6		6		6		5		5		5	

The results obtained by the RULA method indicate that the workload of the worker in terms of technological suboperations is considerable, and the technological suboperation of taking a shirt, taking sleeves, putting together and positioning received a score of 6, while the technological suboperation of machine-hand sewing, machine thread cutting and laying off received a score of 5. In accordance with Table 3, the technological operation of sewing in sleeves requires additional and more detailed investigation of the workload of workers and the need to redesign the workplace in the near future.

The analysis of the worker's workload for the technological operation of sewing the back seam of the sleeve lining according to technological suboperations is presented in Table 4. In Table 4 an overview of the working postures, the angles of curvature of the back and neck of the spine, and the angles of movements of the upper arm and forearm for the right and left is presented.

Table 4: Presentation of the curvature angles of the back (T) and neck (C) part of the spine, the required rotation of the head and eye (E) and the angles of the upper arm (F) and forearm (W)

Technological suboperation	Working posture	Angles of curvature [°]			Angles of the left arm [°]		Angles of the right arm [°]	
		Back (T)	Neck (C)	Rotation of head and eye (E)	Upper arm (F)	Forearm (W)	Upper arm (F)	Forearm (W)
taking sleeves	medium	10	9	20	45	105	45	107
putting together	forward	30	30	0	40	90	22	95
positioning	forward	36	32	0	44	95	22	110
machine hand sewing	forward	38	35	0	45	90	25	108
aligning during sewing	medium	5	8	0	20	102	20	102
machine-hand sewing	forward	38	35	0	45	90	25	108
machine thread cutting	forward	38	35	0	45	90	45	90
laying off the sleeves	backward	10	10	45	10	92	55	40

Based on the defined postures and movements of the worker's body and hands, the workload during the performance of the technological operation was determined using the ErgoFellow computer system module of the REBA method.

Table 5 presents the scores of the worker's workload and the level of risk according technological suboperations for the entire technological operation of sewing the back seam of the sleeve lining according to the REBA method.

Table 5: Presentation of the scores of worker's workload and risk level according to the REBA method for the technological operation of sewing the back seam of the sleeve lining

Technological suboperation	Score		Levels of risk	Interpretation
	Left arm	Right arm		
taking the sleeves	6	7	medium	Medium risk, further investigation, change soon
putting together	7	7	medium	Medium risk, further investigation, change soon
positioning	7	8	high	High risk, investigate and implement change
sewing	7	8	high	High risk, investigate and implement change
aligning during the break of sewing	5	5	medium	Medium risk, further investigation, change soon
sewing	7	8	high	High risk, investigate and implement change
cutting off the thread	7	7	medium	Medium risk, further investigation, change soon
laying off	7	8	high	High risk, investigate and implement change

In the technological suboperation of taking the sleeves and aligning the seam, there is a medium risk (score 7) and changes to the workplace in the form of redesigning the workplace are required. In the technological suboperation of putting together and cutting off the thread, there is also a medium risk (score 7), and a redesign of the workplace is necessary. In the technological suboperations of positioning and sewing, which are performed with less favourable angles of the body and arms in the forward leaning posture, there is a high risk (score 8), and a redesign of the workplace is required. In the technological suboperation of laying off, which is performed in the backward leaning posture with rotation of the trunk and head, the level of risk is high (score 8), and it is necessary to redesign the workplace.

6. CONCLUSION

The technological process of garment production is a complex work system that requires workers to have good motor skills, such as high mobility and coordination of body, arm and leg movements. The high dynamics of movements during

technological operations in very short time intervals leads to physical and mental fatigue. Fatigue is a consequence of static and dynamic loading of the worker's muscular system, unfavorable working postures and the required degree of visual concentration. Previous ergonomic studies of workload in real production processes show that workers impose considerable loads on their bodies when performing technological operations.

In order to reduce the workload of workers in the work system, the working environment must be adapted to the capabilities of the human body so that a given work task can be performed successfully and the impairment of workers' health and the incidence of occupational diseases decrease. Therefore, it is necessary to harmonise the dimensions of the work environmental system with the physical dimensions of the workers, i.e. to redesign or design the workplace accordingly.

Through the proper redesign or design of workplaces and working methods, better work performance, higher productivity, an ergonomically favourable working posture, lower workload and fatigue of workers, as well as a shorter time for carrying out the technological operation can be achieved.

REFERENCES

[1] Kirin, S.; Dragčević, Z.; Polajnar, A.: Radno opterećenje i zamor u tehnološkom procesu šivanja, *Tekstil*, 53, (2004.), 5, 226-243, ISSN 0492-5882,
[2] Kirin; S.; Dragčević, Z.: Investigation of Workers Load in the Technological Cutting Process, Book of Proceedings of the 6th International Textile, Clothing & Desing Conference - *Magic World of Textiles*, Dragčević Z.(ed.), October 7th to 10th, 2012, Dubrovnik, Croatia, 354-359, ISSN 1847-7275
[3] Rogale, D. i sur.: *Procesi proizvodnje odjeće*, Sveučilišni udžbenik Tekstilno-tehnološkog fakulteta, Zagreb, 2011., ISBN 978-953-7105-32-7
[4] Dragčević, Z.; Kirin, S.: Oblikovanje radnog mjesta u tehnološkom procesu šivanja, *Sigurnost* 49, (2007.), 2, 103-111, ISSN 0350-6886
[5] Kirin, S.: Ergonomska istraživanja opterećenja radnika u procesu šivanja odjeće, *Sigurnost* 62 (2020), 3; 239-249, ISSN 0350-6886
[6] Kirin, S.; Hursa Šajatović, A.: Determination of Working Methods and Normal Times of Technological Sewing Operation using MTM System, *Tekstilec*, 63 (2020), 3; 203-215 ISSN 0351 3386, doi:10.14502/Tekstilec2020.63.203-215,
[7] Kirin, S.;Hursa Šajatović A.: Defining standard sets of motions in the technological suboperation of sewing using the MTM-System, *Tekstil* 67 (2018), 7-8; 218-234, ISSN 0492-5882
[8] Verhovnik, V., Polajnar, A.: *Oblikovanje dela in delovnih mest*, II izdanje, Univerza v Maribor Fakulteta za strojništvo, Maribor, 2007, ISBN 86-435-0341-X

[9] Kroemer K.H.E.,Grandjean E.: *Prilagođavanje rada čovjeku*, Ergonomski priručnik,
Ed.I.Manenica, Udžbenik Sveučilišta u Splitu, Split, 1999., ISBN 953-191-096-0
[10] Balantič, Z., Polajnar, A., Jevšnik, S.: *Ergonomija v teoriji in praksi*, Nacionalni inštitut za javno zdravje, Ljubljana, 2016., ISBN 978-961-6911-91-7
[11] Kirin S., Dragčević Z., Firšt Rogale S.: Workplace Redesign in the Computer-Aided Technological Sewing Process, *Tekstil*, 63, (2014.), 1-2, 14-26, ISSN 0492-5882
[12] Pravilnik o zaštiti na radu za mjesto rada (NN 29/13)
[13] Zakon o zaštiti na radu (NN 71/14, 118/14, 94/18)
[14] Šaravanja, B., Hursa Šajatović, A., Dragčević, Z.: Istraživanje uvjeta radne okoline u tehnološkim procesima proizvodnje odjeće, *Tekstil* 67, (2018.), 5-6, 146-154, ISSN 0492-5882
[15] Horvat, J., Regent A.: *Osobna zaštitna oprema*, Udžbenik Veleučilišta u Rijeci, Rijeka (2009.), ISBN 978-953-6911-43-1
[16] Barbu, I., et al: Ergonomics elements and their influence in the garment industry, IOP *Conf. Series: Materials Science and Engineering* 916 (2020), 1-6, https://iopscience.iop.org/article/10.1088/1757-899X/916/1/012007/pdf, pristupljeno 1.11.2020.
[17] Pravilnik o zaštiti radnika od izloženosti buci na radu˙(NN 45/05)
[18] Zakon o zaštiti od buke (NN 20/03)
[19] HRN EN ISO 9612: Akustika- određivanje izloženosti buci na radu, www.hzn.hr, pristupljeno 19.01.2020.
[20] Trbojević, N.: Osnove zaštite od buke i vibracija, Udžbenik Veleučilišta u Karlovcu, Karlovac, (2011.), ISBN 978-953-73343-53-8
[21] HRN EN 12464-1:2012: Svjetlo i rasvjeta - Rasvjeta radnih mjesta - 1. dio: Unutrašnji radni prostori, http://www.hzn.hr/, prestupljeno 11.12.2015.
[22] Stanton, N., et. al.: Handbook of Human Factors and Ergonomics Metods, CRC PRESS, 2005, ISBN 0415-28700-6
[23] David, G. C.: Ergonomics methods for assessing exposure to risk factors for work-related musculoskeletal disorders, Occupational Medicine 55, (2005), 3,190-199, ISSN 0962-7480
[24] Kirin, S.: Uvod u ergonomiju, Udžbenik Veleučilišta u Karlovcu, Karlovac, 2019., ISBN (on line) 978-953-8213-03-8
[25] Kirin, S.: Oblikovanje radnih metoda u tehnološkom procesu šivanja, Doktorski rad, 2020., Zagreb
[26] Sušnik, J.: Ergonomska fiziologija, Didakta 1992., ISBN 86-7707-019-2
[27] Kovačević, S, Brnada, S., Šabarić, I.: Analiza pokreta i opterećenja tijela primjenom MODAPTS metode, Zbornik radova 4. Međunarodno stručno-znanstvenog skupa, Zaštita na radu i zaštita zdravlja, Vučinić J, .Kirin S. (ur.), 19.-22.09.2012., Borik, Zadar, 519-524, ISBN 978-953-7343-40-8
[28] Fulder, T., Pizmoht, P., Polajnar, A., Leber, M.: Ergonomically Designed Workstation Based on Simulation of Worker`s Movements, International Journal of Simulation Modeling 4, (2005),1, 27-34, ISSN 1726-4529

RELEVANT FACTS OF PORTUGUESE LEGISLATION FOR OCCUPATIONAL NOISE

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Abstract

Hearing loss caused by noise is one of the 10 most common occupational diseases in the European Union. Hearing loss or hearing loss caused by noise is one of the diseases listed in the European list of occupational diseases. Data collected by EUROSTAT within the scope of the 'European Statistics on Occupational Disease's show that in Europe (EU15), around 14 300 cases of noise-related hearing loss were detected in 2005, which corresponds to 9.5 cases per 100 000 workers. It should be noted that approximately 98% of the identified cases are men and 73% work in the manufacturing, extractive, and construction industries.

In 2006, occupational noise Portuguese legislation was revised, to establish responsibilities for the general principles of prevention, namely the obligations and obligations of employers and workers.

Keywords: *Occupational noise, Portuguese legislation, working conditions*

1. INTRODUCTION

Hearing loss caused by noise is one of the 10 most common occupational diseases in the European Union. Hearing loss or hearing loss caused by noise is one of the diseases listed in the European list of occupational diseases. Data collected by EUROSTAT within the scope of the 'European Statistics on Occupational Disease's show that in Europe (EU15), around 14 300 cases of noise-related hearing loss were detected in 2005, which corresponds to 9.5 cases per 100 000 workers. It should be noted that approximately 98% of the identified cases are men and 73% work in the manufacturing, extractive, and construction industries. The European Working Conditions Survey, carried out in 2005 by the Dublin Foundation, indicates that around 20% of European workers are exposed, for at least half of their working time, to noise levels so high that they need to scream to be heard. by your colleagues [1]

In 2006, occupational noise Portuguese legislation was revised, to establish responsibilities for the general principles of prevention, namely the obligations and obligations of employers and workers. These principles must be applied mutatis mutandis, namely regarding risk assessment, measures to prevent or reduce worker's

exposure to noise, health surveillance, staff information, training and, finally, consultation and participation of workers in this process. The new legislation, Decreto-lei 182/2006, allows covering, among others, the following items:

- risk identification and assessment
- provisions to prevent or reduce noise exposure
- individual protection equipment
- health surveillance
- information, training, consultation, and participation of workers
- exposure limits
- control measures program
- delimit areas, sign them and control access
- occupational noise measurements
- preparation of individual report

This will improve working conditions and company productivity.

2. LEGISLATIVE EVOLUTION

Legislation related to worker's protection against noise exposure is closely linked to the legislation on the work conditions in general. Thus, the first reference appears in Portaria nº 53/71, of 3rd February, that approves the General Regulation of Safety and Hygiene in the industrial establishments, later modified by Portaria nº 702/80, of 22nd September. Noise exposure, like others physical agents, is also referred in the Decreto Regulamentar nº347/93, of 1st October and Portaria nº 987/93, of 6th October, both related to the minimum requirements of health and safety at work. Although the importance of the previous mentioned legislation, noise exposure appears for the first time, as central element, in Decreto Regulamentar 251/87, of 24th June, known as General Regulation on Noise. This legislation, although with widened objectives, constitutes the first step in legislation concerning noise exposure. In 1989 some disposals of the General Regulation on the Noise are modified, through the Decreto-Lei nº 292/89, of 2nd September. Even if these legislations mentioned occupational noise exposure, all detailed specifications are endorsed to specific legislation, as is the case of occupational noise exposure. Important landmark in what concerns to occupational noise exposure is the European Directive no.86/188/CEE, of 12th May, which establishes the general framework of worker's protection against noise exposure during work, transposed for internal law by Decreto-Lei no. 72/92, and regulated by Decreto Regulamentar 9/92, both of 28th April. In 2000 was published the Decreto-Lei 292/2000, of 14th November, which approves the general regulation on noise, or as it is now called, Legal Regimen on Noise Pollution. This last one, like its predecessor, is not related to any aspects of occupational noise exposure, which are addressed to specific legislation [2].

European directive 2003/10/EC of the European Parliament and of the Council of 6 February adopted new minimum health and safety requirements regarding the exposure of workers to the risks arising from noise. It must be considered that noise levels are not equally harmful in different frequency bands, and that individual susceptibilities can lead to very different effects on different people in a group subjected to the same exposure. Chemicals in the workplace can be ototoxic, with negative effects on the organs of hearing, and can be an increased risk when combined with noise exposure. This synergy is particularly noticeable when noise is associated with some organic solvents used in the plastics and printing industries, as well as in the production of paints and varnishes. On the other hand, the exposure of pregnant workers to high noise levels can have consequences for the fetus. Experiments lead to the conclusion that prolonged exposure of the fetus to intense sound during pregnancy can have repercussions on the child's future hearing ability. Deafness resulting from exposure to high sound levels in the workplace is one of the best-known occupational diseases and currently accounts for about one-third of all occupational diseases. The elimination or reduction of excessive noise is a very important legal obligation for employers and employees, because the safer and healthier the work environment, the less likely it is to cause work-related accidents, high absenteeism, and decreased work performance. Risk assessment, taking measures to prevent or control risks, worker information, training and participation, regular monitoring of risks and control measures, and appropriate health surveillance are all fundamental importance in preventing risks to workers' health. These factors are addressed in the new decree-law and in specific legislation concerning safety and health at work.

Decreto-lei 182/2006, of 6th of September, establishes the exposure limit value and the upper and lower exposure action values and determines a set of measures to be applied whenever these values are reached or exceeded. In certain work situations, the full and correct use of individual hearing protectors may cause greater risks to health or safety, so the directive allows member states, after consultation with the social partners, to derogate from the application of these measures. The present Decreto-lei contemplates such derogations for these situations. For workplaces where daily noise exposure varies greatly from one day to the next, the weekly noise exposure level will be used to assess exposure, provided it does not exceed the exposure limit value. The opinions issued by organizations representing workers and employers, as well as specialists and other organizations, were duly considered, and some provisions of the draft decree-law were altered. As such, it is now possible for noise measurements to be carried out not only by accredited bodies but also by occupational hygiene and safety technicians who hold a valid professional aptitude certificate and have specific training in methods and instruments for measuring noise at work. The designations of the relevant physical quantities are updated, in accordance with those defined in the ISO 1999:1990 standard, namely the levels of daily personal exposure of a worker to noise during work and the weekly average of the daily exposure values. The application of exposure limit values and action values is clarified. The regulation of the methods for calculating the attenuation of hearing protectors is improved. Other methods may

be used in determining daily personal exposure to noise, provided they comply with the applicable standardization.

3. DECRETO-LEI 182/2006

The following are some points of the Portuguese law on occupational noise.

3.1. NOISE EVALUATION

This law defines that it is not permitted, under any circumstances, the daily or weekly personal exposure of workers to noise levels equal to or exceeding 87 dB(A) or peak values equal to or exceeding 140 dB(C), these values being defined as the Exposure Limit Values (ELV) to noise, in whose determination the attenuation of hearing protectors is now considered. This consideration means that if it were possible to measure noise levels inside the ear canal, using a suitable hearing protector, the worker's exposure should never be equal to or greater than the equivalent continuous sound level (LEX,8h) of 87 dB(A) or peak values (LCpeak) equal to or greater than 140 dB(C). Relatively to the repealed legislation, where the daily ELV was 90 dB(A), this parameter is reduced by 3 dB(A), which considering that noise is quantified according to a logarithmic scale, means a 50% reduction in the sound pressure level [3].

In addition to a considerably lower ELV, Decreto-lei 182/2006, substituted what was previously known as the action level (AN) with two distinct levels, now called lower action values and higher action values, respectively.

Three levels of intervention:

Lower action values: LEX,8h = 80 dB(A) and LCpico = 135 dB(C);

Higher action values: LEX,8h = 85 dB(A) and LCpico = 137 dB(C);

Exposure limit values: LEX,8h = 87 dB(A) and LCpeak = 140 dB(C)

3.2. EMPLOYER'S OBLIGATIONS

1. Risk assessment: In activities likely to present a risk of exposure to noise, the employer must assess and, if necessary, measure the levels of noise to which workers are exposed. The following principles must be taken into consideration in this assessment [3]:

a) assess the level, nature and duration of noise exposure of workers, also considering exposure to noise of impulsive characteristics;

b) The evaluation shall be done in accordance with the lower, upper action values and the exposure limit values defined by the regulations;

c) The evaluation must have particular attention to the possibility of workers with special sensitivity to the occupational risks to which they are exposed;

d) The risk evaluation must consider the possibility of interaction between noise, other vibrations and ototoxic substances eventually present in the workplace;

e) Consider the interferences that noise can cause in the proper perception of warning, alarm and alert signals necessary for the reduction of accident risks;

f) Take into account the information made available by equipment manufacturers, particularly with regard to occupational risks associated with its operation

g) Ensure that the replacement work equipment is in accordance with the general principles of noise emission reduction;

(h) take into account the possibility of workers' exposure to noise extending beyond the maximum duration of a normal work period

i) Use, the information resulting from the medical surveillance of the health of workers exposed to labor noise, respecting the restrictions defined by specific legislation

j) Guarantee the availability of hearing protection equipment with attenuation characteristics that are adequate to the characteristics of the noise in question.

The risk evaluation must be carried out with a minimum periodicity of one year, whenever the upper action levels (LEX,8h = 85 dB(A) e LCpico = 137 dB(C)) are reached or exceeded. It should also be updated whenever significant changes are introduced to production processes, namely the installation of new equipment, changes in layout or the creation of new jobs. The measurement of noise levels, besides being carried out by accredited entities, can also be performed by occupational hygiene and safety technicians, with a valid professional aptitude certificate and specific training in instrumentation and measurement methodologies and assessment of occupational noise exposure.

2. Reduction of exposure: In accordance with the general principles of risk prevention, the employer must use all means available to manage to eliminate at source or reduce to the minimum possible the risks associated with noise in the workplace, following the following main guidelines [3]:

a) Seek to adopt alternative working methods that allow the times of exposure of workers to noise to be reduced;

b) Choose work equipment that is well designed, ergonomic, and produces the least possible noise;

c) to design, arrange and organize workplaces and workstations in an appropriate manner

d) provide information and training to workers, with the objective of ensuring the correct and safe use of work equipment and reducing their exposure to noise to a minimum;

e) Use the implementation of technical noise reduction measures, such as the encapsulation of noisy sources, installation of absorbing panels and damping equipment to avoid noise transmission to structures

f) Develop, implement and ensure the correct scheduling of maintenance activities for the work sites and all equipment associated with them;

g) Adopt work organization measures in order to decrease the duration of noise exposure;

h) Adjust the working hours and respective rest periods, considering them as a possible way of reducing the exposure of workers to noise.

3. Individual protection: In all situations in which it is not possible to reduce exposure to noise through the measures referred to above, the employer must ensure the availability of individual hearing protection equipment, whenever one of the lower action values is exceeded, and ensure its effective use, whenever the noise exposure level reaches or exceeds the higher action values.

3.3. INFORMATION, CONSULTATION AND TRAINING FOR WORKERS

In addition to the general responsibilities for worker information and consultation, the employer must ensure information, consultation and training for workers exposed to noise levels at or above the lower action values, considering [3]:

a) the risks to the health and safety of workers exposed to noise in the workplace;

b) the measures already implemented or to be implemented with the aim of eliminating or reducing exposure to occupational noise;

c) The lower, upper action values and the exposure limit values;

d) the results of noise measurements and assessments and their significance in terms of potential risk to the health and safety of workers;

e) The proper technique for placing and using individual protection equipment;

f) How and the importance of early detection of signs of work-related hearing trauma;

g) The need for medical surveillance and its periodicity according to each worker's level of exposure to noise at the workplace;

h) Methodologies and safe work practices with the potential to minimize exposure to noise and its consequent effects.

3.4. WORKER'S HEALTH SURVEILLANCE

In addition to the general obligations concerning health at work, the employer must ensure proper medical surveillance of workers exposed to noise, in order to detect early possible hearing loss and take measures to preserve their hearing capacity. Therefore, the employer must ensure the medical and audiometric surveillance of the workers' hearing function with the following frequency [3]:

Annually (or less if the physician deems it necessary) for workers who have been exposed to noise levels above the upper action values (LEX,8h = 85 dB(A) and LCpico = 137 dB(C)).

Every two years (or less if the doctor thinks so) for workers who have been exposed to noise levels above the lower action values (LEX,8h = 80 dB(A) and LCpeak = 135 dB(C)).

REFERENCES

[1] European Commission *Non-binding guide to good practice for the application of directive 2003/10/EC "Noise at work"*, France, (2007)
[2] Arezes, Pedro; Miguel, A. Sérgio.: Congreso Iberico de Acustica, *Occupational noise exposure in Portugal*, Sevilla, (2015), www.sea-acustica.es/fileadmin/publicaciones/Sevilla02_noi02015.pdf
[3] Ministry of labour and social solidarity, Decreto-lei 182/2006, Diário da República, 1.a série No 172, 6th September 2006

STATISTICAL ANALYSES FOR ACCIDENTS AT WORK IN CONSTRUCTION SECTOR IN NORTH MACEDONIA

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Abstract: *Construction is one of the most risk activities in terms of hazards at work. Construction workers on mobile construction sites are exposed to a lot of number on harms and dangers that cause serious injuries. In this paper some statistical indicators concerning non-fatal and fatal accidents at work in the Republic of North Macedonia from 2016 to 2021 in construction sector were presented. The performed statistical analysis shows that the number of non-fatal and fatal accidents at work in Republic of North Macedonia in 2021 was increased in comparison with 2016. Nevertheless, in the Republic North of Macedonia the value of incidence rate for fatal accidents at work in construction sector in 2021 is much lower compared to the average value in EU-27members.*

Keywords: *construction sector, non-fatal accidents, fatal accidents*

1. INTRODUCTION

Construction is one of the most risk activities in terms of accidents at work. Construction workers are exposed to a number of accidents at work, especially serious and fatal injuries. Despite the existence of law of safety at work, accidents at work in this activity are increasing every year. Increasing the quality of safety at work and health of employees in construction sector, and in the workplace in general, should be the primary goal of every employer. Given the difficult working conditions, as well as the hazards and harmfulness at faced by construction workers, relevant activities should be taken by project holders, contractors, supervisors and all parties involved, for successful completion of project [2]. The process of building and constructing facilities includes activities on temporary and mobile construction sites that include the flow of materials, workers as well as machinery and mechanical equipment. The workers on construction site work in difficult and dynamic conditions. A complete

classification of the hazards and harmfulness of a mobile construction site is given by Hughes and Ferrett, [1]:

- hazards when working at height,
- hazards during excavation,
- hazards during demolition,
- hazards due to the movement of vehicles (internal transport),
- hazards when using equipment on a construction site,
- dangers of electricity,
- fire hazards,
- chemical and biological harmfulness, and
- physical and mental health hazards.

In this paper some statistical indicators for non-fatal and fatal accidents at work in construction sector in the Republic of North Macedonia from 2016 to 2021 were presented.

2. STATISTICAL INDICATORS

In this paper two main types of statistical indicators on accidents at work in construction activity are used: number of non-fatal and fatal accidents at work and incidence rate. The databases on relevant institutions in the Republic of North Macedonia for the values of the number of accidents at work (non-fatal or fatal) were used. For the calculation of the values of the incidence rate the methodology of the European Statistics on Accidents at Work (ESAW) was used [9].

3. RESULTS AND DISCUSSIONS

In the Republic of North Macedonia there are several organizations and institutions that collect statistical data on accidents at work. These include State statistical office, the Labour inspectorate, Institute for public health, the Macedonian Occupational Safety and Health Association, Organization of the employers of Republic of Macedonia and the Trade unions. The data on the number of accidents at work in the Republic of North Macedonia is not confidential for the reason that different relevant institutions published various statistical data [2].
In this paper, the statistical indicators related to the number of non-fatal and fatal accidents at work in construction sector in the period 2016÷2021 are based on the data of the Macedonian Occupational Safety and Health Association [3-8]. The reason for that is what in the statistical reports of the other relevant institutions that register accidents at work no distinction is made between the number of non-fatal and fatal accidents at the workplace. In construction sector

in 2021 there were 30 non-fatal accidents that resulted in at least four calendar days of absence from work and 9 fatal accidents at works (Table 1). In the total number of non-fatal accidents at work in the Republic of North Macedonia between 2015 and 2020, there was increase for 18 accidents i.e. equivalent to enlargement of 60 % (Figure 1). During on 2021, there were 3 fatal accidents at work fewer when compared with 2015 i.e. equivalent to increase of 33.3% (Figure 2).
From Table 1 it is evident that the smallest number of non-fatal accidents at work was recorded in 2016, while the smallest number of fatal accidents at work was recorded in 2020.

Table 1: Total number of non-fatal and fatal accidents at work in construction sector,
Republic North Macedonia, 2016-2021 (persons)

Construction (F)	2016	2017	2018	2019	2020	2021
Non-fatal accidents	12	25	31	36	31	30
Fatal accidents	6	6	8	6	5	9

Source: Macedonian Occupational Safety and Health Association

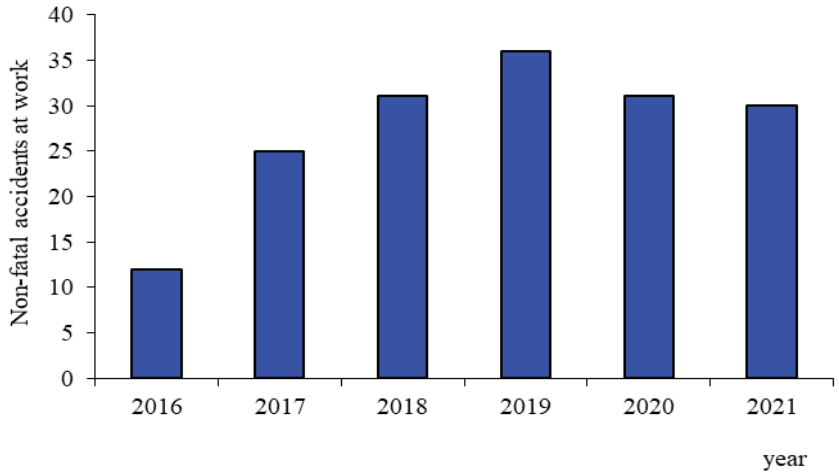

Figure 1: Non-fatal accidents at work 2016-2021

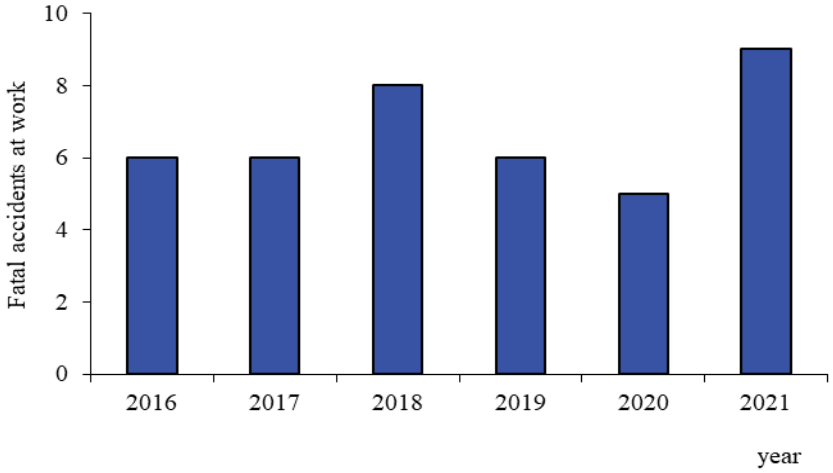

Figure 2: Fatal accidents at work 2016-2021

In EU-27 Member States in 2019 (371800) non-fatal accidents at work were recorded. The highest number of non-fatal accidents at work in construction sector was recorded in Germany (116854), followed by France with (75349), and Spain with (70843). On the other hand in Bulgaria (185), Latvia (198) and Malta (284), were recorded the lowest number of non-fatal accidents at work [10]. In construction of buildings the total number of non-fatal accidents at work in 2019 was (104360). The highest number of non-fatal accidents at work in construction of buildings was recorded in Germany (32876), followed by Spain with (28690), and Portugal with (10607). The lowest number of non-fatal accidents at work in construction of buildings was recorded in Latvia (79), Bulgaria (87), and Malta (114), [10].

In EU-27 Member States in 2019 (755) fatal accidents at work were recorded. The highest number of fatal accidents at work in construction sector was recorded in France (160), followed by Spain with (100), and Italy with (92). On the other hand in Denmark and Luxembourg (2), Cyprus, Malta and Netherlands (3) were recorded the lowest number of fatal accidents at work [10]. In construction of buildings the total number of fatal accidents at work in 2019 was (269). The highest number of fatal accidents at work in construction of buildings was recorded in Spain (43), followed by Romania with (33), and Italy with (32). The lowest number of fatal accidents at work in construction of buildings was recorded in Denmark and Slovenia (0), and Luxembourg, Netherlands and Norway (1) [10].In Table 2 the incidence rates for non-fatal and fatal accidents at work in period from 2016 to 2021 in construction sector are given [3-8].

Table 2: Incidence rates for non-fatal and fatal accidents at work in construction sector in

construction sector, Republic North Macedonia, 2016-2021

Construction (F)	2016	2017	2018	2019	2020	2021
Non-fatal accidents	1.66	3.35	4.08	4.51	3.90	3.77
Fatal accidents	0.83	0.81	1.05	0.75	0.63	1.13

Source: Macedonian Occupational Safety and Health Association

In the period between 2016 and 2020, there is increase in the incidence rate for non-fatal and fatal accidents at work. From Table 2 evident is that the smallest incidence rate for non-fatal accidents at work in construction sector in Republic of North Macedonia was recorded in 2016, while for fatal was recorded in 2019. The incidence rate of fatal accidents at work in 2020 in the Republic of North Macedonia was 1.13 deaths cases from accidents at work per 100000 persons employed. In Figures 3 and 4 the incidence rates for non-fatal and fatal accidents at work in construction sector in EU-27 Member States and North Macedonia are shown. The range for incidence rates in construction sector among the EU-27 Member States was lowest in Bulgaria (137.54) per 100000, while the highest incidence rate was recorded in Switzerland, at (8480.08) non-fatal accidents per 100000 persons employed. The range for incidence rates in construction sector for fatal accidents at work the EU-27 Member States was lowest in Netherlands (1.02) per 100000 persons employed, while the highest incidence rate was recorded in Malta, at (17.47) fatal accidents per 100000 persons employed.

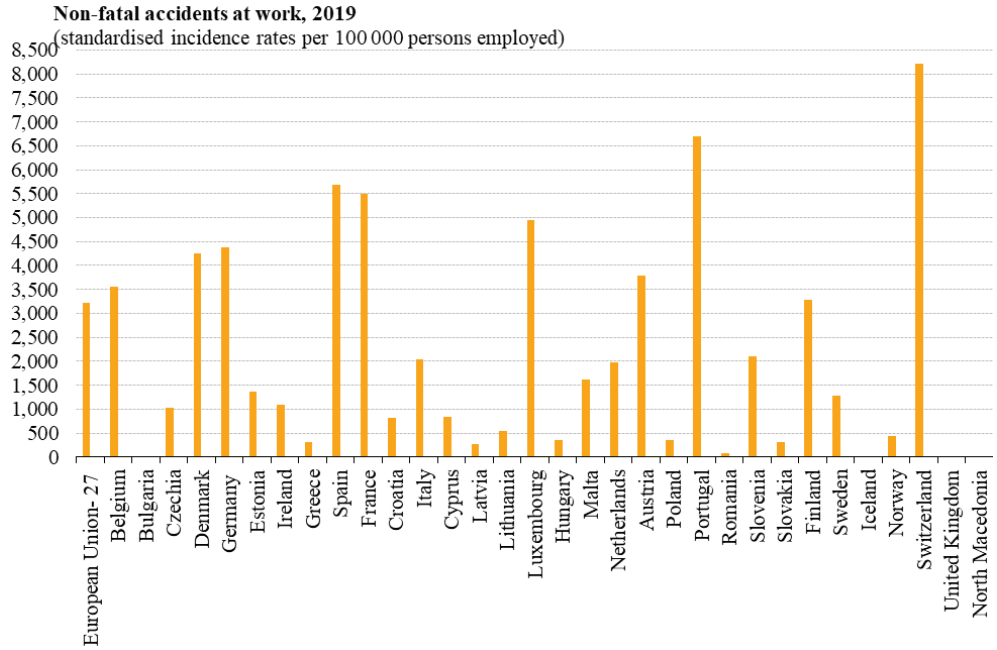

Figure 3: Non-fatal accidents at work in construction sector, 2019 (incidence rates per 100000 persons employed) Source: Eurostat, Last update 20.01.2022

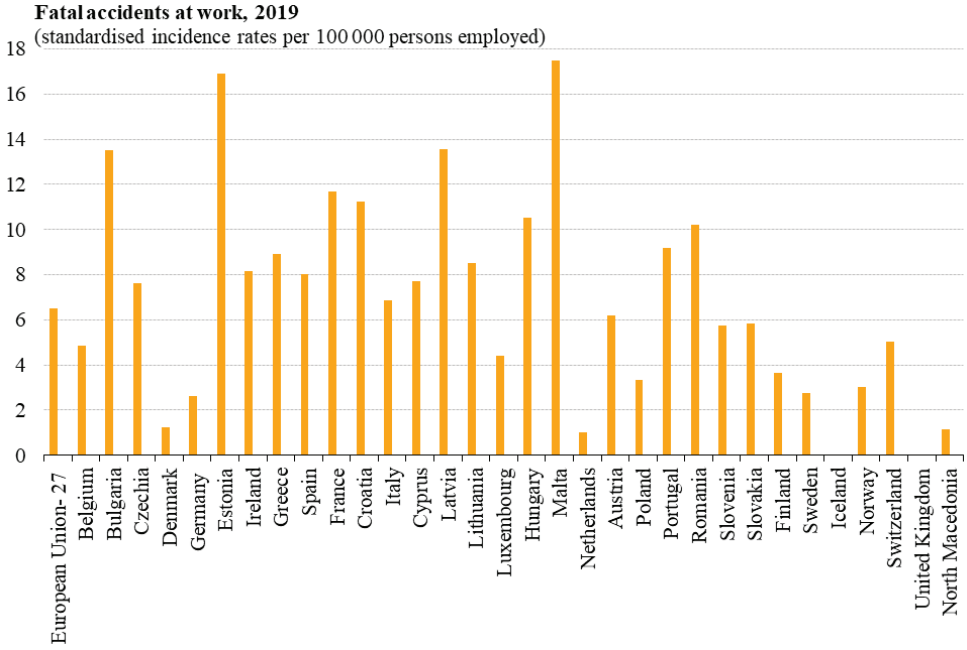

Figure 4: Fatal accidents at work in construction sector, 2019 (incidence rates per 100000 persons employed) Source: Eurostat, Last update 20.01.2022

In construction of buildings in 2019 EU-27 Member States lowest value of incidence rate for non-fatal accidents was recorded in Bulgaria (125.03), while highest value was recorded in Switzerland (8220.45). The lowest incidence rate for fatal accidents at work in construction of buildings was recorded in Denmark and Slovenia (0), while highest value was recorded Malta (36.5) [10]. In comparison with the values of incidence rates of EU-27 Member States, the Republic of North Macedonia can be classified in the country with incidence rates for fatal accidents at work less than 10.

4. CONCLUSION

In this paper some statistical indicators for non-fatal and fatal accidents at work in the Republic of North Macedonia from 2016 to 2021 in construction sector were presented. From the statistical indicators for the number of non-fatal and fatal accidents at work in the Republic of North Macedonia, may be concluded that there is considerable increasing of number of accidents at work in construction sector in relation to 2016. Therefore, it is necessary to build and maintain a national preventive culture and introduce a systemic approach to

managing occupational safety and health at work, as an important prerequisite for reducing the number of accidents at work in the construction sector.

REFERENCES

[1] Hughes, P.; Ferrett, H. E.: *Introduction to Health and Safety in Construction* Routledge, New York, ISBN 9780415824361, (2016).
[2] Mitrevska, C.; Mitrevska, E.; Mitrevski, B.: Statistical indicators for accidents at work in construction sector, *Proceedings of XI International Conference Industrial Engineering and Environmental Protection 2021*, Radoslav, D. (Ed.), pp.539-544, ISBN 978-86-7672-348-5, Zrenjanin, October 2021, Technical faculty Mihajlo Pupin, Zrenjanin, University of Novi Sad, Zrenjanin, (2021).
[3] Annual Report for fatalities, injuries and accidents at work 2016, Macedonian Occupational Safety and Health Association, (2016).
[4] Annual Report for fatalities, injuries and accidents at work 2017, Macedonian Occupational Safety and Health Association, (2017).
[5] Annual Report for fatalities, injuries and accidents at work 2018, Macedonian Occupational Safety and Health Association, (2018).
[6] Annual Report for fatalities, injuries and accidents at work 2019, Macedonian Occupational Safety and Health Association, (2019).
[7] Annual Report for fatalities, injuries and accidents at work 2020, Macedonian Occupational Safety and Health Association, (2020).
[8] Annual Report for fatalities, injuries and accidents at work 2021, Macedonian Occupational Safety and Health Association,(2021).
[9] European Statistics on Accidents at Work (ESAW), Summary methodology, (2013).
[10] Eurostat, Accidents at work statistics, *Published on* https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Accidents_at_work_statistics. Last update 20.01.2022.

OCCUPATIONAL KINESIOLOGY: ADMINISTRATIVE WORKERS

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***Objective**: One of the most significant characteristics of an administrative worker's tasks is sitting and working at a computer. When sitting and working at a computer, workers endure stato-dynamic efforts. Stato-dynamic efforts in the workplace of an administrative worker can cause the occurrence and progression of musculoskeletal disorders, or diseases of the locomotor system. The stato-dynamic efforts of administrative workers should be observed quantitatively and qualitatively. Current practice shows that, when talking about prevention of musculoskeletal disorders in work processes, emphasis is placed on the quantity of work. High workload certainly does not have a positive effect on the health of the locomotor system, but it is also wrong to assume workload is the sole and main culprit for all musculoskeletal disorders. In order to truly claim that administrative workers have some form of musculoskeletal disorders due to the high quantity of sitting and working, it is first necessary to determine whether the worker performs movements and postures in the right way, i.e., whether the quality factors are met. If the worker does not perform these postures and movements in the right way, then the quantity of work cannot be treated as the sole and/or main culprit. Occupational kinesiology looks at the prevention of musculoskeletal disorders primarily through improvement of performance quality of postures and movements during work through educating workers about proper postural movement habits in the workplace. Incorrect postural movement habits are one of the factors that strongly influence the occurrence and progression of musculoskeletal disorders of administrative workers. In the previous sentence, the key word is "habit." Incorrect postural movement habits lead to the appearance of structural and functional changes in anatomical structures, which in combination with the natural aging process, genetic predispositions and other psychosocial factors result in the gradual appearance of degenerative changes in the musculoskeletal system.*

Precisely with the aim of preventing the occurrence and progression of musculoskeletal disorders of administrative workers, the Ministry of Labor, Pension System, Family and Social Policy - Directorate for Labor and Occupational Safety, within the project "Development of e-learning, management and monitoring of occupational safety", co-financed by the European Social Fund, carried out educational and preventive activities aimed at preventing musculoskeletal disorders. The outcomes of these activities are as follows:

- *Implementation of research and preparation of a study entitled Occupational kinesiology: Relationship between posture and movement habits and prevalence of musculoskeletal disorders of administrative workers*
- *Development of a manual for administrative workers on proper postural movement habits and exercise entitled Occupational kinesiology: Proper postural movement habits and exercises with the aim of maintaining health of the musculoskeletal system of administrative workers*

The aim of this research in the field of occupational kinesiology is to determine the prevalence and localization of musculoskeletal disorder symptoms and postural movement habits in the workplace among administrative workers in Croatia. The problem of this research is to determine the possible connection between postural movement habits and the prevalence of musculoskeletal disorder symptoms of administrative workers employed in Croatia. Based on the results of the research, the manual "OCCUPATIONAL KINESIOLOGY - Correct posture and movement habits and exercises with the aim of keeping the health of the musculoskeletal system of administrative workers" proposed targeted recommendations for proper movement and work, as well as active rest with a program of relief exercises specifically tailored to administrative workers and exercising in the office. Through these two project outcomes, occupational kinesiology contributes to the protection of health of the musculoskeletal systems of administrative workers.

This paper will give a brief overview and summary of:

Study: Occupational kinesiology: Relationship between posture and movement habits and prevalence of musculoskeletal disorders of administrative workers

Manual: Correct posture and movement habits and exercises with the aim of keeping the health of the musculoskeletal system of administrative workers

Keywords: *occupational kinesiology, postural and movement habits, musculoskeletal disorder, exercise.*

1. INTRODUCTION

Nowadays, not only do we have less and less time for ourselves, but we have almost no time for it at all. We move less and less, and we sit more and more. We sit at work while on the computer, we sit in the car, we sit in the evening on a couch or an armchair. Neck tension is increasing, our backs hurt. We have the feeling that we have fallen into a vicious circle from which there is no way out. Our bodies cry out for change. We have to change something, but we don't know what. The media informs us that we need to buy specifically their cream, girdle, electrostimulator, exercise device, sleep mattress etc. However, all of the above only alleviate the symptoms and do not solve the cause of pain and neck and back issues. We hope the doctor will recommend an instant solution through miracle pills, but in reality these do not exist.

The representation of musculoskeletal disorders in EU countries is on the rise and presents a significant health and financial problem [1]. It is similar in the United States, where the annual financial loss is around $ 45-54 billion [2] (Institute of Medicine, 2001). One of the more significant characteristics of the work tasks of administrative workers is the work at the computer. When working at a computer, workers endure certain statodynamic efforts. Statodynamic efforts to work with a computer, and according to the Ordinance on Statodynamic, Physiological and Other Efforts [3], which has been in force in Croatia since the end of June 2021, include static efforts

due to prolonged sitting and dynamic efforts due to repetitive movements. The term "efforts" refers to the biomechanical stress endured by the anatomical structures of the body of the worker. This stress refers to kinetic (force), kinematic (movement), oscillator (vibration) and thermal (temperature) energy sources [2]. The EU-OSHA report [4] states that biomechanical stress is an important factor in the onset of musculoskeletal disorders.

In order to really prevent the occurrence or progression of existing painful conditions of the musculoskeletal system in general, and thus back, neck and shoulder pain, it is necessary to listen to recommendations from medicine, occupational safety, ergonomics, but also from the field of occupational kinesiology. We are the ones that have the greatest impact on the health of our spine, joints, muscles, etc., and two important factors are key:

- body postures during daily work tasks,
- targeted exercise.

The postural and movement habits of an administrative worker can be correct or incorrect. Correct postural and movement habits refer to physiological postures and functional movements that directly affect the prevention of musculoskeletal disorders in the form of pain syndromes and overexertion syndromes caused by stato-dynamic efforts in the workplace. Incorrect postural and movement habits refer to non-physiological postures and non-functional movements that directly affect the onset and progression of musculoskeletal disorders in the form of pain syndromes and overexertion syndromes caused by stato-dynamic exertion in the workplace.

Correct postures while performing daily work tasks in the office are a prerequisite for a healthy spine. This project in the area of occupational kinesiology talks about the philosophy called 23:1, which refers to the fact that 1 hour of proper physical activity a day is extremely important, but it is not enough if the other 23 hours we work at the computer, stand, sit, get up, walk, lift different loads, sleep, etc. - incorrectly! Exercise is extremely important, but the effects of even the best exercise programs are quickly lost if we do not adhere to the basics of proper posture on a daily basis.

The best combination for the health of our spine and other musculoskeletal systems is daily application of proper posture and targeted exercise. The targeted exercises presented in this manual are specially adapted for administrative workers and aimed at providing the prerequisites for proper posture, and thus the prevention of pain in the neck, back, shoulders, hips, etc. We notice that one does not go without the other.

It is completely wrong to put an emphasis on the quantity of work when talking about prevention of musculoskeletal disorders caused by stato-dynamic efforts in the workplace. The quantity and quality of stato-dynamic efforts have at least equally strong influence on the occurrence and progression, but also on the prevention of musculoskeletal disorders.

According to the Occupational Safety and Health Act [5], every worker must be trained to work in a safe manner. Accordingly, the administrative worker should also be trained to work safely, from the point of view of the quality of postural movement habits in the workplace, all in order to prevent damage to anatomical structures over time. Sitting down, sitting, getting up, rotating the body, bending, leaning, bending

and rotating, raising the arms above head level, etc. are nothing but basic motor skills that can only be learned through exercise, demonstration, repetition, etc.

Those motor skills are seemingly simple and harmless, but they are not:

- Incorrect long-term sitting can cause back pain and long-term sick leaves of administrative workers
- Incorrect movement when taking documents from the bottom drawer can result in sharp pain, as a result of cumulative low back trauma
- Incorrect head rotations can cause pain in the cervical spine
- Improper position and incorrect movements in the cervical spine while working on the keyboard and monitor can cause dizziness, headaches, painful syndromes in the neck and upper back
- Incorrect hand position when working with a mouse can cause forearm and hand strain syndrome, etc.

There are two main goals of this project in the area of occupational kinesiology. The first goal is to show the most common incorrect and correct ways of body posture when moving and working in the office, as well as raising awareness of the importance of their daily use. The second goal is to present the exercises that are in the function of providing the prerequisites for proper sitting and movement in the office, and thus maintaining and improving the health of bones, joints and muscles of administrative workers.

Numerous scientific studies have shown that a large number of administrative workers have issues with musculoskeletal disorders. Previous research has not determined the postural movement habits of administrative workers in Croatia, as well as the possible connection between the symptoms of musculoskeletal disorders and postural movement habits. The aim of this research in the field of occupational kinesiology is to determine the prevalence of musculoskeletal disorder symptoms and postural movement habits in the workplace among administrative workers in Croatia. The problem of this research is to determine the possible connection between postural movement habits and the prevalence of symptoms of musculoskeletal disorders of administrative workers employed in Croatia.

2. METHODS

2.1. Sample of subjects

The sample of respondents consists of administrative workers who are employed and work in Croatia. The link to the online survey questionnaire created via the digital Google platform was sent to the official e-mail addresses of respondents employed in public administration bodies, employees in the banking system and some other companies. The research was conducted in the period from 10th to 19th of November,

2021. The text of the research invitation contained: a request to complete the questionnaire, an explanation of the research and questionnaire, the purpose of the research, and an estimate of its duration (10 minutes). A total of 1,620 respondents responded to the questionnaire. After the exclusion of unfit respondents, 1,307 respondents entered data processing.

2.2. Sample of variables

The sample of variables consisted of a group of 62 questions with sub-questions that determined the general information about the respondents and the prevalence of musculoskeletal disorder symptoms and postural movement habits of administrative workers. By activating the link and/or scanning the QR code below, the original questionnaire can be obtained.

Link and QR code for the original questionnaire.
https://forms.gle/dnezaeLfda19dy6b9

Standardised Nordic questionnaire for the analysis of musculoskeletal symptoms [6] was used to determine the prevalence of musculoskeletal disorder symptoms by self-assessment. The Nordic questionnaire consists of two parts. The first part of the questionnaire is general and provides information on the prevalence of musculoskeletal disorder symptoms (dull pain, pain, discomfort) in nine anatomical regions of the body (Figure 1) in the last 12 months and the last 7 days. The second part of the questionnaire is specific and provides more detailed frequency information on the prevalence and consequences of musculoskeletal disorders of low back, neck, and shoulders.

2.3. Data analysis

The results were processed by the software package STATISTICA 14.0.0.15. Descriptive statistics methods were used to determine the prevalence of musculoskeletal disorder symptoms and postural movement habits in administrative workers. The connection between postural movement habits and the presence of musculoskeletal disorder symptoms was determined using a series of logistic regression analyzes (logistic regression). To determine the statistical significance of differences between subjects who have and who do not have symptoms of musculoskeletal disorders in certain parts of the body in relation to the correctness of postural movement habits, a chi-square test was applied with a descriptive display of frequencies of certain groups.

3. RESULTS AND DISCUSSION

3.1. Prevalence of musculoskeletal disorder symptoms

After the exclusion of unfit respondents, 1307 respondents entered the data processing, out of which 68.17% (N 891) were women and 31.82% (N 416) were men. The average age of the respondents was 41.95 years. The average body weight of the subjects was about 73 kg The average body height of the subjects was 172.66 cm. The results of the research showed that administrative workers in Croatia, in the 12 months preceding the questionnaire, have shown most symptoms in the low back (71.53%) and neck (69.93%). They have slightly fewer symptoms in the shoulder area (59.83%) and upper back (56.85%). These are followed by wrists/hands (33.66%), then knees (33.13%) and hip/thighs (26.70%). In the previous 12 months, respondents had the fewest symptoms of musculoskeletal disorders in the ankles / feet (18.97%) and elbows (13.47%).

Low back problems experienced by administrative workers in Croatia in the last 12 months (71.53%) show a tendency of slightly higher representation compared to some other studies: 47% [7], 43% [8], 36.6% [9], 40.4% [10], 46.0%, 44.2% and 33.6% [11]. However, some studies have also shown greater representation: 72.4%, [12], 75% [13]. The results of the presentation of symptoms of musculoskeletal disorders in the area of the neck (69.93%) in administrative workers in Croatia in the last 12 months also show a tendency of slightly higher representation compared to some other studies: 38.6% [14] (14 Kumar et al., 2015), 45% [15], 47% [16] , 48% [17], 51% [7], 55% [18], 51% [19], 64% [20]. Likewise, the results of this study show slightly lower values compared to a study that showed greater representation: 76% [21]. It can be noted that neck problems in administrative workers are even greater than in the other studies. The representation of symptoms of musculoskeletal disorders in other studies in the shoulder area ranges from 15.2% [10], 17.2% [22], 42% [23], 45% [8], 47% [7] to 48% [24]. Based on the above, it can be noted that the symptoms of musculoskeletal disorders and problems in the area of the neck, lower back and shoulders represent major public health problems.

3.2. Postural-movement habits and mechanisms of injury

Through 10 questions on postural movement habits, it was found that administrative workers in Croatia largely apply irregular postural movement habits, i.e. mechanisms of injury, and on average each of the presented mechanisms of injury is used daily by about 64% of respondents. Additionally, each respondent applied an average of 6.5 injury mechanisms daily.

3.3. Relationship between the prevalence of musculoskeletal disorder symptoms and postural movement habits

The results of logistic regression analysis showed that those respondents who apply the presented incorrect postural movement habits, i.e., injury mechanisms, are statistically significantly more likely to get symptoms of musculoskeletal disorders in the neck, shoulders, upper back, low back, wrists/arms, hips/thighs and/or knees in relation to those subjects who do not apply the stated mechanisms of injury.

The average probability ratio of each of the 10 injury mechanisms on the occurrence of musculoskeletal disorders in any part of the body is 3.15. Based on the abovementioned results, it can be assumed that incorrect mechanics of movement and work in administrative workers on average increase the risk of musculoskeletal disorder symptoms by more than 3 times.

Non-physiological postures and non-functional movements of administrative workers presented through 10 questions represent the mechanisms of injury most often cumulatively. These are mechanisms of cumulative trauma that depend on both quantity and quality of work. The human body functions as a kinetic chain. Like the domino effect, the position of one part of the body inevitably affects the position of another part of the body. When solving any problem, it is always necessary to find the cause. When it comes to incorrect body posture of administrative workers, it is necessary to start from the center and move towards the periphery and from a sitting position. This specifically means that when studying the most common incorrect postural habits of administrative workers one should start from the hip joint position while sitting. In ergonomics, it is usually said that when sitting, it is necessary to keep a 90˚ angle between the thighs and the torso. Occupational kinesiology approaches this problem in more detail and observes not only the angle of the femur and spine, but also the relationship between the pelvis, sacral bone and lumbar, thoracic and cervical spine, and then other distal parts of the body. With proper posture, the most important thing is that the pelvis, sacral bone and lumbar spine are in a neutral position. If the pelvis is tilted, both the sacral bone and the entire spine are tilted. What is unacceptable is that the pelvis is tilted backwards and the sacral bone and spine are tilted forward. This leads to lumbosacral and lumbar instability development. The ligaments of the lumbosacral part become loose, and there is increased friction and wear of the articular cartilage.

3.4. Theoretical fundamentals of correct and incorrect postural movement habits

Musculoskeletal and cardiovascular system. The segment of human health that primarily depends on movement is divided into health of the cardiovascular and musculoskeletal systems. The quantity of movement is important for the health of the cardiovascular and respiratory system, and the quality of movement is primarily responsible for the health of the musculoskeletal and musculo-tendon systems.

Quality and quantity of movement. The quality of movement is a prerequisite for increasing the quantity of movement, and thus the prevention of cardiovascular system disorders.

Cause of mechanical damage to the spine. Postures and body movements that we repeat countless times every day in the office can be correct and incorrect. Proper postures and movements have the function of maintaining and improving our health, and continuous application of incorrect postures and movements leads to overexertion, and consequently to mechanical damage to our bones, joints, muscles, ligaments, tendons, and our nervous system. Incorrect movement mechanisms impair the health of anatomical structures.

Correct and incorrect movements and postures. The main characteristics of office work are repetitive movements without the use of force and forced positions in the form of prolonged sitting. Prolonged sitting certainly does not help improve one's conditioning or physical fitness, but it is also completely wrong to say that our backs hurt because we sit. It would be more accurate to say that our neck and back hurt because we sit incorrectly. In addition to sitting, there are a number of irregular postures and movements that we should avoid. In this guide you will also find information on the basics of proper sitting, bending over, handling light loads, walking, walking in heels, turning around, working at the keyboard, body posture while using a mobile phone, etc.

Importance of correct postures and movements. The importance of correct postures and movements increases in proportion to the time spent in a position, the amplitude of the movement, the number of repetitions, speed of movement, weight of the load, previous injuries and age.

Time spent in a position. The longer the time spent in an incorrect position, such as with bent back, the more likely we are to feel back pain. It is not just the fact that such sitting will stretch the back muscles and we will feel muscle tension that evening, but the fact that we will only feel the real consequences in the long run.

The amplitude of movements/postures. The amplitude of incorrect body posture plays a major role in the occurrence and progression of mechanical damage and the occurrence of back pain. Imagine sitting with your back slightly bent and yourself with your back strongly bent. We conclude that the greater the amplitude of incorrect movement, the greater the probability of pain, current and long-term, in the back and neck.

Number of repetitions. The number of repetitions does not refer to just one action, for example, lifting a piece of paper from the floor in an incorrect way, i.e., with a bent back. The importance of the number of repetitions refers to the fact that many daily tasks we do in an incorrect way. For example, we sit incorrectly and get up with our backs bent, we bend our back when washing our hands, while sitting and typing, etc. When you add up all the back bending we did in one day, then that is no longer a negligible number. If we add up the monthly number of back bending, then the figure is worrying. If we add up the annual or ten-year number of bends, then it becomes clear to us that we have back problems due to the accumulated small mechanical damages.

Speed of movement. The higher the speed of raising and lowering the torso in an incorrect way, i.e. with a bent back, the greater the risk of instantaneous pain. However, this momentary pain is not the result of a single incorrect movement of back bending but is the result of previously accumulated mechanical damage (cumulative trauma). That one incorrect movement, like lifting a piece of paper off the floor, is just a drop in the bucket.

Weight of the load. Imagine pulling a heavy suitcase out of the back of a car after a business trip. If we pull out and lower this suitcase in an incorrect way, i.e. with our backs bent, then the higher the weight of the suitcase, the higher the probability of injury.

Previous injuries. Imagine a person who is completely healthy and a person who has had lower back surgery. If both people with their backs bent, i.e. incorrectly, pull out and lift a heavy suitcase from the back of the car in such an incorrect way, it is logical to conclude that a person who underwent spine surgery is much more likely to feel pain and get injured.

Age. Imagine an eight-year-old child and an eighty-year-old person. Imagine that both people want to lift a piece of paper off the floor and that they both lift it with their backs bent, i.e. incorrectly. Which person do you think is more likely to feel back pain? Of course, an eighty-year-old person. The reason for this is simple. An older person has long felt and had the consequences of physiological aging, unlike a child who has a completely healthy and young spine. Also, no matter how old we are at this point, now is the right time for us to stop the progression of mechanical damage and pain in the back, neck, shoulders, etc. and allow our joints to recover, thus ensuring more active and healthy aging.

3.5. Practical examples of most common mechanisms of cumulative trauma and mechanisms for keeping the health of the musculoskeletal system of administrative workers

Below is a link and QR code number 1 for a shared reproduction of all 30 educational video clips of most common mechanisms of cumulative trauma and mechanisms for keeping the health of the musculoskeletal system of administrative workers.

Link and QR code number 1. Link and QR for a shared reproduction of all 30 educational video clips of most common mechanisms of cumulative trauma and mechanisms for keeping the health of the musculoskeletal system of administrative workers. https://youtu.be/QKF6HACSG8Y

In the original manual, each cumulative trauma mechanism has both a separate link and a QR code for individual video playback.

3.6. Exercises for correct postures

Years of life. With age, there is a decrease in bone density, muscle mass, collagen content in muscles and tendons, weakening of balance, weakening of intermuscular coordination, etc. All this is part of physiological aging, i.e. the natural aging process. However, did you know that proper daily movement and appropriate physical activity can delay and slow down the natural aging process of the body?!

Physical activities. And did you know that proper physical activity doesn't necessarily have to be a classic exercise? Did you know that going to the countryside, picking apples, cleaning the apartment, putting laundry in the dryer, washing dishes, ironing, vacuuming, painting the walls, dressing and carrying a small child, etc. are also exercises? Our backs don't hurt primarily because we sit, our backs hurt because we sit incorrectly.

The function of this exercise program. This exercise program is primarily aimed at providing the prerequisites for maintaining and improving the health of the musculoskeletal and musculo-tendon system through stability and mobility exercises. The exercise program is not in the function of achieving a greater amount of muscle mass, nor is it in the function of reducing the amount of adipose tissue. This exercise program is in the function of making movement a pleasure again, not an inconvenience as it is now.

Proper posture and exercise. Proper sitting, upright sitting, proper position of the cervical spine and shoulders, etc. presents an effort for us. The main reason for this is an imbalance in ligament and muscle tension, i.e. an imbalance of mobility rather than muscle strength. We are all mobile when we need to bend our backs forward, and we are not mobile when we need to straighten up. We are all mobile when the shoulders need to make an internal rotation, but we are not mobile when we need to straighten the shoulders and keep them that way. It is this imbalance in mobility. This is exactly what this exercise program is for. This exercise program is aimed at achieving optimal balance in mobility and providing other prerequisites for proper posture.

This exercise program affects stability and its components. The balance of administrative workers is especially endangered, so this exercise program specifically emphasizes it. It increases the mobility, i.e., mobility in specific joint systems, those that are critical for administrative workers and which are crucial for achieving and maintaining proper postures and movements. It also has the effect of stimulating circulation, which is slowed down by prolonged sitting. It works to create synovial fluid that "lubricates" the joints. This program activates the exchange of water and nutrients in the "nucleus pulposus" which directly affects the health of the intervertebral disc, and thus the preservation of the intervertebral space, which is necessary to prevent mechanical damage to the spine and its components.

This exercise program is specific because it primarily focuses on the quality and not the quantity of exercises.

The most important movement of this program is the hip hinge (link and QR code number 2). Hip hinge is an essential human movement, movement of movements, the Holy Grail of a healthy spine. It is a movement that, when learned, preserves the health of the spine. It is a movement that prevents overexertion and mechanical damage to the spine.

Link and QR code number 2. Link and QR code for reproduction of the educational video clip „Hip hinge“

https://youtu.be/yKocTynMfac

It is a movement we need to use every time we tilt the torso. It is a movement that allows the torso to be lowered and tilted with a straight back, and the axis of rotation is in the hip joints. Best of all, with this movement we activate the buttock muscles every time we lean this way. Hip hinge is a movement used in many exercises. In the exercise "deadlift", the hip hinge is the main movement. If a person were to learn from this whole manual and apply only one single movement technique every day, then it should be the hip hinge. If all people instead of tilting the torso with a bent back bent the torso in a hip hinge way, i.e. this movement, it is likely that the number and intensity of musculoskeletal problems in the low back, but also in other parts of the body, would be significantly lower.

This exercise program is called "Exercises for proper posture" because it is its most important function and ultimate goal. The recommendation for exercising is that we should get up, walk, and do a few exercises every time we feel the need to move, when we feel that we are "stiff". It is recommended that these exercise packages be done in the office, but if you do not have the conditions to exercise in the workplace, you can also exercise at home. Additionally, not all exercises necessarily have to be performed at once, but partially, when you feel the need for movement and physical activity during the workday. This program consists of two sets of different exercises. Both sets of exercises consist of 10 dynamic exercises and 10 static exercises. The first set of exercises is basic and the second is advanced. In the beginning, a basic set of exercises should be done, and after a while, you should move on to advanced ones. The number of repetitions at the beginning should be 10, and later it can be up to 20. At the beginning, one series is necessary, and later up to 3 series in one day. Below you can find a link and QR code number 3 and 4 for a shared reproduction of all exercises from the basic and advanced programme.

Link and QR code number 3. Link and QR code for a shared reproduction of all 20 exercises from the basic programme.
https://youtu.be/F2eRX9gOsBM

Link and QR code number 4. Link and QR code for a shared reproduction of all 20 exercises from the advanced programme.

https://youtu.be/KmGu41A3LPo

Regardless of these recommendations, everyone should exercise in accordance with their current physical abilities and state of fitness. If you have additional questions, seek the advice of a kinesiologist.

4. CONCLUSION

The natural aging process combined with improper mechanics of movement are factors that strongly influence the onset and progression of musculoskeletal disorders of administrative workers. Correct postural movement habits have a positive effect on the prevention of overexertion syndrome, degenerative changes, and painful conditions, reducing the likelihood of recurrence of old painful conditions, and in general on maintaining and improving physical health. The things we do every day have the biggest impact on our health. Correct movement patterns and proper daily movements should become our lifestyle, a new form of exercise, the primary form of fitness.

Incorrect postural movement habits are nothing but mechanisms of cumulative trauma. The results of the research indicate the need to introduce systematic education of current and future administrative workers on proper and safe ways of working. In order to effectively act on the primary and secondary prevention of musculoskeletal disorder symptoms caused or associated with stato-dynamic loads in the workplace, it is necessary to primarily avoid the mechanisms of cumulative trauma through the application of physiological postures and functional movements. Contents of the manual “Occupational kinesiology - Correct posture and movement habits and exercises with the aim of keeping the health of the musculoskeletal system of administrative workers” is based on the results of study “Occupational kinesiology: relationship between posture and movement habits and prevalence of musculoskeletal disorder of administrative workers” and is the basic literature for education of administrative workers, students, kinesiologists, occupational safety experts, ergonomists, occupational medicine specialists, doctors and all other experts involved in the occupational health system of administrative workers, on proper and safe postural and movement habits in the workplace. Since prevention is the most cost-effective measure for the prevention of musculoskeletal disorder, it is proposed to introduce lectures and exams in basic principles of occupational kinesiology not only for vocational but also for all other high schools. Additionally, it is proposed to introduce lectures and exams in occupational kinesiology at colleges. For more information see the original research [25], and original manual [26].

REFERENCES

[1] Schneider, E.; Irastorza, X. & Verjans, M.: *OSH in figures: Work-related musculoskeletal disorders in the EU - Facts and figures. European Agency for Safety and Health at Work*, European risk observatory report, (2010).

[2] Institute of Medicine.: *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities*. National Academies Press, Washington, DC, (2021).

[3] Pravilnik o zaštiti na radu radnika izloženih statodinamičkim, psihofiziološkim i drugim naporima na radu, Narodne Novine, 73/21. *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2021_06_73_1375.html *Accessed:* 2022-06-14

[4] Vandekerckhove, S.; Lenaerts, K.; Szekér, L., Desiere; S., Lamberts, M. & Ramiou, M.: *Musculoskeletal disorders and psychosocial risk factors in the workplace — statistical analysis of EU-wide survey data*. European Agency for Safety and Health at Work, Report, (2021).

[5] Zakon o zaštiti na radu, Narodne Novine, 71/14, 118/14, 94/18, 96/18. *Available from* https://www.zakon.hr/z/167/Zakon-o-za%C5%A1titi-na-radu *Accessed:* 2022-06-14

[6] Kuorinka, I.; Jonsson, B., Kilbom; A., Vinterberg, H. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics*, 18(3), 233–237, (1987).

[7] Juul-Kristensen, B. & Jensen, C. Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: The "BIT" follow up study on office workers. *Occupational and Environmental Medicine*, 62(3), (2005).

[8] Shikdar, A. A. & Al-Kindi, M. A.: Office Ergonomics: Deficiencies in Computer Workstation Design. *International Journal of Occupational Safety and Ergonomics*, 13(2), 215–223, (2007).

[9] Giahi, O.; Khoubi, J.; Barkhordari, A.; Darvishi, E. & Ebrahemzadih.: M. Daily visual display terminal use and musculoskeletal disorders among Iranian bank tellers. *Journal of Advances in Environmental Health Research*, 2(1), 1–6, (2014).

[10] Kumar, R.; Pal, L. & Moom, N.: Prevalence of Musculoskeletal Disorder among Computer Bank Office Employees in Punjab (India): A Case Study. *6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015*, Procedia Manufacturing, 6624-6631, (2015).

[11] Campos-Fumero, A.; Delclos, G. L.; Douphrate, D. I.; Felknor, S. A.; Vargas-Prada, S.; Serra, C.; Coggon, D. & de Porras, D. G. R.: Low back pain among office workers in three Spanish-speaking countries: Findings from the CUPID study. *Injury Prevention*, 23(3), 158–164, (2017).

[12] Mohammadipour, F.; Pourranjbar, M.; Naderi, S. & Rafie, F.: Work-related Musculoskeletal Disorders in Iranian Office Workers: Prevalence and Risk Factors. *Journal of Medicine and Life*, 11(4), 328–33, (2018).

[13] Bontrup, C., Taylor, W. R., Fliesser, M., Visscher, R., Green, T., Wippert, P., & Zemp, R. Low back pain and its relationship with sitting behaviour among sedentary administrative workers. Applied Ergonomics, 81(June), 1–8, (2019).
[14] Kumar, R.; Pal, L. & Moom, N.: Prevalence of Musculoskeletal Disorder among Computer Bank Administrative Employees in Punjab: A Case Study. *6th International Conference on Applied Human Factors and Ergonomics*, 6624–6631, India, (2015).
[15] Johansson, J. Å.: Work-related and non-work-related musculoskeletal symptoms. *Applied Ergonomics*, 25(4), 248–251, (1994).
[16] Melrose, A.; Graveling, R.; Cowie, H.; Ritchie, P.; Hutchison, P. & Mulholland, R.: *Better Display Screen Equipment (DSE) workrelated ill health data*. Institute of Occupational Medicine for the Health and Safety Executive, Research Report, (2007).
[17] Prodanovska-Stojchevska; V., Jovanovic, J.; Jovanovska, T. & Isjanovska, R.: Evaluation of computer workstation ergonomics and prevalence of the musculoskeletal symptoms—A cross sectional study of Macedonian office workers. *Healthmed*, 6(10), 3532–3537, (2012).
[18] Klussmann, A.; Gebhardt, H.; Liebers, F. & Rieger, M. A.: Musculoskeletal symptoms of the upper extremities and the neck: A cross-sectional study on prevalence and symptom-predicting factors at visual display terminal (VDT) workstations. *BMC Musculoskeletal Disorders*, 16, 1–16, (2008).
[19] Zejda, J. E.; Bugajska, J.; Kowalska, M.; Krzych, Ł.; Mieszkowska, M.; Brozek, G. & Braczkowska, B.: Upper extremities, neck and back symptoms in office employees working at computer stations. *Medycyna Pracy,* 60(5), 359–367, (2009).
[20] Ayanniyi, O.; Ukpai, B. O. O. & Adeniyi, A. F.: Differences in prevalence of self-reported musculoskeletal symptoms among computer and non-computer users in a Nigerian population: A cross-sectional study. *BMC Musculoskeletal Disorders*, 11:177, (2010).
[21] Griffiths, K. L.; Mackey, M. G. & Adamson, B. J.: Behavioral and psychophysiological responses to job demands and association with musculoskeletal symptoms in computer work. *Journal of Occupational Rehabilitation*, 21(4), 482–492, (2011).
[22] Žitnik, Z.: *Anketno istraživanje zastupljenosti nekih muskulo-skeletalnih poremećaja kod korisnika računala (diplomski rad).* Filozofski fakultet, Odsjek za psihologiju, Sveučilište u Zagrebu, (2006).
[23] Bogadi, A.: Zdravstvene smetnje pri radu s računalom. *Available from* http://www.hzzzsr.hr/wp-content/uploads/2016/11/Zdravstveni-aspekti-rada-s-računalom.pdf *Accessed:* 2022-06-14, (2018).
[24] Isusi, I.: *Work-related musculoskeletal disorders – Facts and figures (Syntesis od 10 national reports).* European Agency for Safety and Health at Work, (2020).
[25] Nakić, J.: *Occupational kinesiology: relationship between posture and movement habits and prevalence of musculoskeletal disorder of administrative workers*. Ministry of Labour, Pension System, Family and Social Policy, Republic of

Croatia, Zagreb. *Available from* https://uznr.mrms.hr/wp-content/uploads/2022/06/Prirucnik-web.pdf *Accessed:* 2022-06-14, (2022).

[26] Nakić, J.: *Occupational kinesiology: correct posture and movement habits and exercise with the aim of keeping the health of the musculoskeletal system of administrative workers*. Ministry of Labour, Pension System, Family and Social Policy, Republic of Croatia, Zagreb. *Available from* https://uznr.mrms.hr/wp-content/uploads/2022/06/Prirucnik-web.pdf *Accessed:* 2022-06-14, (2022).

2

OCCUPATIONAL SAFETY

RISK ASSESSMENT - BASIC DOCUMENT IN THE OCCUPATIONAL SAFETY SYSTEM

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Abstract: *The main objective and purpose of risk assessment is to determine the level of danger, harmfulness and effort in terms of appearance of occupational injury, occupational diseases, diseases related to work and disturbances in the labour process which could cause harmful consequences for the safety and health of workers. Although employers are obliged to make a risk assessment and inform workers about the risks assessed, this obligation is avoided. It is therefore necessary to make employers aware that risk assessment is their legal obligation and that it is the fundamental document of the occupational safety system.*

Keywords: *Risk assessment 1, health protection 2.*

1. INTRODUCTION

The employer shall ensure that the employee is provided with risk assessments for the workplace and tasks to be performed in that workplace. On the basis of risk assessment the employer shall be obliged to apply occupational health and safety rules, preventive measures, organize and implement work and production procedures as well as undertake other actions to prevent and reduce the exposure of employees to the identified risks in order to avoid or to reduce to the lowest possible level the likelihood of injuries, occupational diseases or diseases in relation to work with the purpose of providing a better level of occupational health and safety at all stages of the organization of work. They also must define and determine who will perform occupational safety activities in the company. It can be himself or his authorized officer, employed occupational safety expert or occupational safety expert employed by an authorized company for performing occupational safety tasks, which depends on special regulations.

When conducting inspectional supervision with employers, it has been established that one of the most frequent deficiencies is that employers do not have a prepared risk assessment or does not correspond to the actual situation or does not contain all the items prescribed in the Ordinance on risk assessment. The aim of this paper is to inform employers about the obligation to make risk assessment and point

to them the importance of completeness of this most important document in the occupational safety system.

The main objective of risk assessment, besides determining the level of danger, harmfulness and effort, is to plan measures to remedy defects and improve occupational safety systems, and the purpose is to completely avoid the possibility of accident/illness or to minimise them. Additional advantages of risk assessment include:

- developing awareness of possible dangers, dangers and efforts;
- identifying persons at increased risk of injury or disease;
- defining a list of compulsory personal protective equipment;
- defining the period of testing of working equipment and means of work;
- assessing the effectiveness of existing measures in terms of risk reduction and in terms of economic and other factors;
- creation of a basis for the preparation of a quality training programme for work in a safe manner;
- reducing employers' economic losses;
- fulfilment of legal obligations of employers.

Figure 1 : Pathogram for methodological risk assessment

The risk assessment shall be carried out with the active participation of the workers carrying out the work and taking into account their views. Workplace is not a term defined by law, but is often used in practice (in the case of job systematization, employment contracts, internal regulations of employers, collective agreements, etc.). As regards the preparation of risk assessments, the workplace is a set of tasks carried out at certain places of employment.

2. RISK ASSESSMENT

The risk assessment must be based on the situation encountered with regard to the application of (basic and specific) occupational safety rules with the employer and shall represent a document subject to audits in accordance with changes in the technological process. During the preparation of the evaluation, a number of questions, conditions and methods and contents of the preparation are asked, and clear and unambiguous answers have to be given. Through risk assessment, all relevant elements are analysed, such as the type of work performed and their nature, work means used during work, working environment, workplace arrangement, organisation of work process etc.

Risk assessment shall be made in accordance with the risk assessment matrix according to the general criteria and in accordance with the special Regulation. It is created by an occupational safety expert employed by an employer or occupational safety expert of level II who is employed in an authorised company for performing the tasks of preparing risk assessment. In the risk assessment, along with occupational safety experts, participation of workers working with employers is obligatory. The occupational safety expert must document and prove the participation of the worker by including, in support of the risk assessment, a form with personal data of the worker, which the worker is obliged to sign personally.

Interactive Internet tools (OiRA) related to work in certain professions or activities may also be used to assess and document the risk assessment, when these tools are placed on use through the website of the ministry responsible for work.

The risk assessment shall contain information on the place of work, the analysis and assessment of the data collected, the plan of removal measures, or the reduction of the level of risk, damage and effort, and documentation. It is very important that workers realise that no job is absolutely safe and accordingly they must continuously be aware of the possible risks, and it is extremely important that they adapt their behaviour to possible dangers, harmfulness and efforts during their performance.

Information on the place of work shall include data on:

- employer: name of the company, head office, OIB, activity of employer, start of work of the company, name and surname of the person representing the company and data on the number of workers broken down by sex and other characteristics;
- organisation of work and schedule of working hours;
- the method of conducting occupational safety tasks;
- occupational safety experts;
- employer's powers to implement occupational safety and training;
- the Workers' Council;
- commissioners and coordinators of workers for occupational safety and their trainings;
- workers qualified to provide first aid;
- selected specialist in occupational medicine;
- the Committee for Safety at work;
- organising evacuation and rescue and conducting exercises;

- participants in the preparation of the risk assessment;
- the qualifications of workers for work in a safe manner;
- implementation of health checks for workers working in work with special working conditions;
- a description of the workspace;
- a description of the work process;
- place of work;
- analysis of injuries at work.

The first step of the analysis is to check the application of basic occupational safety rules. If the protection of workers it cannot fully ensure the application of basic occupational safety measures, the application of special occupational safety rules is approached.The analysis and evaluation of the collected data shall be carried out for all work carried out by the workers with the employer and shall include:

- identification of hazards, harmfulness and effort;
- assessment of danger, harmfulness and effort;
- identification of measures to eliminate or reduce hazards, harmful or effort.

Identification of hazards, harmfulness and effort is carried out with the participation of workers, and it is necessary to bear in mind that in addition to technical equipment and working process a major role in the injury is played by the human factor, so special attention should be paid to psychosocial risks. The assessment of hazards, harmfulness and efforts is carried out by an occupational safety expert in collaboration with a doctor specialising in occupational medicine. It is therefore important that the occupational safety expert be appropriately trained and knows the work process. The acceptability of risks depends on the technological development of the company, the state of safety and safety at work, the application of national and international regulations and standards, the professional qualifications of workers and other factors important for the safety and protection of workers' health. Risks cannot be avoided, therefore it is necessary to carefully assess whether the risk is acceptable. If the risk is acceptable, appropriate safeguards and preventive or corrective measures should be established taking into account the general principles of prevention.

The new Ordinance on the safety at work of workers exposed to statodynamic, psychophysiological and other work efforts brought novelties related to the preparation of a risk assessment for the safety and health of workers during manual handling of cargoes and related to methods for assessing the burden of workers during manual handling of cargoes and during repeated tasks. Calculation of worker workload during manual handling of cargo or during repeated tasks means work performed by a worker.

Hand handling of cargo has two components: weight of cargo and time needed to carry cargo. The bigger the burden, the slower the task can be done. Likewise, the smaller the weight of cargo, the greater the number of repetitions of the work operation can be. Hand handling of cargo means any of the following activities carried out by one or more workers: lifting, holding, lowering, pushing, withdrawing, carrying or moving cargo. Repetition of a task is defined by the frequency of movement and number of performance of work operations (tasks), that is, it answers the question of how often one operation is repeated per minute, and how long it is performed during a work shift. Tasks with a high frequency of repetition can be

identified as recurring tasks, which means that the duration of one cycle of a single operation is less than 30 seconds. Movements are quite short in duration, constantly or frequently repeated and are usually always the same. In working processes they mostly include hand movements. Limit values shall take into account the sex, the height to which the cargo is raised and the distance of the cargo from the body. Exceeding these values indicates an increased risk of injury and damage to the movement system. Risk assessment is carried out by comparing the weight of goods and values in individual zones. When handling the cargo through more than one zone, the lower value of the cargo shall be taken into account. If the weight of the load exceeds the limit values and/or the operation is repeated more frequently than once every two minutes, the risk level assessment should be carried out using a special method in accordance with the provisions of the Ordinance.

The risk level assessment shall also be carried out for each work task where manual handling of cargo is present and should be carried out separately for "lifting — posture — transfer" and "withdrawal — push". The calculation of the final value and the assessment of the overall risk level for "lifting — holding — transfer" shoud be calculated according to the following formula: UO = (T2 + T3 + T4) × T1 where: T1-load time; T2-weight of cargo; T3-location of the body; T4-working conditions. The calculation of the final value and the estimate of the overall risk level for "drag-push" should be calculated according to the following formula: UO = (T2 + T3 + T4 + T5) × T1 (if the female invoice is multiplied by factor 1.3) where: T1-load time; T2-mass of cargo; T3-precision in positioning and movement speed; T4-body position; T5-working conditions.

The risk level assessment when performing recurring tasks should be carried out for each work task where recurring tasks are present and must be carried out separately for the right and left hand, if due to the working process, there is a difference in the number of movements of each hand according to the following formula: UO = (T2 + T3 + T4) × T1 where T1 is the duration of the work task; T2-value of recurring movements; T3-value of the power required; T4-body position.

If a worker performs several actions described above, it is very important to point out that when calculating the risk size in the risk assessment, only the total burden with the highest number of points is taken into account.

The plan of measures for removal or reduction of the level of danger, damage and ef fort shall contain:

- deadlines;
- the authorised persons responsible for the implementation of the measures;
- the manner of control over the implementation of the measures.

Based on established irregularities and non-compliances, the planning of measures or procedures to reduce the estimated risks is approached, that is, to improve the state of occupational safety and the safety and protection of workers' health. These measures and procedures do not in practice cover only the procedures to be implemented because they are prescribed by law or subordinate legislation (e.g. testing and examination of working equipment and the working environment, ensuring inspection of specialists of occupational medicine for work with special working conditions etc.). The measures are taken with the aim of improving occupational safety status and encompass all activities that can improve the system (e.g. provision of colotur or

hydraulic lifting lifts; ensuring quality personal protection of equipment; restoring work training in a safe manner, etc.). Therefore, in the plan of measures, the emphasis should be placed on preventive activities rather than activities that have to be undertaken because it is a legal or sub-legal obligation.
The documentation of the risk assessment shall contain personal data of the workers involved in the preparation of the risk assessment. Other Annexes such as the questionnaire for psychosocial risk assessment, the calculation of risks to workers' safety and health in the handling of cargo, records on the position and examination of work equipment and the working environment, a list of applications and omissions of basic occupational safety rules, etc. can also be documented.

3. CONCLUSION

Risk assessment is a basic document in the occupational safety system that an employer must draw up in order to fulfil his legal obligation, but also in order to implement health and safety protection at work of his workers. All activities identified in the risk assessment analysis and all measures identified should be carried out effectively and in synergy of all stakeholders, starting from workers, through the management of enterprises to legal and natural persons authorised to carry out the risk assessment. In doing so, it is necessary to adhere to certain deadlines in order to act proactively and successfully, all with the aim of improving the occupational safety system. The risk assessment should be up to date and should correspond at any time to the current occupational safety situation with the employer. In this sense, the employer is expected to obligatory involvement of workers in the preparation of risk assessment, and employees are expected to express their views regarding everything that can influence the determination of possible hazards, harmfulness and efforts during the performance of work, on the basis of which the type and level of risk will be determined. If the total burden of workers handling cargo shows an increased or higher risk to workers' health, employers are obliged to provide workers with appropriate technical equipment and take appropriate organisational measures to reduce the risk of damage to the movement system. Only through joint cooperation between employers, workers and occupational safety experts can the occupational safety system be improved and workers' health preserved. Working in a safe manner means thinking at all times about the risks that surround us when doing business. Occupational safety requires discipline, accountability and compliance with rules without deviation and errors. Therefore, employers must become more responsible and actively involved in the preparation of the risk assessment and must update it in a timely manner.

REFERENCES

[1] Occupational Health and Safety Act (Official Gazette 71/14, 118/14, 94/18 and 96/18)

[2] Ordinance on the preparation of risk assessment (Official Gazette 112/14 and 129/19)
[3] Ordinance on the safety at work of workers exposed to statodynamic, psycho-physiological and other work efforts (Official Gazette 73/21)

Requirements for working on high voltage systems of electric vehicles and components of electric vehicles

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Abstract: *The goal of the paper is to meet people about new needs for training and requirements for employees on special working condition jobs that are not listed in Ordinance on special working condition jobs – specifically for work on High voltage systems on electric vehicles (batteries, powertrains, vehicles). The paper compares Croatian requirements by law regulation and real needs for safe work (trainings, medical examination, PPE, risk assessments, signs, instructions), based on Rimac Technology and Bugatti Rimac experience and needs. One of the main reasons of informing people about this topic is raising awareness about dangers of high voltage systems on electric vehicles (and their components) and hopefully sharing knowledge and experience amongst HSE profession.*

Keywords: *occupational health and safety, special working condition jobs, high voltage training, electric vehicles, lithium-ion batteries*

1. INTRODUCTION

At a time when new technologies and knowledge are taking over the world around us, whether in the engineering, production, testing or simulations world, occupational safety is also changing its concept and meaning.

Rimac Technology and Bugatti Rimac implements different codes of practice and norms from around the world and develops new, specific trainings and educations for their employees focused on healthy and safe work around and with hazardous and dangerous materials, components, and work procedures. High voltage training is safety training divided in levels for different access to high voltage components and work.

The goal is also to raise awareness about hazards of components of electric vehicles so the whole system of occupational safety, fire protection and environmental protection in Croatia could be a part of the improvement in their field on the international level.

2. HAZARDS OF HIGH VOLTAGE WORK

High voltage (HV) in the automotive sector, particularly in hybrid and fuel cell technology and on electric vehicles, high voltages comprise voltages > 60V and ≤ 1500 V DC and 30 V and ≤ 1000 V AC.

Most common hazards when working with high voltage systems on electric vehicles are electrical current through human body, lightning arcs, and secondary accidents due to electrical current.

The consequences of these hazards are leaving psychological, physical, and chemical effects such as: muscle contraction, nerve shakes, external burns, fluid losses, blood pressure increase, cardiac arrest, ventricular fibrillation, electricity marks, external burns, fluid losses, internal burns, glare, electric arcs.

3. EMPLOYERS REQUIERMENTS FOR HIGH VOLTAGE WORK

3.1. Requirements for high voltage work area

High voltage work needs to be defined by risk assessment for any phase of work with high voltage components, prepare work area and people to work safely and be safe in the vicinity of high voltage work, which means:

- Designate area with barriers and hazard signs of prohibition, obligations, and information
- Draft a Risk assessments for different stages of high voltage work area
- Draft clear work procedures and instructions for work in a safe manner (for equipment, components, chemicals, use of PPE, first aid kit, fire protection devices)
- Inspected all equipment before start of work and make sure that is suitable for high voltage work (orange colour)
- Maintain personal protective equipment and test it before every use

Figure 1: High voltage work area [1]

3.2. Requirements for employees working with high voltage systems

For employees is very important to determine a role that they have in the high voltage work/area, which are following [1]:

- Employees who don't work with high voltage or in high voltage area
- Non-electrical workers
- Works for electrical work in non-live state
- Workers for live electrical work

Beside the role of the employee, there is a type of high voltage work [1]:

- Non-electrical work comprise task on vehicle, such as mechanical work (e.g., panel work, oil and wheel changes, brake component replacement in the proximity of wheel hub motors, work on dampers in the proximity of the HV lines) and electrical work on the conventional vehicle electrical system (up to 30 V AC and 60 V DC)
- Electrical work comprises tasks on or involving electrical systems or within their hazard area, such as trialing and measurement, repair, replacement of components, modification, extension, erection, and testing
- Live electrical work on HV systems is any work on the HV system during which an employee's body or items (tools, devices, equipment, or apparatus) encounter live parts, or work during which the non-live state is not assured

When the roles and type of work are determined, employees are taking training based on their needs [2],[3]:

Level 0: Awareness training

For whom: Employees and students – awareness training

Trainer: Internal trainer (Onboarding H&S training)

Topics of the level:

- HV Terms, definitions, legislation, and standards
- Safety signs and instructions
- Electrical hazards and risk
- Requirements for working in a high voltage area
- Permit procedures, roles, and responsibilities

Requirements for accessing the training:

- Rimac Technology/Bugatti Rimac employee or student

Level 1: Fundamental training – non-electrical work

For whom: non-electrical workers who carrying out all non-electrical work which is required on a vehicle or installations containing HV systems

Trainer: External company (EVALUS GmbH)

The goal of the training: train employees to be able to work on the vehicles safely, to understand their structure and principles of safe work, and to be familiar with the markings of the components.

Topics of the training:

- Operation of vehicles and associated equipment
- Performance of general tasks which do not require isolation of the HV systems
- Performance of all mechanical tasks on the vehicle (except orange!)
- Isolation of the HV system, additional safety measure in the form of withdrawal and plugging in of the service LV disconnect/maintenance plug
- Appointment of the individual to be consulted in the event of uncertainty
- Impermissible work on the vehicle

Requirements for accessing the training:

- 18+ age
- Rimac Technology/Bugatti Rimac employee or student

Level 2: Fundamental training - dead work

For whom: workers for disconnection and electrical work in the non-live state

Trainer: External company (EVALUS GmbH)

The goal of the training: to provide theoretical and practical knowledge in safe working for employees carrying out electrical work on HV systems on the vehicle and around the vehicle and components in the non-live state.

Topics of the training:

- Basic electrical knowledge
- Electrical hazards and first aid
- Measures for protection against electric shock and fault arcs
- Organization of safety and health for electric work
- Specialist and man-management responsibility
- Employee qualifications in electrical engineering
- Use of HV systems in the vehicle
- Design and function of vehicle electrical systems

Requirements for accessing the training:

- 18+ age
- Electrical engineering basics
- Entry exam in electrical basics
- Experience in mechanical and electrical work
- Rimac Technology/Bugatti Rimac employee or student

Level 3: Fundamental Training – live work

For whom: workers for live electrical work on high voltage systems

Trainer: External company (EVALUS GmbH)

The goal of the training: provide theoretical and practical knowledge in safe working for employees carrying out electrical work on n HV systems on the vehicle and components in the live state.

Topics of the training:

- Definition of the scope

- Conditions for live work on HV systems: competence of the employees, organization of the work, protective and other equipment to be used
- Electrical instrumentation and performance of measurements in accordance with the electrical standards
- Circuit engineering
- Use of tools in electrical fitting work
- Laying and securing of wiring
- Creation and wiring of circuits according to circuit documentation
- Sensor technology in control engineering
- Connection and operation of peripheral equipment
- Function testing on digital switching devices and circuits
- Fault analysis, systematic troubleshooting, use of vehicle or system diagnostics equipment
- Elimination of faults
- Practical exercise

Requirements for accessing the training:

- 18+ age
- Medical examination by Ordinance on jobs with special working conditions ('Official Gazette', no.5/84), Article 3, Paragraph 10 [4]
- First aid for work with HV
- Certificate from Level 2 HV training
- Experience in mechanical and electrical work
- Rimac Technology/Bugatti Rimac employee or student

4. CONCLUSION

Occupational safety and health act defines employers' obligations such as implementing general principals of prevention and basic, specific, and recognized health and safety rules. For requirements such as work with high voltage on electric vehicles and their components, there are no clear and defined steps that need to be taken for safety of employees, so Rimac Technology and Bugatti Rimac apply recognized rules for insuring safety of their employees – mandatory high voltage trainings for different roles in HV work, medical examination for HV Level 3 employees, prescribing suitable personal protective equipment and setting up safe HV work area.

Companies are using practices from around the world to learn about the best ways to protect their employees, by connecting it with their needs and tailoring it to make the perfect program for all Croatian companies with electrical future.

REFERENCES

[1] Kartal D: *Electric Vehicle Access Level II+III (training material)*, EVALUS Arbeitssicherheit und Gesundheitsschutz GmbH, Berndorf, (2019)
[2] Deutsche Gesetzliche Unfallversicherung: Training for work on vehicles with high voltage systems, *Available from* https://publikationen.dguv.de/dguv/udt_dguv_main.aspx?MMRSV=1 *Accessed:* 2022-06-14
[3] Deutsche Gesetzliche Unfallversicherung: Qualifizierung für Arbeiten an Fahrzeugen mit Hochvoltsystemen, *Available from* https://publikationen.dguv.de/dguv/udt_dguv_main.aspx?MMRSV=1 *Accessed:* 2022-06-14
[4] Ordinance on jobs with special working conditions, 'Official Gazette', no. 5/84, *Available from* https://digarhiv.gov.hr/arhiva/18/18255/www.hidra.hr/hidrarad/pobirac-upload/CD-1947-2000/023669.pdf *Acessed:* 2022-06-14

CONCEPTUAL DEFINITION OF RISK

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Abstract: *Risk is a multidimensional concept, i.e. a term, and as such it is often mistranslated, and thus misunderstood and misinterpreted in practice. The paper gives an etymological review of the concept risk. A number of academic and administrative definitions of the concept (term) risk have been analyzed. Due to the limited size of the paper, the methodology of definition analysis is not presented, but only the results of the analysis used as a basis for one approach to conceptual definition of risk in the context of uncertainty of the outcome of an event with the expected negative consequences, i.e. the conceptual definition of risk determined by the probability and consequences of an event.*
Key words*: risk, probability, consequences.*

1. INTRODUCTION

Risks are present in all forms of human activity. Modern aspects and scope of development of modern society contribute to the increase in the number of potentially dangerous events, in a narrower sense for human life and health, and in a broader sense for the entire environment. To a greater or lesser extent, the values and functioning of the system, society and communities are endangered. Technology has taken a key position in the "world" of risk, in terms of decision-making, organization, improvement and harmonization of systemic links among different social structures, analysis of alternatives at different levels of management, and selection of optimal technologies. Consequently, there are complex conditions for decision-making, due to increasing uncertainty based on advances in technology, information technology and the creation of new values in society.

Risk, as a phenomenon, contains certain elements that determine its essence: (1) the choice of alternatives; (2) the possibility of deviating from the required purpose for which the choice of alternative has been made; (3) the probability of achieving the desired goal /value/result; (4) lack of confidence in achieving the set goal; and

(5) the possibility of material, human, environmental and other losses associated with the realization of the chosen alternative in conditions of uncertainty.[1]

The aforementioned implies the multidimensionality of the conceptual definition and the presence of risks in modern society, but also the complexity of the processes that seek to identify risks, i.e. to manage them. The focus in these processes lies on the decision-makers, i.e. decision-making as a part of the planning function, but also other process functions of management. Consequently, decision-making is the essence and focus of all changes.

In order to better understand the multidimensionality of risk, i.e. the application of risk management in practice, there is a need for proper understanding, interpretation and comprehension of risk as a concept or term. The above-mentioned has been the aim of this paper, in which a number of academic and administrative definitions of the concept (term) risk were presented. Based on the analysis of definitions, the basis for the conceptual definition of risk was established, which is determined by the probability of the occurrence and the consequences of an event.

2. ETYMOLOGY OF THE CONCEPT OF RISK

The etymology of risk is based on the interpretation of risk as historical and economic category. In the historical context, risk is inextricably linked to all stages of social development and is focused on the possibility and level of human knowledge of potential danger. Risks viewed as a historical category are known as "pure risks". In economic terms, risk is the possibility of the occurrence of an event that can have both positive and negative effect, or that can also have no effect on the expected outcome. Risks viewed as an economic category are called "speculative risks".

The concept risk appeared at the end of the 15th century in European languages. The concept risk (English: risk, French: risque, Italian: rischio, Spanish: riesgo, Portuguese: risco, German: risiko) is related to various synonyms or correlative concepts: danger, exposure to danger, gambling, hazard, chance, randomness, possibility, speculation, riskiness, probability, threat, endangerment, insecurity, fear. The concept risk has often been used in maritime and trade activities. In the first place, this concept was used in terms of insurance in economic activities.

The use of the term "risk" was primarily related to the explanations of the following phenomena: (1) dangers that threatened ships from rocks and / or cliffs; (2) a bold, courageous feat, that is, the completion of a business deal that was fraught with dangers or when there was a great possibility of losing the initial investment; (3) the loss or damage suffered; (4) conscious exposure to danger and (5) giving up the business deal, if it would be assessed that there was no expected profit.[2]

Very quickly, the concept risk began to be used in activities related to insurance in economic activities, banking, but also in many other spheres of human activity. However, in order to introduce the concept "risk" into science, and thus treat it as a

term, it was necessary to define it more precisely, but attempts to give a single definition in all areas of research did not lead to results, precisely due to the multidimensionality of this concept, which quickly found its application in various scientific fields, i.e. scientific disciplines (probability theory, economics, existential philosophy, nuclear physics, decision theory). Consequently, depending on the theoretical orientations and interests of researchers, the authors define risk in different ways.

Consequently, in the literature, from the academic point of view, the concept risk means:

the possibility of loss or injury, or exposure to such a possibility;[3]

a condition in which there is a possibility of harmful deviation from the desired outcome;[4]

a combination, or product of the probability of the occurrence of damage and the scope of the damage;[5]

a measure of the probability and consequences of an uncertain future event and is a function of a series of parameters;[6]

objective uncertainty which, as a rule, happens as the occurrence of an undesirable event;[7]

a measure of the likelihood of the occurrence of adverse consequences for life, health and environment as a result of a certain danger;[8]

the possibility of realizing the adverse consequences of an event;[9]

(Italian: rischio, French: risque) originally: the danger that threatened the ships from the rocks and cliffs; later: danger, exposure to danger, daring feat; a business deal or investment connected with the potential failure; insurance; commercially: insured goods, insured item."[10]

a measure of the probability of the occurrence of technogenic or natural phenomena that are characterized by the occurrence, formation and effect of hazards, as well as social, economic, environmental and other types of losses and damages;[11] and so on.

From the administrative point of view, risk is defined as:

a combination of the probability that the disaster will occur in a certain period of time and with certain negative consequences;[12]

"the effect of uncertainty on goals";[13]

the likelihood that the potential for injury will be realized under conditions of use and / or exposure, as well as the possible degree of injury;[14]

"the chance that something happens that would affect the goals";[15]

a combination of the probability of the occurrence of a dangerous event or exposure and the severity of the injury or threat to health (damage to health), which may be caused by a dangerous event or exposure;[16] and so on.

Based on the presented definitions, risk in general can be determined as a function of various parameters, among others:

$$R = f(H, V, E, CC, R, M, P, C \ldots) \quad \textbf{(1)}$$

where:

H – Hazard;
V – Vulnerability;
E – Exposure;
CC – Coping Capacity;
R – Resilience;
M – Manageability;
P – Probability;
C – Consequences.

The analysis of definitions also distinguishes between two common constituents of risk, namely: (1) unwanted loss / consequence / due to the occurrence of an adverse / negative / event and (2) uncertainty of the occurrence of loss or consequences. An adverse event occurs as a consequence of the initiating mechanism-source of danger which is the essence of the critical point / trigger /, after which it is no longer possible to influence the adverse event or its effects on the surroundings / environment / in which the adverse event was initiated.

3. ONE APPROACH TO THE CONCEPTUAL DEFINITION OF RISK

Risk is a combination of the probability of the occurrence of an adverse event and the consequences that an adverse event causes, i.e. the uncertainty of the occurrence of consequences for the environment in which the adverse event was initiated. Consequently, the risk represents the uncertainty of achieving the goals. However, a clear distinction should be made between the concepts of risk and uncertainty – risk is always a "chance" with an undesirable outcome, i.e. when there is a possibility of a favorable or unfavorable event, risk is always a measure of the probability of the occurrence and consequences of an adverse event.

Figure 1 gives a schematic representation of the possibility of determining the risk observed through the prism of the distribution of the probability of the occurrence of an adverse event (abscissa) and the occurrence of an adverse event (ordinate). The positive parts of the axes of the coordinate system determine the certainty, i.e. the knowledge of the probability and consequences, and the negative parts the uncertainty, i.e. the ignorance of the probability and consequences of the adverse event. The first quadrant is an ideal case, when the probability and consequences are known, the occurrence of adverse events can be predicted, there is no uncertainty, i.e. it is a case of "certainty", and the risk can be measured and managed accordingly. The second quadrant illustrates the case of "subjective uncertainty", i.e. the probability of the occurrence of an adverse event is unknown, but the consequences are known, so the decision-maker based on pragmatic experience, theoretical knowledge and intuition can subjectively assign risk

preferences. This method is desirable in some situations, but the problem that arises is how decision-makers implement their subjective inputs in the formal decision-making process.

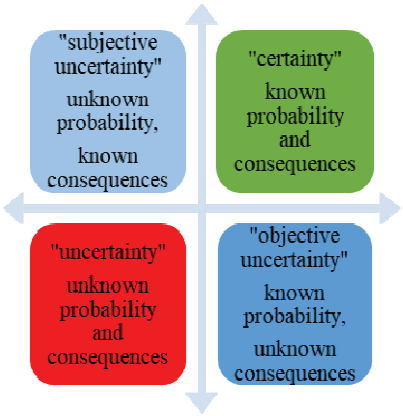

Figure 1: Determining risk using the probability of the occurrence and consequences of events

The fourth quadrant is the case of "objective uncertainty", when the distribution of the probability of the occurrence of an adverse event is known, but the consequences (outcomes) of the adverse event are not known. In this case, the risk cannot be precisely determined, but the possibility of the occurrence of an adverse event can be determined, i.e. the factors that combine into critical points can be determined, so based on their characteristics, the potential consequences of adverse events can be defined. The third quadrant is the case of "uncertainty", i.e. when there is no possibility of defining the factors that represent the initiating mechanism, because neither the probability of the occurrence nor the consequences of an adverse event are known. Here, the risk cannot be determined by probability and consequences, so we try to examine other parameters that determine the risk, such as the parameters given in the formula (1).

4. CONCLUSION

One of the characteristics of the modern age is the permanence of changes in all spheres of human life and work. The relationship between science and the frequency of changes is causal and reversible, because science is most often the cause of changes in human activity, and thus the living and working conditions of people, which determine the spheres of scientific research interests in terms of benefits of the existing state. In modern society, the concept "risk", i.e. the term as the linguistic definition of a concept in science, has become one of the most frequent. Depending on the sphere of action, interests and / or research of people, in which the concept / term risk is used, it also gets its own definitions, i.e. meanings.[17]

In the first part of the paper, the focus was on the etymology of the concept (term) risk, as well as a review of a certain number of definitions of risk as the basis for conceptual definition. In the second part of the paper, a step-by-step illustration of one approach to the conceptual definition of risk was given:

- analysis of academic and administrative definitions of risk (due to the scope, the methodology according to which the analysis had been performed was not given, but only conclusions),

- the conclusions from the analysis were used to prove the correlation between the concepts of uncertainty and risk, and

- the correlation of these concepts is the basis for determining the risk using certain parameters, among which the probability of the occurrence and the consequences of the occurrence of a risky (harmful, negative) event particularly stand out.

The results obtained in the paper at the level of scientific description represent the proof of existing knowledge on defining the concept (term) risk, but also the contribution to further understanding of risk as an interdisciplinary and multidimensional concept (term).

REFERENCES

[1] Савић, С.; Станковић, М.: *Теорија система и ризика*, Академска мисао, ISBN 978-86-6087-002-9, Београд, 2012
[2] Гроздановић, Д. М.; Стојиљковић, И. Е.: *Методе процене ризика*, Факултет заштите на раду, ISBN 978-86-6093-049-3, Ниш, 2013
[3] Вујошевић, М.: *Оперативни менаџмент – квантитативне методе*, ДОПИС, Београд, 1997
[4] Vauglan, E. J.: *Risk Management,* John Wiley & Sons Inc, New York, 1997
[5] Николић, Б.; Гавански, Д.: *Машине, оруђа за рад, уређаји – радно место и околина*, ВТШСС, ISBN 978-86-84853-79-2, Нови Сад, 2010
[6] Каровић, С.: *Кризни менаџмент*, Медија центар „Одбрана", ISBN 978-86-335-0439-3, Београд, 2015
[7] Rowe, W. D.: *An Anatomy of Risk*, John Wiley & Sons Inc, New York, 1976
[8] Sage, A.: *Systems Engineering for Risk Management – Computer supported Risk Management*, Kluwer Academic Publishers, Netherlands, 1995
[9] Чупић, М., Сукновић, М.: *Одлучивање*, Факултет организационих наука, ISBN 978-86-7680-145-9, Београд, 2010
[10] Вујаклија, М.: *Лексикон страних речи и израза*, Просвета, Београд, 1980
[11] Цхадая, Н. Д.; Подосенова, Н. С.: *Управление безопасностью труда*, ЦентрЛитНефтГаз, Москва, 2008

[12] *Закон о смањењу ризика од катастрофа и управљању ванредним ситуацијама*, Службени гласник РС број 87/2018
[13] *ISO/IEC Guide 73 – Risk Management – Vocabulary* u SRPS ISO/IEC 27005:2017, Институт за стандардизацију Србије, Београд, 2017
[14] Council Directive 89/391/EEC, *The introduction of measures to encourage improvements in the safety and health of workers at work*, Official Journal of the European Union, 12th June 1989
[15] *Standards Australia & Standards New Zealand – AS/NZS 4360:2004, Available from*: http://www.finance.gov.au/Comcover/conferences *Accessed:* 2022-05-11
[16] SRPS BS OHSAS 18001:2008, Институт за стандардизацију Србије, Београд, 2008
[17] Ковачевић, Н.: *Модел процене ризика употребе понтонирских јединица у ванредним ситуацијама*, докторска дисетација, Војна академија, Универзитет одбране, Београд, 2021

INDUSTRY 5.0 FROM THE PERSPECTIVE OF SAFETY AT WORK

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Abstract: *Since Germany's introduction and implementation of the Industry 4.0 concept in 2011, all EU countries and the rest of the world have been undergoing a massive digital transformation. This entails not only boosting production by incorporating all current means of production, such as modern ICT solutions and robotics, but also introducing new expert profiles and ways of working. And, as that process became increasingly intensive, a new phrase, Industry 5.0, emerged in 2015. This concept focuses on human potential as well as different ways to use IoT and Big Data to improve human job and talents. Its goal is to bring people who work with robots in automated industrial situations together. It is obvious that protecting worker safety and well-being includes not only physical health in the workplace, but also mental health, autonomy, dignity, privacy, and inclusion. Thanks to new technologies and Industry 5.0, we can have safer and more productive jobs thanks to connected workers.*

Keywords: *Industry 5.0, human-centric approach, cobots, safety at work, inclusiveness.*

1. INTRODUCTION

The term and concept "Industry 4.0" (I4.0), as a new strategy for the development of German industry, was presented at the Hannover Messe 2011 and announced as the beginning of a new 4th Industrial Revolution (4IR). It is presented as a means of increasing the competitiveness of the German manufacturing industry through the increasing integration of "Cyber-Physical Systems" (CPS) into factory processes. [1] Hundreds of years have passed between the previous three industrial revolutions, and this one has already arrived after half a century. The first was started in the 18th century by the energy of water and steam, which enabled a higher degree of mechanization (construction of the first loom powered by steam in 1784). The lower need for human labor and the dismissal of workers has caused great social unrest, workers' revolt and the destruction of these machines. In the 19th Century, electricity replaced steam energy, beginning the 2nd Industrial Revolution (construction of the first mechanized slaughterhouse in Cincinnati in 1870). The 3rd Industrial Revolution was marked by the use of electronic and information-

communication systems, and on their basis the wide application of automation in production processes (application of the first Programmable Logic Controller in 1970). According to some authors [3], I4.0 is not a new industrial revolution, but a continuation of the 3rd Industrial Revolution based on intensive modern technological development. But the fact is that this development based on modern information and communication solutions is so powerful that it deserves the term 4IR. Furthermore, each of the industrial revolutions brought a new attitude of employers toward workers, as well as a change in their place in society, in addition to raising the intensity and lowering production costs. The emergence of I4.0 and the intensive robotization of production have also had a strong impact on the status of workers in production and society. And as this process became more intense, in 2015 a new term Industry 5.0 (I5.0) appeared. [1, 2, 3]

The aim of this paper is to analyze the characteristics of I4.0 and the shifts brought by I5.0, their differences, connections, as well as the impact on the status of workers from the perspective of safety at work.

2. METHODS

The applied research methodology includes the analysis of available written and online sources. The collected information is supported by our own experiences of accelerated digital transformation (DT) during the COVID-19 pandemic in Croatia and the world [4].

3. CHARACTERISTICS OF INDUSTRY 4.0

As stated in the introduction, I4.0, also known as the 4IR, denotes a shift in the way people live, work, produce, and manage business and public resources. The path of technological adaptation to the realization of this concept is called DT. DT relies on the accelerated development of information and communication technology, but there are also changes in people's understanding of the necessary changes in all segments of activity, as well as changes in curricula, which must create new staff to support the realization and sustainability of this concept. [4, 5] The impacts of this concept on companies are basically: localized and identified production series that provide more knowledge about the production process; connectivity within the organization; adaptability and ability to optimize the production process through continuous collection of external and internal data; competitive advantage; individualization of production according to customer requirements and greater connection with customers. From the perspective of workers, the impacts are: additional requirements for employees, training (IT knowledge); greater involvement in the innovation process; a new kind of human-machine interaction with less worker presence inside the factory; support for smart

assisted systems; decentralized structures and governance forms; more decision-making space. Organizational connectivity is crucial and is based on vertical and horizontal integration. Vertical integration implies networked production systems that approach changes in the production process through alternative strategies. The regulatory framework for vertical integration is the "Smart Factory". Production blocks will no longer be static and predetermined. [2] IT configuration rules will be defined from which a specific production structure will be created. Horizontal integration implies optimized flow of raw materials and information from different suppliers in the global value chain to end users. Connected IT systems monitor the needs for raw materials in all steps at the global level. Based on the information, they can create production plans and thus forward requests to suppliers in real time for components and raw materials for production. [2] The technological solutions and trends on which the above functionalities of I4.0 are based, ranked in order of importance, are: Internet of Things (IoT); big data analytics; additive technologies (3D printing with various materials), advanced (autonomous) robotics; smart sensors; augmented reality; cloud computing; energy storage; artificial intelligence; nanotechnology; synthetic biology; simulation; man-machine interface; mobile devices; cyber security; quantum computation. IoT has many different definitions, and one of the shortest is the global network that connects smart things (International Telecommunication Union, 2012). It is a collection or set of things (objects or devices) that can be monitored and provide information wirelessly over the Internet utilizing the most common monitoring or management mobile application. In addition to communication, it includes devices, infrastructure and applications. The offer of applications to users takes place using software platforms (IoT platforms) that integrate things and continuously collect their data. This necessitates the processing of massive amounts of data (Big Data), typically in real time, as well as the consolidation and recording of data from various sources in a unique manner. The leading new paradigm is machine-to-machine (M2M) communication. Not just between machines in the factory, but communication between all existing devices and systems. The industry is believed to have several reasons for introducing networked software into machines and products in the classic industrial division of design, production, and support of products and services. Artificial intelligence and robotics are an integral part of current and upcoming changes. Today, an industry without the application of robotics is unthinkable. In previous applications, robots have usually been in cages or behind workstation fences. Changing their position and role is a fundamental idea of the coming changes i.e., it is believed that intelligent machines that learn independently, that are adaptable and can take into account their environment, should naturally cooperate with people. According to the vision of the 4IR, robots and humans should work together and perform tasks. It should be emphasized that although robots are given a greater role, the central idea is that they adapt to humans, not the other way around. Robots are expected to have the following capabilities: locating and navigating, computer vision, adaptive planning, multi-agent strategies. Larger robotic systems play an important role in a number of industrial activities, from the automotive industry to the biotechnology sector. Another change brought about by DT is the way data is collected. For many years, companies have made decisions

based on information obtained from a variety of traditional sources, including production reports, internal reports, market research studies, and so on. Today, there are many more available data sources, including data generated by sensors in smart products, as well as data from Internet search engines or social media. Big Data Analytics opens up new opportunities for companies in the form of advertising that allows them to stay on top of current trends and opportunities in international markets without having to invest significant resources in local marketing, as well as more efficient procurement, production, and distribution. The ability to process and analyze this collected data for further use is exactly what makes this technology very valuable. However, it should be emphasized that a prerequisite for the functioning of these systems is good broadband Internet coverage, the unavailability of which is a major brake on DT in less developed countries. Three-dimensional (3D) printing has revolutionized the way products are manufactured and delivered. Traditional production processes are subtractive, which means that the material is removed from the workpiece using proper equipment, resulting in the shape of the given object. Parts and components are assembled to create the final object. In contrast, 3D printing is an additive process by which an object is obtained by laying different layers of material in succession. Products can be better adapted to the needs of end users as 3D printing allows the production of small quantities in a much shorter time with optimization of material consumption and no waste. [2, 4, 5] It is true that this industrial revolution is also creating a surplus of labor within certain occupations. But on the other hand, it creates new jobs in professions that include the development, management and application of smart systems. For this purpose, it was necessary to adjust the education, which is intensively focused on STEM (science, technology, engineering and mathematics) areas starting from primary education. In the field of higher education, there is an insistence on innovative projects of university entities that must be brought to a prototype ready for use in the economy or the creation of new start-up companies. [1] The emergence of the COVID-19 pandemic has significantly accelerated all these changes in the economy, public services and education. Enormous efforts have been made to digitize all of these systems almost overnight and bring them closer to the ideal of I4.0. In fact, the development took place in order to adapt and survive in the new situation. In terms of humanity, society has become almost completely contactless. [5, 6] Critics of I4.0 point out that technological advances and robotics have led to new forms of alienation and exploitation of workers (robots dictate the pace of work) with the goal of intensively increasing production and capital. Education is focused on the use of advanced systems for learning management and distance communication. They believe that I4.0 brought complete "dehumanization", the rise of technology above man and the consequent alienation. [6, 7]

4. WHAT DOES INDUSTRY 5.0 BRING?

First of all, it should be noted that the development of I5.0 or the 5IR is still based on intensive technological development and improvement of information and communication systems defined in the concept of I4.0. However, instead of taking

new technology as a starting point and examining its potential to increase efficiency, the human-centric approach puts fundamental human needs and interests at the heart of the production process. Instead of wondering what we can do with new technology, we wonder what technology can do for us. Instead of asking industry workers to adapt their skills to the needs of rapidly evolving technology, we want to use technology to adapt the production process to the needs of workers e.g., to guide and train them. It also means ensuring that the use of new technologies does not jeopardize the fundamental rights of workers, such as the right to privacy, autonomy and human dignity. A worker for a company is no longer a "cost" but an "investment". This means that the employer is interested in investing in the skills, abilities and well-being of its employees, in order to achieve its goals. Clear boundaries are being lost between the so-called white and blue collars. In addition to human-centric orientation, I5.0 must adhere to the concepts of sustainability and resilience. Resilience refers to achieving a higher degree of robustness in industrial production i.e., prevention of disturbances and providing support to critical infrastructure in times of crisis. Crises, such as the COVID-19 pandemic, have highlighted the fragility of our current approach to globalized production. This approach should be balanced by the development of sufficiently resilient strategic value chains, adaptable production capacities and flexible business processes, especially where value chains serve basic human needs, such as health care or security. So, the three key factors of Industry 5.0 are: a human-centric approach, sustainability and resilience. [7]

In terms of production workers, some authors (Østergaard H. E.; Rada M.) argue that after the industry is reorganized according to the I4.0 paradigm, even the small number of workers that remain would work like machines. They agree that man should be returned to industrial production with the use of new techniques such as collaborative robots (cobots). [8, 9] For example, company “Universal Robots” has embraced this concept in response to large companies focused on I4.0, and their robots have become the most widely accepted collaborative robots. The company points out that I5.0 is more "anti-industrial" than industrial, because it is a return to the time before industrialization, a return to a time when skills and crafts were valued, when each product was unique according to the customer's wishes. Over time, it has become widely accepted that I5.0 is a new type of human-robot collaboration that takes advantage of both machines and humans' talents. I4.0 achieved the sale of goods to a known customer prior to production, and I5.0 introduces the option of further bespoke production specifications. [10]

Machines are more precise and with more power, and workers possess skills, as well as cognitive and critical thinking. [11] This mode of operation is suitable for jobs that are between fully manual assembly and fully automated production lines. Working with cobots allows companies of any size to implement automation even in places where it is unprofitable or difficult to implement. This is supported by the growing desire of customers for personalized products according to their wishes and needs. This breakthrough into the processes of production through the collaboration of cobots and humans, some authors also call the revolution of "human touch". [9, 10, 11] It is believed that this is the return of workers to the production process, taking advantage of the benefits of automation and cognitive abilities of people.

Cobots cannot be considered a revolutionary invention, but it is a logical evolutionary step in the development of robots. They are getting more and more sensors to be able to perceive the environment, recognize objects and their position in space, and the built-in higher level of artificial intelligence enables adequate decisions to be made. [10] The concept of I5.0 was also reflected in the change of educational approach. Its purpose explicitly refers to the specific outcomes that people need to achieve as a result of a particular learning experience. It's not about handing out laptops or tablets to every student. It's not just about bettering infrastructure and connectivity. It's not about creating digital platforms and tools. Instead, it's about preparing students to be intellectually, socially, and emotionally strong persons, while also considering their health and personal development, as well as general motivation, creativity, and restoring students' joy of studying. Digital equipment, infrastructure, and platforms are still important, but only as drivers, not as the purpose itself. It is taken into account not only the needs of the market / company (employability), but also the needs of society and students. It provides "big picture education," emphasizing how the educational offer fits into the overall learning path, labor market, and global development, and students are viewed as change agents who are actively involved in curriculum development and implementation. [6]

5. CONCLUSION

I4.0 is a concept aimed at establishing "Smart Factories" in which all activities, from communications to production, are automated in order to maximize profit. Because the number of employees is decreasing and the structure of employees is changing, new knowledge, particularly in the field of informatics, is required. This concept is mainly intended for production plants that produce large quantities of products, which can be different, personalized, but use the same type of work technology. Because the end product is increasingly influenced by the customer's requirements, factories that generate high-volume products are evolving into factories that produce mass products. I5.0, on the other hand, focuses on the interaction between humans and machines. The collaborative work of humans and robots combines human creativity and skill with the speed, productivity and precision of robots in order to create new commercial and social values. I5.0 is human-centric and returns "human touch" to production. Although this concept of work can be applied to huge industries, it is best suited to medium and small companies where full automation is not possible or cost-effective, and market demand is increasingly looking for products personalized to consumer preferences. There are some technological operations in large industrial businesses where full automation is neither cost-effective or very difficult, thus this type of collaborative work between cobots and employees is cost-effective. For instance, there is great potential for collaborative work in the field of plant maintenance. I5.0, according to certain critics and theorists, is not a significant upgrade to I4.0, nor even a new industrial revolution. However, based on the comparison of these two concepts

presented, we can conclude that this is a significant organizational and production transformation that alters social and economic relationships and places the man-worker at the center while respecting his privacy, autonomy, and human dignity, as well as his true capabilities in order to be included in society and the economy. Aren't these some of the most important characteristics of the industrial revolution?

REFERENCES

[1] Nikolić, G.: Industrija i obrazovanje, Andragoški glasnik, Vol. 21 (2017), No. 1-2, p. 37-48, ISSN 1331-3134

[2] Croatian Chamber of Commerce: Industry 4.0, Available from: https://www.hgk.hr Accessed: 2022-06-01

[3] Roser, C.: A Critical Look at Industry 4.0 (2015), Available from: http://www.allaboutlean.com/industry-4-0/ Accessed: 2022-05-15

[4] Kralj, D.; Mehmetaj, D.: The Impact of The Covid 19 Pandemic on the Dynamics of Digital Transformation - Croatian Perspective, International Journal of Computer Science and Engineering (IJCSE), Vol. 11 (2022), No. 1, p. 1-16, ISSN: 2278-9979, DOI: 10.5281/zenodo.5818060

[5] Franc, S.; Dužević, I.: Digitalna transformacija i trgovina, Sveučilište u Zagrebu, Ekonomski fakultet, ISBN 978-953-346-115-1, Zagreb, (2020)

[6] Dervojeda, K.: Education 5.0: Rehumanising Education in the Age of Machines, Available from: https://www.linkedin.com/pulse/education-50-rehumanising-age-machines-kristina-dervojeda Accessed: 2022-05-15

[7] European Commission: Industry 5.0: Towards a sustainable, human-centric and resilient European industry, Publications Office of the European Union, ISBN 978-92-76-25308-2, Luxembourg, (2021)

[8] Rada, M.: INDUSTRY 5.0 - Human Industry, Available from: https://www.linkedin.com/pulse/industry-50-human-michael-rada/, Accessed: 2022-05-15

[9] Østergaard, H.E.: Industry 5.0 – Return of the human touch, Available from: https://blog.universal-robots.com/industry-50-returnof-the-human-touch Accessed: 2022-06-02

[10] Østergaard, H.E.: WELCOME TO INDUSTRY 5.0, Available from:https://info.universal-robots.com/hubfs/Enablers/White%20papers/Welcome%20to%20Industry%205.0_Esben%20%C3%98stergaard.pdf?submissionGuid=00c4d11f-80f2-4683-a12a-e821221793e3 Accessed: 2022-05-02

[11] InfinityQS: Inside the Next Factory of the Future: Industry 5.0, Available from: https://www.infinityqs.com/blog/april-2017/inside-the-next-factory-of-the-future-industry-5 Accessed: 2022-05-02

WIND POWER PLANTS – SAFETY AT WORK

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Abstract: *Wind energy is a relatively new industry with great potential. However, although wind farms are among the "green" energy producers, they pose significant risks to workers. This industry is developing rapidly and often workers are not sufficiently trained to work safely, are exposed to many new risks and are often not sufficiently aware of all the dangers that can result in serious injuries, death and occupational diseases. They work at height, in confined spaces with mechanical hazards and electric hazards. They mostly work in isolated areas, are often surrounded by the sea and exposed to bad weather and strong winds. The paper presents the types of wind farms and the risks to safety and health protection in some of them, as well as in the production, installation, maintenance, dismantling and disposal and recycling after life.*

*Key words**:** wind power plant, occupational health and safety, risk, health protection*

1. INTRODUCTION

Today, wind is one of the main renewable energy sources. Due to the development of technology, efficiency and economy, wind currently seems to be the most promising source of energy of the future, and is already a significant source of electricity of the present. The use of wind energy dates back to the time when people first set sail on ships and thus made long journeys possible. For a long time after the first sails, wind energy was used to perform mechanical work in the mills and to start water pumps. With the invention of electricity, wind power plants began to be used for the purpose of producing the same, so that today it would be one of the main sources of energy for the near future.

This source will be important for achieving the European renewable energy target for the next period, combating climate change, strengthening energy security and creating new jobs. Given the new energy crisis that is shaking the whole world, in the EU and thus in Croatia, the emphasis is on the production of energy from renewable sources. Namely, Croatia expects a strong increase in the use of energy from renewable sources and predicts that by 2050 it will double production and meet its electricity needs.□□1□

The capacity of new European wind power plants in 2019 was 15.4 GW. Of that, three-quarters goes to onshore and a quarter to offshore wind power plants. □2,3□

There are no exhaust emissions during the operation of wind power plants, which reduces CO2 and SO2 emissions. The positive side is that wind power plants can be located on arable land, agricultural land or open sea, and under the pillars of the wind farm can be performed agricultural, livestock and similar works.□□4□
However, workers in the wind energy sector are exposed to hazards that can result in deaths and serious injuries during the various phases of the wind power plants project. They are exposed to harmful substances, work at height, work in confined spaces, etc. For offshore wind power plants, extreme weather conditions lead to additional and more specific hazards. Wind energy is a relatively new industry, and some of the workers are often not fully aware of the dangers that exist in the work environment. In addition, the speed used by the EU wind industry has led to a lack of skills among workers. Inexperienced workers are involved in processes for which they are not trained, and therefore their safety and health are endangered. □5□

2. TYPES OF WIND POWER PLANTS

Wind power plants use wind to generate electricity. The kinetic energy of the wind is first converted into mechanical energy by the rotors of the wind power plant and then into electricity, which is transferred into the grid. □6□
Wind power plants are installed both onshore, including inland and costal installations, and offshore, those installations that are located away from the coast. Whether located onshore or offshore, wind power plants consist of similar components: a tower, which rests on a substructure or foundation; a nacelle, which sits on top of the tower; and a rotor assembly, which connects to the nacelle and includes a hub to which the blades are attached and which will hold them in position as they turn. The nacelle, the 'brain' of the turbine, contains large primary components such as the main axle, gearbox, generator, transformer and control system and other mechanical components. Most commercial wind power plants have three rotor blades.

The existing types of wind power plants also are: high-altitude wind power plants and micro power plants.□□7□

3. OSH RISKS

Over the years there has been a large number of reviews and reports that have focused on the evidence of the health and safety impacts of wind power plants. These reports vary in range and depth and have been undertaken by international governments, independent scientific institutions, expert panels and supporters and opposers to wind energy developments. The one thing that all these studies have in common is that they highlight the potential impacts of wind power plants on the health of local populations. The impact and effects that a wind power plants development can have on public health and the environment have been widely

documented, but none of these reports considers the OSH risks to which workers are exposed.

To ensure that health and safety remains a top priority throughout the wind industry, more research is required on the OSH implications for staff working on wind turbine projects.□□9,10□

3.1. OSH risks - Design

The design process should be seen as the best place to 'design out' hazards and risks and help to prevent or minimise work-related accidents and ill health throughout the turbine's entire life cycle. Prevention through design is a concept that requires a holistic understanding of the entire life cycle process, and is relevant in the development of new technologies, processes and materials in the wind energy sector. This is a concept that should be promoted as a cost-effective means of preventing or reducing work-related accidents and health problems and enhancing OSH within the sector.

Discussion between designers and contractors can often result in a number of engineered solutions and more efficient operations that will minimise the amount of time workers spend on hazardous activities at all stages of the wind power plants life cycle, for example employing remote diagnostics to reduce service and maintenance frequency. Minimising the need to visit wind power plants decreases the number of operational maintenance hours, and therefore the overall risk to personnel. Some of the newer wind turbine concepts, such as floating platform technologies and airborne wind power plants or kits, can potentially reduce the number of falls from height and musculoskeletal problems because they can simplify some of the more difficult tasks. The longer design lives of some components in wind power plants also improve the OSH of workers simply because they spend less time working in and around them on unscheduled maintenance tasks. One such example is the use of nanomaterials in smart paint. Smart paints were developed to help reduce weathering effects on wind power plant components. The conductivity of the paint has also allowed for the use of remote control sensors and remote robots that can closely inspect the integrity of wind turbine blades from a remote control room. However, the use of nanomaterials raises potential issues for workers involved in manufacturing and at any other stage where repairs or decommissioning work might result in exposure to the paint or dusts containing carbon nanotubes or other nanomaterials. There is some evidence that some types of carbon nanotubes may have asbestos-like effects.□□9□

3.2. OSH risks - Production

The production of wind power plants and all parts employs almost 60% of workers in the wind energy sector. The International Labor Organization considers that their production poses dangers to workers similar to those in the automotive and

aerospace industries. Workers are exposed to a number of hazards associated with manual handling, use of machinery and equipment, electrical hazards, noise and hazardous chemicals. The most commonly mentioned chemicals are epoxy resins and glass-reinforced plastics (GRP). Synthetic epoxy resins are used in paints, adhesives or composite materials. They are used in production, so there is a risk of infection with the appearance of allergies and dermatitis. Wind turbine blades are made of GRP, so worker exposure to the solvent (styrene) released during the process is difficult to control, especially since wind power plant blades can be up to 90 meters long. □11□

In addition to the chemical hazards of exposure to epoxy resins, styrene and solvents, other harmful gases, vapors and dusts generated during the manufacturing process must be taken into account. Dust and fumes from fiberglass, hardeners, aerosols and carbon can cause health problems including dermatitis, dizziness, drowsiness, liver and kidney damage, chemical burns and effects on the reproductive system.

Newer production facilities are investing in modern production processes, such as robotic spray booths or vacuum-assisted resin transfer, which reduces workers' exposure to hazardous substances and direct contact. It is also necessary to assess the impact of increasing and heavier components on the protection of production workers, especially in terms of physical activity (manual handling, awkward position, musculoskeletal problems, etc.).

3.3. OSH risks - Transport

Moving huge components of wind power plants hundreds of kilometers is an extremely demanding logistical challenge. A number of health and safety issues are being raised for all workers involved. Although most traffic accidents occur due to falling parts from the conveyor, accidents can include overturning the vehicle, shifting the load forward and causing serious injury to the driver as well as collisions with other vehicles, especially on smaller side roads. In order to ensure the safe transport of wind power components on land and at sea, it is necessary to take into account the risks already in the project development phase. In this way, measures are identified, such as the need for escort, planning activities in crisis situations, restrictions on access roads, steep slopes, limited road corridors, limited switches. It is necessary to anticipate the ways of necessary communication. Furthermore, road sections need to be analyzed before transport in order to anticipate and avoid dangerous situations.

Components for offshore wind power plants are produced on land, but there are problems with transport at sea. The choice of ships for the transport of wind power plants components is important to ensure that workers complete their voyages safely and that the resulting fatigue and discomfort are kept to a minimum in order to avoid any impact on workers' health and safety and their ability to perform tasks safely. Vessel safety guidelines are developed that provide guidance and consider the effective selection of ships. Ship and project crews on small vessels at risk of injury due to full body vibration, severe shock due to impact or vibration-related risks that

may cause fatigue or seasickness that may affect ability and safety shall be taken into account.□□□□12□

3.4. OSH risks - Construction

Construction is seen as the most complicated and possibly the most dangerous stage in a wind power plants life cycle. The development of onshore and offshore wind facilities requires extensive planning and thorough knowledge of site conditions, for example location, topography, ground conditions and other factors. Operations both on land and at sea will require a staging area for storing large components before the installation process begins. Some of the hazards encountered during the construction phase of wind power plants include:

- falling structures, loads or objects during lifting operations; □9□
- falls from heights;
- mechanical hazards, such as contact with moving parts;
- electrical hazards — short circuits, overcharge, electrostatic phenomena or falls due to shock;
- fire or explosion of turbine (use of combustible materials) or vessel;
- manual handling of heavy power plants components;
- ergonomics hazards — fatigue from climbing ladders or working in confined spaces, or physiological effects caused as a result of heavy lifting and repetitive movements;
- working with dangerous substances;
- working in confined spaces — the configuration of all nacelles will classify them as confined spaces;
- environmental effects — wind, wave and currents, or lightning;
- organisational hazards — time pressure, insufficient or lack of safety equipment, lack of competence or skills for wind energy sector, different actors/companies all involved in the same operation;
- exposure to noise and vibration;
- the challenging evacuation of persons from wind power plants as a result of changing weather conditions and locations; and
- offshore hazards — marine operations and transportation, for example ship collisions or man overboard.

The management of OSH in the supply chain is paramount. For the wind energy sector this is even more vital because most of these workers will never have worked in the wind energy industry, particularly offshore. Successful management of the project will therefore depend on:□□9□

- the appointment of suitable competent persons for key safety-related roles;
- appropriate contractor selection, considering the safety culture and ensuring that the contractor's investment in developing competent people and safe methods brings a competitive advantage
- effective communication of safety information to the relevant personnel, including between contractors and phases of a project;

- agreement of suitable contractual arrangements, which promote safe working and define relevant key performance indicators; and
- effective monitoring of contractor performance according to key performance indicators and compliance with method statements.

3.5. OSH risks - Operation and maintenance

Once operational, wind power plants are essentially unmanned facilities with personnel accessing them only to perform maintenance and repairs. Regardless of whether the wind turbine is onshore or offshore, once the technician is inside the turbine, the operational and maintenance tasks are exactly the same. Some of the operational failures that personnel working in or around a wind power plant could be exposed to include: tower collapse; blade failure; tower strike; fire; lightning strike.

Weather is a key operational feature that can create risks for workers on both onshore and offshore wind power plants. Work plans should take into account information from national meteorological offices. The advice that national meteorological offices can provide to wind farm operators should not be underestimated. Figure 1 shows a collapsed wind power plants due to strong winds (bora) on the island of Pag. □13□

Maintenance activities include common tasks such as cleaning blades, lubricating parts, full generator overhaul, replacing components and repairing electrical control units. These may be more repetitive tasks, which mean that maintenance technicians become, in general, more familiar with the risks and the procedures in place for working at heights, interacting with electricity and working in confined spaces.

Figure 1: Demolished wind farm on the island of Pag

4. RISK ASSESSMENT

Hazard identification and risk assessment are of paramount importance. For this purpose, checklists are used to identify potential hazards to workers throughout the life cycle of wind power plants from the production and transport of parts, through their installation, operation and maintenance, to emergency rescue and waste treatment. Additional information or expert assistance may be needed to assess more complex risks. The questionnaire should be tailored to each job and workforce characteristics as specific environments and staff may have their own specific needs. For practical and analytical reasons, such verification questionnaires present hazards separately, but in the workplace they can be intertwined. Therefore, interactions between the various problems identified and risk factors must be taken into account. □14□

5. CONCLUSION

The wind energy sector employs many workers at different stages of the life cycle of wind power plants. At the same time, it is extremely important to take care of the protection of health and safety at work. Extensive research in the field of wind energy is currently being carried out in the EU. Although health and safety at work does not in itself have a prominent place in the current research plan, some areas of research will certainly have an impact on it.

Given the lack of data on workers' exposure to risk (most research to date has focused on public safety), more occupational-based research is needed to see the wind energy sector as a safe and responsible sector to work in. Special research is needed in areas such as: the impact of work activities on the long-term career and health of all workers in this industry;

new combinations of traditional risks in new environments, including noise, vibration, electromagnetic radiation, use of hazardous substances, vibroacoustic disease and wind turbine syndrome; use of nanomaterials and possibly other new substances with unknown health effects.

REFERENCES

[1] Bohutinski, J., Hrvatska energetska (ne)ovisnost, Nedjelja, Večernji list, 24.10.2021.

[2] Energetika – net, Snaga novih vjetroelektrana u Europi uvećana za 15,4 GW lani, Available from http://www.energetika-net.com/vijesti/obnovljivi-izvori-energije/snaga-novih-vjetroelektrana-u-europi-uvecana-za-15-4-gw-lani-29951, 17.02.2020.

[3] Energetika – net, Sve više odobalnih vjetroelektana u Europi, Available from http://www.energetika-net.com/vijesti/obnovljivi-izvori-energije/sve-vise-odobalnih-vjetroelektrana-u-europi-26294, 07.02.2018.
[4] Nova energija, Prednosti i koristi od iskorištavanja energije vjetra, Available from http://novaenergija.hr/energijavjetra/hrvatska/prednosti_i_koristi_od_iskorištavanja_energije_vjetra/
[5] Lipnjak, G., Rizici za zaštitu zdravlja i sirurnosti pri primjeni novih tehnologija, *V. Međunarodni stručno-znanstveni skup Zaštita na radu i zaštita zdravlja,* Zadar, 2014
[6] Wiki, Vjetroelektane, Available from https://hr.wikipedia.org/wiki/Vjetroelektrana
[7] Hrastović, D,, Mikro vjetroturbine, Available from_https://www.hrastovic-inzenjering.hr/alter-energija/34-hrastovic/savjeti/258-mikro-vjetroturbine.html
[8] Energetika – net, Slucaj: Šišmisi protiv vjetroelektrana , Available from http://www.energetika-net.com/u-fokusu/res-publica/slucaj-sismisi-protiv-vjetroelektrana-17129
[9] OSHA, Occupational Safety and Health Wind Energy Sector, Available from https://osha.europa.eu/en/publications/occupational-safety-and-health-wind-energy-sector/view
[10] Lipnjak, G., Identifikacija opasnosri pri proizvodnji, radu i održavanju vjetroelektana,
23. Međunarodni simpozij o kvaliteti, 16.03.-18.03.2022., Poreč, Hrvatska
[11] Ponten, A., Carstensen, O., Rasmussen, K., Gruvberger, B., Isaksson, M. and Bruze,
M., 'Epoxy-based production of wind turbine rotor blades: occupational dermatoses',
Contact Dermatitis, Vol. 5 0, 2004, pp. 329–338.
[12] Renewable UK: Offshore Marine Health Safety Guidelines, Available from
https://cdn.ymaws.com/www.renewableuk.com/resource/collection/AE19ECA8-5B2B-4AB5-96C7-ECF3F0462F75/Offshore_Marine_HealthSafety_Guidelines.pdf
[13] Hina, Pogledajte kako je olujna bura slomila vjetrenajču od 600 tisuća eura, Available from https://www.tportal.hr/vijesti/clanak/pogledajte-kako-je-olujna-bura-slomila-vjetrenjacu-od-600-tisuca-eura-foto-20171008
[14] OSHA, Hazard identification checklist: occupational safety and health (osh) risks in the wind energysector, Available from https://www.google.hr/search?q=osha+E-facts+80

OCCUPATIONAL SAFETY AND LIVE WORK TECHNOLOGY IN HEP–ODS, ELEKTRA ZAGREB

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Abstract: *Live work technology is becoming almost as common as working on de-energized electrical systems and equipment. Major live work technology benefit is dealing with customers' demands for uninterrupted electrical energy supply. HEP–ODS, Elektra Zagreb keeps track with development of this working technology and implements it in its everyday use. This technology also brings special requests for ensuring electrical safety of personnel that carries out this type of work on energized electrical grid and power station equipment. Qualified employees, use of personal protective equipment and special live work tools and devices are necessary to enable safe work and prevent injuries caused by electric shock or electric arc.*
Key words*: live work techniques, electrical safety, workers training, personal protective equipment, live work tools*

1. INTRODUCTION

Live work is any work on power plants, networks and electrical installations in which the worker knowingly and intentionally comes into contact with live parts or enters the live work zone (the part around an uninsulated live conductor where the dielectric properties of air do not provide protection from effects of electricity without the application of other protective measures), either by parts of his body, or by tools and devices that he handles. [1] The limit distance of the live working zone depends on the nominal voltage and is defined by technical regulations and standards. As the rated voltage increases, so does the limit distance of the live working zone around the non-insulated conductor. Regarding the issue of employee safety, the application of the live work method, compared to the method of working in a de-energized state, requires additional personnel training, special live work tools and personal protective equipment, as well as a strict adherence to safety procedures when performing work.

2. LIVE WORKING TECHNOLOGY

During the historical development of live work technology, three basic methods of performing this type of work were formed:

1. Insulating gloves
2. Hot stick
3. Bare-hand

By applying „insulating gloves" work method, work is performed in such a way that the worker is in direct contact with live parts, with the use of insulating gloves and isolation of the worker's standing position, and the use of isolated tools and equipment. In this way, there is a double protection of the worker, considering that the worker is isolated from the active live parts on which he is working, and at the same time also isolated from the ground. To prevent an electric arc, all other live parts that are not being worked on and other conductive parts in the work area are covered with suitable insulating means.

„Hot stick“ method is a way of working in which the worker is at a certain distance greater than the minimum permitted distance of approaching live parts and uses sufficiently long insulating poles for work.

When applying the „bare-hand“ working method, the worker performing the work is at the same potential as the live parts that he is working on. He performs all work in such a way that a sufficient level of insulation towards grounded parts and all parts that are at a different electric potential than his is ensured. No insulating equipment or insulated tools are used when touching live parts.

Each of these three basic live work methods is based on the application of measures to protect against electric shock and an electric arc. However, there are certain limitations that make it impossible to apply each of these methods at all voltage levels [2].

2.1. Live work technology on low voltage lines and equipment

In low-voltage networks, there is a large number of works that can be performed on energized lines or equipment, such as, assembly and disassembly of overhead connections, replacement of insulators, reconstruction of the underground power lines, etc. The two basic methods used when working under voltage at low voltage are „hot stick” and „insulating rubber gloves” method.

„Hot stick” working means staying outside the minimal approach distance for low voltage from active non-insulated parts and the use of suitable long insulating tools that allow the worker not to penetrate the live working zone with his body, considering that the worker is at the ground potential . The use of the „insulating gloves” method involves wearing insulating gloves in order to be able to come into direct contact with uninsulated live parts that are being worked on, while other live

parts, as well as other conductive parts at ground potential, are protected with insulating covers. In addition, if it is a type of work where the worker is standing on the ground, the stand is insulated with appropriate insulating matting. „Bare-hand" method is not used at low voltage lines or equipment.

2.2. Live work technology on medium voltage lines and equipment

On medium-voltage networks, pole replacement, maintenance and replacement of disconnectors, replacement of insulators, etc. can be carried out live. In these networks, there are a large number of facilities whose disconnection affects a large number of consumers. Work on medium-voltage overhead networks and facilities is possible using the „hot stick", „insulating gloves" or „bare-hand" method, applying these methods individually or as a combination of these methods. The choice of method depends on the type of network/plant, as well as the type of work that needs to be performed. Using the "hot stick" method, the worker stands outside the minimum approach distance, and works on live parts using tools attached to the ends of insulating poles. Using "insulating gloves" method, the worker is adequately protected (isolated) from the active parts being worked on. When applying the "bare-hand" work method, the worker is at the same electric potential as the live parts he is working on and, at all times, the worker must maintain a distance greater than the minimum approach distance between himself, the tool and the live parts he is holding on one side and other parts that are at a potential different from the one being worked on.

2.3. Live work technology on high voltage lines and equipment

"Bare-hand" method is applied for live work at high voltages. When using this method, the worker is in direct contact with live parts, and is isolated from the ground and grounded parts and conductors at other electric potentials. This type of work can be performed with an insulated ladder or a hydraulic platform. If necessary, a combination of "barehand" and "hot stick" methods is used, whereby workers using „hot stick" method help the worker that is using „bare-hand" method, by adding certain tools and objects to him using insulating poles and insulating rope.

3. LIVE WORK TECHNOLOGY IN HEP ODS, ELEKTRA ZAGREB

In HEP–ODS, Elektra Zagreb, the live work technology at low voltage is used for works on the construction of connections to electric power grid. The works are carried out in such a way that all works are first carried out on the user's facility (in a de-energized state), and the connection to the low-voltage overhead line is performed on live lines (without de-energizing the overhead lines). The worker performs live work method from mobile elevating working platform, insulated tools,

and insulating blankets for insulation of parts that may be at a different electric potential than the worker. Before each use, all insulating tools must be visually inspected and determined to be correct (that the insulation has not been damaged).

The worker must also use personal protective equipment for live working - a protective electrically insulated safety helmet with a face shield, insulating gloves - class 0/00 (insulation level up to 500V/1000V) [3], protector gloves (that must be worn over insulating gloves for protection against mechanical hazards), protective clothing against the thermal hazards of an electric arc (made of flame resistant materials), and protective footwear for live work (without metal parts). Special attention should be paid to the correct way of using personal protective equipment, so as not to reduce its effectiveness. This especially applies to the correct use of insulating gloves, which must be at least 5 cm longer than the protector gloves, and also must not be covered by the sleeves of the protective clothing (sleeves must be tucked inside the gloves), so as not to reduce their insulating function. In addition, the collar of the protective work suit must be fully buttoned, so that in combination with the lowered visor of the helmet, it fully protects the worker's neck area. Given that this type of work is performed using mobile elevating working platform (areal lift), workers must also meet the conditions for this category of work and use protective equipment for working at height (safety belt with rope).

Figure 1: Live working on overhead lines 0.4 kV in Elektra Zagreb

(April 2022, own photos)

Another type of working live, which is often used on power substations owned by Elektra Zagreb, is dry ice blasting. Dry ice means CO_2 granules, (temperature -80 °C, diameter up to 3 mm), which are blown under high pressure onto the substations equipment that needs to be cleaned [4]. This method is used for cleaning distribution power substations 10(20)/0.4 kV, and due to its efficiency it is very convenient for cleaning substations that are exposed to heavier industrial pollution. During this type of work, the entire substation remains energized, which means that the works have no impact on electricity supply for consumers. Since it is a technology that requires special equipment, Elektra Zagreb currently uses specialized external contractors to carry out these works. Permanent supervision of an authorized employee of Elektra Zagreb is mandatory. The task of the worker in charge of supervision is to determine the permitted approach zone and to determine the equipment in the substation that need to be cleaned. Dry ice blast cleaning is a type of "hot stick" live work method because the worker at all time maintains a safe distance from live parts (which depends on the voltage of a certain part of the plant), and handles insulating equipment (a device for dry ice cleaning whose pipes are made of insulating material). In terms of personal protective equipment, the worker uses electrically insulated safety helmet with a face shield, protective clothing against the thermal hazards of an electric arc, protective gloves and protective footwear for live work. In addition to the already described electric hazard, this work is also characterized by a high level of noise caused by the operation of dry ice blasting equipment. Because of the above, the use of personal protective equipment for hearing protection is mandatory. When it comes to cleaning the medium-voltage parts, it is also mandatory to measure the relative humidity of the air before starting the work. If the relative air humidity is higher than 80%, it is not allowed to perform dry ice blast cleaning on energized equipment.

Figure 2: Dry ice blasting on power substation 10(20)/0.4 kV in Elektra Zagreb (May 2022, own photos)

It is important to emphasize that during the application of live working technology in HEP-ODS, Elektra Zagreb, not a single safety incident has been recorded so far.

3. CONCLUSION

The advantages of the live line technology are becoming more pronounced with need to ensure the continuity of the electricity supply. In addition to economic effects, there are also positive effects in terms of organization and execution of works. By applying all the safety rules, live work technology of can be as safe for the worker as working on de-energized lines and equipment.

REFERENCES

[1] *Pravilnik o sigurnosti i zdravlju pri radu s električnom energijom*, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2012_08_88_2019.html *Accessed:* 2022-07-02

[2] Stojkov, M.; Raljević, D.: *Tehnologija rada pod naponom*, Sveučilište Josipa Jurja Strossmayera u Osijeku, Strojarski fakultet u Slavonskom Brodu, ISBN 978-953-6048-87-8, Slavonski Brod, (2016)

[3] Caha, V.; Lovrenčić, V.; Lovrenčić, A.: *Izolacijske rukavice za električare – usporedba međunarodnih normi i iskustava*, Hrvatski ogranak međunarodne elektrodistribucijske konferencije – HO CIRED, 6. (12). savjetovanje, Opatija, (2018)
Available from
https://ho-cired.hr/images/OPATIJA2018/Referati_po_studijskim_odborima/SO1/SO1-38.pdf *Accessed:* 2022-07-04

[4] Raljević, D.; Sokač, V.: *Čišćenje pod naponom – granulama ugljikovog (IV) oksida (suhim ledom)*, Hrvatski ogranak međunarodne elektrodistribucijske konferencije – HO CIRED, 6. (12). savjetovanje, Opatija, (2018) *Available from* https://ho-cired.hr/images/OPATIJA2018/Referati_po_studijskim_odborima/SO6/SO6-22.pdf *Accessed:* 2022-07-05

ANALYSIS OF BIBLIOGRAPHIC RECORDS IN THE FIELD OF OCCUPATIONAL SAFETY AND HEALTH IN THE REPUBLIC OF SLOVENIA BETWEEN 1991 AND 2021

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Abstract: *The article presents activity of publishing scientific research papers, professional and other types of articles in the field of safety and health at work in the Republic of Slovenia in the period between 1991 and 2021. For the purposes of obtaining relevant data, we used the Slovenian library information system (COBISS). COBISS is intended for electronic management of bibliographies and the classification of works according to the UDK, which we processed with Office tools. The final goal of the paper is to present key findings about the scientific research and professional activity of the authors in the field of safety and health at work in the Republic of Slovenia. Through a bibliographic analysis with an emphasis on the typology of documents, we try to show the productivity of the authors in relation to their scientific, professional and other works in the field of safety and health at work.*

Key words*: analyses of bibliographic records, COBISS, occupational safety and health, Slovenia, UDC*

1. INTRODUCTION

The analysis of bibliographic records contributes to a better understanding of trends in the publication of different types of scientific and other articles in the field of occupational safety and health. This knowledge can be useful for different

organised groups. In the field of research of bibliographic records, we can use a set of different management software tools.

Our analysis included bibliographic records from the fields of occupational safety and health registered in the COBISS+ system [2], in the period between 1991 and 2021, with the aim of a scientific and professional review of the state of occupational safety and health in the Republic of Slovenia according to the typology of documents, which are intended for managing bibliographies in the COBISS+ system [2] with the possibility of reviewing the classification according to the Universal Decimal Classification (UDC) system [6] [7].

In the beginning of our research we observed there has not been much research in the field of bibliographic analysis in Slovenia. We have primarily relied on some of our own works [2] [7] [8] [12]. In relation to the analysis of document typology, we recognised only a handful of research or short papers [1] that did not survey the field of occupational safety and health.

In modern science, scientific fields are covered, so there is a need to strengthen cooperation in research and development in the field of safety and health at work in the Republic of Slovenia. With such an approach, the profession will experience progress in the scientific and not only the professional field.

2. COBISS

COBISS (short for *Co-operative Online Bibliographic System & Services*, in Slovene *Kooperativni spletni bibliografski sistem in servisi*) is a Slovenian library information system developed by the Maribor Institute of Information Sciences (IZUM).

It is an organisational model of connecting libraries into the national library information system with mutual cataloguing, mutual bibliographic-catalogue database COBIB and local databases of participating libraries, database on COLIB libraries, normative database CONOR and many other sources and functions.

In addition to accessing these databases, Slovenian users of the system also have access to SGC, CORES and ELINKS databases and separate access to the following sources or databases, which are otherwise integrated into the COBISS system: JCR, SNIP, DOK / UKM and ZAL / ISBN. The COBISS system is being used by the library systems of Slovenia, Albania, Bosnia and Herzegovina, Bulgaria, North Macedonia, Serbia and Montenegro.

All these systems are connected to the COBISS.net network.

The COBISS+ web application and its mCOBISS mobile version are available to end-users to search for material in the databases of all libraries included in the national COBISS system [3] [4].

3. TYPOLOGY OF DOCUMENTS AND WORKS FOR MANAGING BIBLIOGRAPHIES IN COBISS SYSTEM

The typology of documents can be defined as a numerical code system (from 1.01 to 3.25), which classifies and marks publications such as articles and components, monographies, completed works and other works, which is intended for keeping bibliographies of authors in the COBISS system.

Bibliographic records in the COBISS system are created by qualified cataloguers/bibliographers in libraries and/or information documentation centres.

Articles and other components, monographies and other completed works are being processed on the basis of a primary document/work.

Implemented works (events) are recorded on the basis of appropriate evidence of implemented work.

If a publication is not available in the library, the author must provide it to the librarian.

Authors are primarily responsible for the correct classification of bibliographic units according to this typology, and the type of document/work can also be determined by an expert in the subject field [5] [9].

4. UNIVERSAL DECIMAL CLASSIFICATION (UDC)

The UDC is the world's foremost multilingual classification scheme for all fields of knowledge and a sophisticated indexing and retrieval tool.

It is a highly flexible classification system for all kinds of information in any medium. Because of its logical hierarchical arrangement and analytical-synthetic nature, it is suitable for physical organisation of collections as well as document browsing and searching.

The UDC is structured in such a way that new developments and new fields of knowledge can be readily incorporated.

The code itself is independent of any particular language or script (consisting of Arabic numerals and common punctuation marks), and the accompanying class descriptions have appeared in many translated versions.

The scheme is in worldwide use, and has been published in whole or in part in over 40 different languages (see bibliography of UDC editions). It is used in bibliographic services, documentation centres and libraries in around 130 countries worldwide.

Library collections indexed by UDC can be found in library OPACs and databases (see information about larger collections).

The International Federation for Information and Documentation (FID) managed the UDC, from its creation around the year 1900 until 1992, when it became clear that a more broadly based and financially autonomous organisation was needed to administer and exploit UDC. FID, together with the publishers of the Dutch, English, French, Japanese and Spanish editions, became the founding members of a new body: the UDC Consortium (UDCC).

The Consortium assumed ownership of UDC on 1 January 1992 [10].

4.1 How is UDC maintained?

The UDCC appoints the UDC Editorial Team and the UDC Advisory Board with international membership to oversee the content of UDC and contribute to its revision [11].

5. THE AIM OF THE ARTICLE

The aim of the article is to develop key findings on the diversification of the typological system with emphasis on the scientific and professional field of occupational safety and health in the Republic of Slovenia and its appropriate systemic classification in the UDC.

6. METHODOLOGY AND METHODOLOGICAL TOOLS

The survey was conducted in four steps, i.e.:

1. determination of key words in the field of occupational safety and health on the basis of the applicable legislation before and after 1991 in the field of safety and health at work, as well as good practice of words provided by the profession;
2. search of bibliographic works with the help of selected keywords in a command manner in the COBISS system from 1991 to 2021;
3. processing of results or records using Excel;
4. processing and analysis of prepared data on the basis of frequency or percentage composition of publications by typologies of documents.

7. DETERMINATION OF KEY WORDS IN THE AREA OF OCCUPATIONAL SAFETY AND HEALTH

For the purpose of inquiries in a command manner according to the typologies of documents, the following two (2) supporting and main key words/expressions are occupational safety and health and safety at work and 81 complementary words.

Here is an example of such a composite query by command:

PY=1991:2021 and CO=svn and TD=1.01 and (KW=occupational safety and health OR SU=occupational safety OR KW=safety at work) and (KW=occupational medicine OR KW=protection* OR KW=stress OR KW=health care* OR KW=fire safety OR KW=health care* OR KW=hospital* OR KW=illness* OR KW=injuries OR KW=analysis* OR SU=hazard* OR KW=threats OR KW=mobbing OR SU=mobbing OR KW=psychosocial violence OR SU=harassment* OR KW=maltreatment* OR 33KW=therapies OR KW=prevention OR KW=preven*

OR KW=work* OR KW=ergonom* OR KW=electricity* OR KW=explosion* OR KW=economy* OR KW=inspect* OR KW=ministry* OR KW=vaccination OR KW=incidents OR KW=accidents OR KW=manager* OR KW=manage* OR KW=flammable* OR KW=construction* OR KW=organisation* OR KW=traffic* OR KW=police* OR KW=psychologist* OR KW=school* OR KW=sport* OR KW=finance* OR KW=measure* OR KW=public administration OR KW=hygiene* OR KW=humanise* OR KW=eco* OR KW=econom* OR KW=worker* OR KW=logistics* OR KW=industry* OR KW=company* OR KW=statist* OR KW=guideline* OR KW=standard* OR KW=promotion OR KW=material* OR KW=policy* OR KW=construct* OR KW=inform* OR KW=chemical* OR KW=permit* OR KW=music* OR KW=office* OR KW=violence* OR KW=direct* OR KW=access* OR KW=dive* OR KW=worlds* OR KW=COVID OR KW=profession* OR KW=known* OR KW=technologist* OR KW=corr* OR KW=curative*)

8. ANALYSIS OF BIBLIOGRAPHIC HITS BY TYPOLOGIES OF DOCUMENTS

With the help of queries in a command manner with the emphasis on the typology of documents in the public catalogue COBISS+ we obtained 4798 (100%) works, of which a typology was assigned to 3860 (80.45%) works, while to 938 works (19.55%) no typology was assigned (Table 1).

Table 1: Percentage and frequency composition of publications based on the typology of documents

Typology of documents/works	Percent	Frequency
All publications	100	4798
Publications with unallocated typology	19,55	938
1.01 Original scientific article	1,83	88
1.02 Review article	0,44	21
1.03 Short scientific article	0,12	6
1.04 Professional article	10,23	491
1.05 Popular article	1,76	84
1.06 Published scientific conference contribution (invited lecture)	0,29	14
1.07 Published professional conference contribution (invited lecture)	0,29	14
1.08 Published scientific conference contribution	2,31	111
1.09 Published professional conference contribution	4,71	226
1.10 Published scientific conference contribution abstract (invited lecture)	0,02	1
1.12 Published scientific conference contribution abstract	0,46	22
1.13 Published professional conference contribution abstract	0,38	18
1.16 Independent scientific component part or a chapter in a monograph	0,4	19
1.17 Independent professional component part or a chapter in a monograph	0,67	32
1.18 Professional entry in dictionary, encyclopaedia or lexicon	0,06	3
1.19 Review, book review, critique	0,27	13
1.20 Preface, editorial, afterword	0,48	23
1.21 Polemic, discussion, commentary	0,12	6
1.22 Interview	1,02	49
1.24 Bibliography, index, etc	0,02	1
1.25 Other component parts	2,27	109
2.01 Scientific monograph	0,15	7
2.02 Professional monograph	0,92	44
2.03 Reviewed university, higher education or higher vocational education textbook	0,52	25
2.04 Reviewed secondary and primary school textbook or other textbook	0,15	7
2.05 Other educational material	1,1	53
2.06 Dictionary, encyclopaedia, lexicon, manual, atlas, map	0,83	40
2.08 Doctoral dissertation	0,37	18
2.09 Master's thesis	3,63	174
2.10 Specialist thesis	0,15	7
2.11 Undergraduate thesis	37,89	1818
2.12 Final research report	1,48	71
2.13 Treatise, preliminary study, study	1,9	91
2.14 Project documentation (preliminary design, working design)	0,19	9
2.15 Expertise, arbitration decision	0,33	16
2.18 Scientific film, scientific sound or video publication	0,04	2
2.19 Radio or television broadcast, podcast, interview, press conference	0,04	2
2.20 Complete scientific database of research data	0,08	4
2.25 other monographs and other completed works	1,38	66
2.30 Proceedings of professional or unreviewed scientific conference contributions	1,02	49
2.31 Proceedings of peer-reviewed scientific conference contributions (international and foreign conferenc	0,06	3
2.32 Proceedings of peer-reviewed scientific conference contributions (domestic conferences)	0,06	3

9. RESEARCH RESULTS

From the analysis of the results we have established that in the area of monographies diploma theses predominated. According to the typology from 2.01 to 2.05, there are 2.84% or 136 works in total, which can be used as teaching material at various levels of the education system in the Republic of Slovenia. Primary (elementary education) and secondary (high-school education) are included in the share of 0.15% or in 7 parts. At the level of tertiary education (university, higher education or higher education textbook with a review) there is a share of 0.52% or 25 works.

An important share for the scientific development of the profession is represented by scientific monography with a share of 0.15% or 7 works. The professional monography comprises a share of 0.92% or 44 works.

From the obtained analysis we have also found out that professional articles predominated (10.23% or 491 works).

We are establishing that publications with unassigned typology represent a very high part of the material, as it amounts to 19.55% of all bibliographic units or 938 works.

Table 2: Content range of bibliographic units by UDC area between 2004 and 2016 from the conferences of the Faculty of Chemistry and Chemical Technology, University of Ljubljana

UDC areas	*Note*
61	Medicine. Occupational and sport medicine. Accidents etc.
0	Librarianship. Informatics. Organization etc.
62	Engineering. Technology in general.
331.4	Working environment. Working conditions. Ergonomics etc.
34	Law. Jurisprudence etc.
351.78	Public safety
37	Education. Training etc.
54	Chemistry. Chemical technology etc.
159.9	Psychology
336	Finance. Financing etc.
351.81	Traffic safety. Traffic police
35	Public administration. Administration
53	Physics
33	Economics. Economy sciences etc.
32	Politics. Political sciences
502	Ecology. Environmental protection etc.
3	Social sciences. Sociology
7	Architecture. Urbanism. Sport etc.
8	Linguistics. Semantics etc.
9	Geography. History etc.

17	Ethics. Morale etc.
51	Mathematics. Natural sciences
311	Statistics
351.74	Police
343.3/.7	Criminal acts. Criminality

Table 2 shows the content range of articles from the conferences of the Faculty of Chemistry and Chemical Technology of the University of Ljubljana from 2003 to 2014 by UDC area.

As seen from Table 2, the areas that were in connection with the sought field of occupational safety and health, such as occupational medicine (UDK 61), informatics, organisational science, management (UDK 0) and engineering, construction, electrical engineering, apparatus, materials, technology (UDC 62) are strongly predominant. In the group with a medium frequency there are for example ergonomics (UDC 331.4), law and jurisprudence (UDK 34), topics in the field of public safety (UDK 351.), education / training (UDK 37), chemistry, chemical technology etc. (UDK 54), psychology (UDK 159.9), and finance / financing etc. (UDC 336).

The last group included topics from the following areas: traffic safety, public administration, physics, economics, politics, environmental protection, urbanism, sports, linguistics, geography, history, ethics, statistics, police and criminal acts / criminality [8].

10. FINDINGS

The typology of documents and works allows the classification of these works in order to create a hierarchy of works.

The highest in the hierarchy is the original scientific article (1.01), which publishes original scientific results. In the field of occupational safety and health, there are only 88 original scientific articles, which represents 1.83% for the period from 1991 (from the independence of the Republic of Slovenia) to the present, that is the period of 30 years.

Most articles are professional articles (1.04), with 491 hits or 10.23%. Papers that by typology exceeded one percent are published scientific papers at the conference (1.08); 111 or 2.31% were published, published professional papers at the conference (1.09), of which 226 or 4.71% were published, and other components (1.25), of which 109 or 2.27% were published.

Among monographies and other completed works, the following stand out: diploma theses (2.11), which amounted to 1818 or 37.89%. There is a total of 51 scientific and professional monographies, which represents 1.07% of published works.

The results also showed that as much as 19.55% of all bibliographic units or 938 parts of publications with unassigned typology represent a very high part of the

material. Why so many works with unassigned typology may be based on the assumption that the entries in the COBISS system were inaccurate or improperly entered according to the (non) existing typology.

We also have to consider the data that, according to the UDC, the field of safety and health at work is still a relatively young and not established scientific science if we compare it with medicine, for example.

We also estimate that we do not yet have sufficiently developed clear criteria for classifying scientific and professional works in the field of safety and health at work.

Our findings also show the breadth of the interdisciplinary field of safety and health at work, as many other areas are included under the UDC area, such as the areas of medicine, librarianship, organisation, management, chemistry or engineering sciences, working environment, law and jurisprudence, public safety, education etc.

11. CONCLUSION

The analysis of bibliographic records based on the typology of documents is very important for it provides us with important knowledge about the composition of various types of scientific, professional and other publications, while the diversified field of safety and health at work by UDC tells us that this field is highly interdisciplinary.

According to the selected keywords and a certain typology, we obtained 4798 (100%) works using the command query on the COBISS+ public catalogue, of which a typology was assigned to 3860 (80.45%) works and to 938 works (19.55%) typology was not assigned.

The predominant share of professional articles may also indicate the facts that they are easier to write and publish than original, transparent and short scientific articles.

We must also be aware of the fact that in the Republic of Slovenia original, transparent and short scientific articles are reviewed by doctors of science who have obtained their PhD in other fields, such as occupational medicine, transport and sports, chemistry and chemical technology, mechanical engineering, electrical engineering, construction and architecture, law, management, work organisation etc.

All these areas are connected to the area of occupational safety and health.

Furthermore, we note that the field of occupational safety and health is basically not properly defined terminologically and it is not harmonized with the UDC, as several derivatives are used to search for the field (e.g. occupational safety, safety at work, occupational safety and health as the main keyword) and thus makes it practically difficult to properly search for the field and/or works as well as system research in the COBISS system.

We can conclude that the field of safety and health at work in both scientific and professional environment is a very attractive field for various experts, especially from other professional fields or other disciplines, as well as that the appropriate regulation of the field would be an even more important step forward scientifically

and professionally, as it would be necessary to fully regulate and unify the profession.

The problem we see is mainly systemic, i.e. the lack of doctoral studies in the Republic of Slovenia in the field of occupational safety and health, since only with the highest academic level of academics the area of occupational safety and health could develop comprehensively and take a well-deserved place among other sciences in a comprehensive system of science. It is necessary to strive for the fact that it must be one of the leading forces of a comprehensive and even more important scientific field.

REFERENCES

[1] Bahor, S.: Vrednotenje v znanosti in tipologija dokumenta. Revija policija, Vol. 15 (1995) No. 1-3, pp.157-165. ISSN 1318-055X

[2] Batis, R. & Petrič, K.: Analiza bibliografskih zapisov : primer nasilja na športnih prireditvah. Uporabna informatika, 20 (2012) No. 4, pp. 250-258. ISSN 1318-1882 Dodatna navodila za katalogizacijo bibliografskih enot, ki se upoštevajo pri vrednotenju raziskovalne uspešnosti http://home.izum.si/cobiss/bibliografije/Dodatna_navodila_za_katalogizacijo.pdf *Accessed:* 2022-05-05

[3] Dodatna navodila za katalogizacijo bibliografskih enot, ki se upoštevajo pri vrednotenju raziskovalne uspešnosti http://home.izum.si/cobiss/bibliografije/Dodatna_navodila_za_katalogizacijo.pdf *Accessed:* 2022-05-05

[4] INSTITUT informacijskih znanosti Maribor. (2013). Spletna aplikacija COBISS/OPAC: -> citat: (INSTITUT informacijskih znanosti Maribor, 2013) http://cobiss.izum.si *Accessed:* 2022-05-18

[5] INSTITUT informacijskih znanosti Maribor. (2013). Spletna aplikacija COBISS/OPAC: 1997–2022: Prenos zapisov za osebno uporabo v formatu RIS. http://cobiss.izum.si *Accessed:* 2022-05-18

[6] Legat, D.: Načela znanstvenega publiciranja in tipologija dokumentov v sistemu COBISS. In Razvoj visokošolskih knjižnic za univerzo 21. stoletja : zbornik referatov, Centralna tehniška knjižnica, ISBN 961-6112-04-X , Ljubljana, (2002), pp. 145-160.

[7] Petrič, K.; Mravlja, M.; Petrič, T. & Rajkovič, V.: Primer analize bibliografskih zapisov s področja različnih vrst kriminalitete in povezanih tem. Uporabna informatika, Vol. 21 (2013), No. 3, pp. 128-137. ISSN 1318-1882

[8] Šrekl, J.; Petrič, K.; Mravlja, M.; Vedenik, L. & Lukežič, M.: Analiza bibliografskih zapisov s področja varnosti in zdravja pri delu v obdobju 2003 do 2014. Tradicionalni strokovni posvet o poklicni, procesni in požarni varnosti ter svečana akademija ob 50-letnici institucionalnega izobraževanja s področja varstva pri delu : dvodnevni posvet z mednarodno udeležbo, pp. 1-9, ISBN 978-961-6756-67-9, Portorož, 17.-18. 5., Fakulteta

za kemijo in kemijsko tehnologijo, Katedra za poklicno, procesno in požarno varnost, Ljubljana (2016)

[9] Tipologija dokumentov/del za vodenje bibliografij v sistemu COBISS del http://home.izum.si/cobiss/bibliografije/tipologija_slv.pdf *Accessed* 05.05.2022

[10] Univerzalna decimalna klasifikacija https://udcsummary.info/php/index.php?lang=sl&pr=Y *Accessed:* 2022-05-06

[11] Univerzalna decimalna klasifikacija, https://udcc.org/index.php *Accessed:* 2022-05-11

[12] Vedenik, L.; Petrič, K. & Mravlja, M.: Kronološki pregled strokovnih in znanstvenih del na področju varnosti in zdravje v policiji v obdobju med 1991 in 2015. Prvi posvet o raziskovalni dejavnosti v policiji : zbornik prispevkov, Durić, D. (Ed.), pp. 145-160, ISBN 978-961-6797-37-5, Tacen, December 2016, Ministrstvo za notranje zadeve, Policija, Ljubljana, (2016)

FAST AND SIMPLE EMPLOYEE SAFETY TRAINING WITH ELEARNING

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Abstract: *Recent changes to the Croatian Law covering employee health and safety have enabled the use of eLearning tools in obligatory safety training. We have compared four different tools and techniques that are used for delivering eLearning content and exams. Since these tools are broadly available and already proven in other fields, safety engineers have an opportunity to fast-track their skills and implement them with ease. Some of these tools also enable full automatization and self-admission of employee training, from employee contracting to taking care of the obligatory paperwork. By implementing quality eLearning tools, safety engineers can reduce the time needed to deliver obligatory trainings and with analytical abilities integrated in these tools, they can improve their training courses by focusing areas where employees have made the most incorrect answers in their exams. With the reduction in time taken to fulfill training needs, safety engineers have more time to work on ongoing safety issues and increase the overall safety standard of the organization.*

Keywords: *eLearning, WebZNR, Moodle, software, occupational health and safety*

1. INTRODUCTION

Although *eLearing* today is a broad and well-known term which represents many forms of learning using computers, smartphones, and similar devices: The main point of implementing eLearning is not replacing real life classrooms and teachers with PDFs and PowerPoint presentations distributed via email or shared folders and expecting that students will print out their tests, complete and sign them and return them for evaluation and safe keeping inside some physical folder. [1]

Implementing good eLearning solutions must involve digital transformation of the whole business process. The point of making something "digital" must not mean simply replacing pen and paper with bytes. Digital transformation presents an opportunity to change the business process in order to increase its efficiency and effectiveness, not only for occupational safety engineers but for all other parties involved, primarily workers and in some scenarios external contractors, visitors and other people that ones business must include. [2]

In the digital transformation process it is important to set clear goals and consider all the proposed constrains, from budget perspective and learning curves of specific tools to applicability in specific business processes.

2. WHY SHOULD WE IMPLEMENT ELEARING?

Covid-19 pandemic sped up the digital transformation of many business processes, from simple implementation of remote work tools to reorganizing and rethinking basic workplace needs. In that process occupational health and safety (OHS) was left a side as one of the main goals of OHS is prevention through education. With eLearning tools, it is simply impossible to transmit any kind of disease between teachers and students.

The costs involved in organizing employee training is significantly reduced with the eLearning tools compared to in-person classes. Not only is there no need to spend the budget on renting or owning a classroom, but the time safety engineers also spend repeating the same lectures over and over is reduced. That time can always be put to better use. There are no travel expenses for both teachers and students. With these cost-savings combined, return on investment for implementing eLearing tools is guaranteed.

Educational availability, specifically the speed in which we can education newly employed workers is minimal. In a fully automated eLearing system, a newly employed worker will receive a "welcome email" having all the necessary OHS topics immediately at the day of employment. Also, when an employee is transferred to a different process or workplace, he will receive an update on OHS topics specific for his new position. All this can happen without any manual intervention from his safety engineer. Besides decreasing the time to educate employees, the whole process can be held in anywhere, from corporate offices, home offices to factories and geographically dispersed locations.

On the other side, by automating educational processes, auditing is made easy, and it becomes a by-product that is generated automatically on per-need basis. As is with most digital tools, all the log entries are available automatically, from employee login time, time spent learning the topics to time taken to answer all the exam questions.

The quality of provided educational materials is always at the same level. Video materials that are created once, are always reproduced the same. This way any important details or nuances of a specific business activity will not be excluded. Also, the feedback from students attending the course can be used to improve the provided materials.

Since recent increase in foreign workers employment in Croatia, multilingual content and exams is way easier to organize by translating the educational materials (either automated or a real person) then it is for a safety engineer to learn a new language. The process of translation can be done manually by including professional translation services or in some eLearing tools it can also be automated using cloud translation providers (Google, Microsoft, etc.).

Besides creating their own content, safety engineers can buy read-made content from an increasingly bigger marketplace of eLearing content providers specific to OHS. Most of this content can be further customized to better suite a specific need while some content can even be found under lax Creative Commons license.

By Croatian work safety laws, safety training program must be made according to the risk assessment. Risk assessment must always reflect current workplace state. This also means that employee safety training must reflect current workplace state. If there is a new risk detected, or there is a new business process implemented, safety engineer must update the risk assessment, safety training program and educate all the workers that are involved in those business processes. In traditional learning, even a simple change of a business process is hard and labor-intensive to fulfill. This type of change could include a large number of workers that would need to take an additional course covering safety issues regarding the new business process. With eLearing tools, it does not matter if one is educating a single worker or a few hundreds, even thousands of workers.

Last, but not least, the ecological aspect of learning, that is, "the carbon footprint" is undoubtably reduced through the forementioned travel cost reduction band also through less use of paper and storage space required for safe keeping it. Since implementing eLearning tools usually is not the first thing that is being "digitized" and all the necessary ICT infrastructure is usually in place, from network connectivity to availability of network connected devices (computers, tablets, smartphones), this digital transformation is usually reusing and expanding existing investments.

3. LEGAL FRAMEWORK

The Regulation of training and development in workplace safety and professional licensing (Croatian National Gazette 142/2021), article 4, subarticle 5 states:

5) Training program, in its theoretical part, is held by workplace safety expert and the program can be held through corresponding on-line methods. [3]

Unfortunately, the term "corresponding on-line methods" is quite ambiguous and left to ones interpretation. When we consider methods that are broadly available for a number of years and are in current use throughout primary, middle and higher education, the first important part of choosing a law-abiding eLearning tool is the method it uses for authenticating students.

To authenticate a person, we can choose from following methods of authentication:

- Username and password
- Single use links sent to registered email addresses
- Single use PIN sent to registered mobile phone via SMS
- Single shared password and personal identification number (OIB)

Besides the authentication method of choice, some eLearning tools feature a signature pad which can be useful for a student using a touch sensitive screen to sign an exam. This method of an additional factor of authentication is often used in postal deliver and bank services so it can also come in handy to prove ones identity.

4. PROBLEMS IN IMPLEMENTING ELEARNING

Although the computer literacy today is way higher than a decade before, we must take into account that it can still present a major obstacle in implementing eLearning tools. This is usually true in more labor intensive sectors, but considering the omnipresence of digital devices in everyday lives and influence of digital social networks, even those sectors are having less and less resistance in implementing digital tools.

The most common stumbling stone in implementing eLearning is computer literacy and motivation of safety engineers. Younger engineers have already been exposed to eLearning tools through their higher education, but the ones that haven't, will now immediately be put in a content creator and administrator role without experiencing eLearning tools as a student. Experience in using eLearning tools as a student can greatly motivate a safety engineer to share that experience with other work colleges. [4]

A good way to experience the ease of use and availability of eLearning tools is through a recently published project by Ministry of Labour, Pension System, Family and Social Policy. This project uses Moodle platform as a tool to prepare coordinators and safety professionals. [5]

5. ELEARNING TOOLS

5.1. STANDARD OFFICE TOOLS

For the most basic form of eLearning that is in use today, standard office applications are being used. Distribution of educational material is done by sending PowerPoint presentations or PDFs through email to students, which in return can fill out a Word document containing exam questions. This is then printed, signed, and sent or scanned back to the safety engineer via email.

Although basic and crude in todays standards, this method is quite attractive since it does not involve any additional learning curve from the perspective of the safety engineer. The main disadvantage can arise on the students side: software and licensing availability and tedious manual work involving sending scanned documents.

Also, as the work environment grows bigger with more employees and more complex business processes, keeping track of which person received which training can become cumbersome and labor intensive even for the most IT-skilled safety engineers.

Other technical disadvantages of this approach can be

- email message size limitations which usually cannot handle larger educational materials containing video or interactive materials,

- inability to use smartphone devices or other digital devices with smaller screens or special accessibility features
- manual tracking of passed and failed exams
- manual issuance of records required by Law
- inability to track time spent learning the materials and taking the exams

5.2. CLOUD TOOLS

Google Drive, Dropbox, Microsoft OneDrive and similar cloud file storage solutions are primarily being used as a way to overcome problems with sending large files through email messages. Besides, by keeping permanent links to relevant educational materials, safety engineers can delegate their distribution to managers responsible for their workers. Any change that is made in the materials hosted on a cloud distribution platform will remain available under the same permanent link and some cloud solutions even offer an automated change notification.

When choosing a cloud storage platform, it's important to consider its privacy policy and regulatory requirements. Complying with GDPR and relevant law regulations can limit the choice of a cloud provider specifically considering recent Schrems II ruling.

Implementing company wide cloud distribution just for safety engineers' needs can be too big of a challenge for the IT department, but if a company already uses these tools for other purposes there shouldn't be many obstacles to overcome.

Since this approach is just a small upgrade to the use of standard office tools, most of the disadvantages remain but it overcomes email attachment size limits.

5.3. MOODLE/LMS

By far the most common and popular Learning Management System today is Moodle. Besides being common, one of the main advantages it offers is it's open-source license. This type of license provides not only free, meaning no cost, but free to change its source code and features to tailor to specific business needs. In Croatia, the biggest (counting the number of users and courses available) instance of Moodle is CARNET Loomen having more than 300.000 user [6], integration with eCitizens for authentication and a dedicated team of IT professionals maintaining it. [7]

This type of system is recommended if it is already being used for other needs in a company. Because of its numerous features and customization possibilities tailoring a wide diversity of occupations, Moodle also needs qualified and dedicated IT support. Creating courses and course materials requires a lot of effort from a safety engineer. There are a lot of books, online courses and even certifications that are supplied directly from Moodle for becoming a certified Moodle Educator. To put things into a perspective, certification currently costs US$499, covers 6 modules, and

lasts around 8 weeks. Although, the certification is not necessary to work with Moodle, it describes that Moodle is a well-thought-out system with infinite possibilities which can cover even the most demanding business needs but at a steep learning curve.

To provide a fully automated eLearning experience it should be necessary to integrate Moodle with a human resource management (HRM) system. Some HRMs offer Moodle integration "out-of-the-box", like certain SAP products, but these are rarely used in Croatia. Since Moodle provides Web API access it is possible to make a custom integration with almost any kind of HRM but at a certain added cost of development. [8]

5.4. WEBZNR ELEARNING

With changes in the regulatory requirements and arising market needs, WebZNR (leading Croatian OHS management system) implemented its own module specialized for eLearning needs at no added cost for its current users.

WebZNR took an integrated approach to implementing eLearing with regards for different safety engineers needs and IT backgrounds. Course creator can upload his already existing materials (PDFs or PowerPoints) or create a complete course in a WYSIWG (What You See Is What You Get) editor. Using the integrated editor, the content is better served to the student and automatically resized to their screens size providing better visibility and easier deployment (for example to mobile workers). The editor can also embed content from multiple online sources, for example YouTube videos, Sharepoint sites and similar.

After creating the content, the same interface is used for designing exams. There are around 20 different types of questions available, from simple ABC choices and text entry forms to picture chooser and signature pads. These signature pads can be used if a student accesses the exam from a touchscreen interface.

If needed, every exam can be printed out and the design of the printed document can be made using all the features of Microsoft Word and by simply dragging and dropping the fields generated by the exam questions (like circular letters).

Each course gets its own unique address which can be sent out to students manually by their safety engineer or the application can be put in automatic mode where it will automatically send a link to each course a student must attend to based on their workplace and risk assessment requirements.

Once a student tries to access the exam, he can authenticate himself using any of the following methods:

- Username and password credentials – usually these are impractical since it is hard to create and distribute them to a large number of users (hundreds or thousands) and it creates additional password fatigue

- Single use PIN and workers VAT number (OIB) – probably the easiest method of authentication but can be easily spoofed if a person knows another ones VAT number
- Via email – If a student enters an email address that is recorded in his profile, a unique login link will be sent to that address that is valid for one hour.

After an exam is fulfilled, WebZNR can send out a message to the safety engineer, workers manager and even the student which enter the exam. The message can have a certificate of the exam or just a pass/fail grade if necessary.

With the integrated reports, safety engineers can easily find out if there are students that should have taken a specific exam but still have not. All the exam results can be exported to Excel and used to find out if there are certain questions which are often incorrectly answer. This in turn can signal a safety engineer to try and improve the course materials and further improve upon his course. [9]

6. CONCLUSION

By implementing eLearning tools safety engineers can increase their efficiency and spend less time chasing paperwork. Time invested in implementing this type of work will have a quick return and create an additional space for improving occupational health and safety in their environment. The point of each tool that is available to us is not to replace us or our expertise, quite the opposite, it's here to help us point out our importance and importance of providing a safe and healthy workplace for all.

7. REFERENCES

[1] M. i. J. M. Ćukušić, e-učenje: koncept i primjena, Zagreb: Školska knjiga, 2012.

[2] D. M. Damir Kralj, "The impact of the COVID 19 pandemic on the dynamics of digital transformation - Croatian perspective," vol. 11, no. 1, 2022.

[3] "PRAVILNIK O OSPOSOBLJAVANJU I USAVRŠAVANJU IZ ZAŠTITE NA RADU TE POLAGANJU STRUČNOG ISPITA," Narodne Novine, 12 2021. [Online]. Available: https://narodne-novine.nn.hr/clanci/sluzbeni/2021_12_142_2418.html.

[4] T. Jajetić, "OKVIRNI MODEL MJERENJA KVALITETE PROGRAMSKE POTPORE VOĐENJU EVIDENCIJA ZAŠTITE NA RADU," Veleučilište u Karlovcu, Karlovac, 2020.

[5] "Sustav e-učenja u području zaštie na radu: MROSP - Kviz," 2022. [Online]. Available: https://uznr.mrms.hr/kviz/. [Accessed 30 06 2022].

[6] "Portal otvorenih podataka," 2022. [Online]. Available: https://data.gov.hr. [Accessed 01 06 2022].

[7] "Carnet - Loomen - osnovne informacije," [Online]. Available: https://www.carnet.hr/usluga/loomen/.

[8] Z. Martinović, "Moodle API (Web servisi)," Zagreb, 2022.

[9] "WebZNR - o aplikaciji," 2022. [Online]. Available: https://www.zastitanaradu.hr/o-aplikaciji/. [Accessed 01 06 2022].

SAFETY AND PROTECTION RULES AT LIVE LINE WORKING

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Abstract: *Demand for electricity is growing, so constant monitoring and maintenance of the electricity grid is necessary. Working with electricity is one of the jobs with special working conditions. In order for end users, i.e. consumers, not to be left without electricity supply during the regular maintenance of the network, the concept of live operation is being introduced more and more often. Working under voltage (live working or live operation), which until a few years ago was still the exception (especially at medium, high and very high voltage) becomes more and more common way of working. Live work includes the education of persons who perform live work, as well as their safety and protection when working under voltage. The paper describes the basic rules and means of safe work under the voltage.*

Key words*: electricity, live working, safe and protection at live working*

1. INTRODUCTION

Nowadays electricity is available to the end customer in almost every place. In order to ensure uninterrupted power supply to the end user, it is necessary to monitor, control and maintain the entire power system. Electrical facilities and installations must be built in accordance with applicable regulations and maintained in good condition. Working with electricity is one of the jobs with special working conditions. Electric shock and injury to workers can occur by working with electricity. General, organizational and technical safety and protection measures must be taken to avoid any injuries. The danger of electricity occurs when the worker comes into contact with live parts due to damage to electrical equipment or circuit failure. The higher the voltage is, the higher the current is. Working under voltage (live working), which until a few years ago was still the exception (especially at medium, high and very high voltage), is becoming more and more common way of working. Live work is any work where workers with their body, tools or equipment enter or touch parts of equipment under the voltage. Live line

working belongs to jobs with special working conditions. Depending on the type of work, workers should be taught and trained under the same conditions as during real work, and additionally specially trained for special work. Training programs for live work are determined by the appropriate institution for training workers for working under voltage. Everyone must stick to safety measures without endangering anyone's health or life. In order to provide customers with uninterrupted power supply, maintenance of electrical power facilities, transmission and distribution lines is performed under voltage. In this paper, the procedure of safe operation under voltage and necessary equipment will be explained. [1]

2. METHODS OF LIVE WORKING

The operation process itself ensures, above all, the protection of the live line workers from the danger of voltage presence, as well as a sufficient level of insulation between parts under different voltages to avoid the risk of short circuits.

Working under voltage requires a greater degree of knowledge and experience, special training, significant psychophysical abilities of workers and work discipline.

According to the Ordinance on safety and health when working with electricity NN 88/12, article 87, live operation requires the use of prescribed and tested modes of operation, as follows:

- working at a distance from live conductors,
- working with insulating gloves,
- working on the conductor potential. [2]

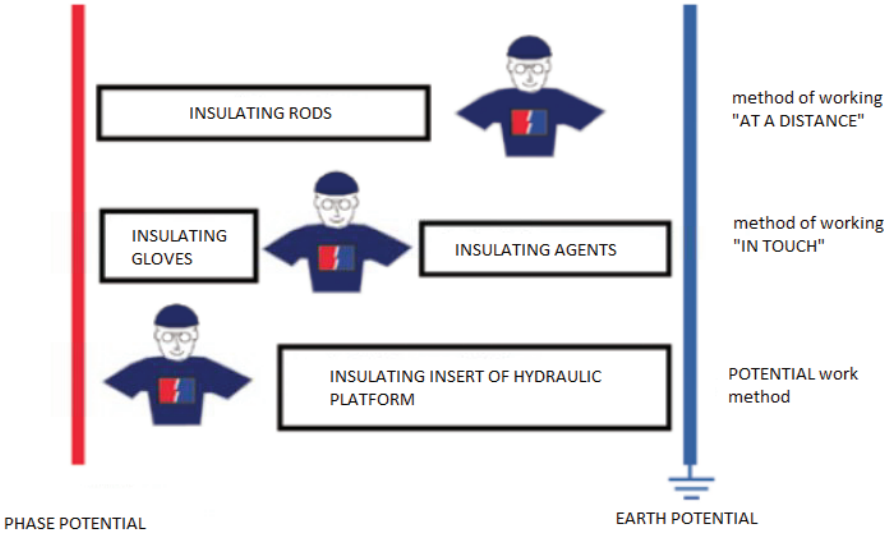

Figure 1: Positions of protective elements according to live line working methods

2.1. Method of working "AT DISTANCE"

The operator stands outside the minimum approach distance, unless established protective systems are used, and works on live parts using tools secured to the ends of insulating poles or ropes that are suitably insulated for the voltage level parts which will be worked on. [3]

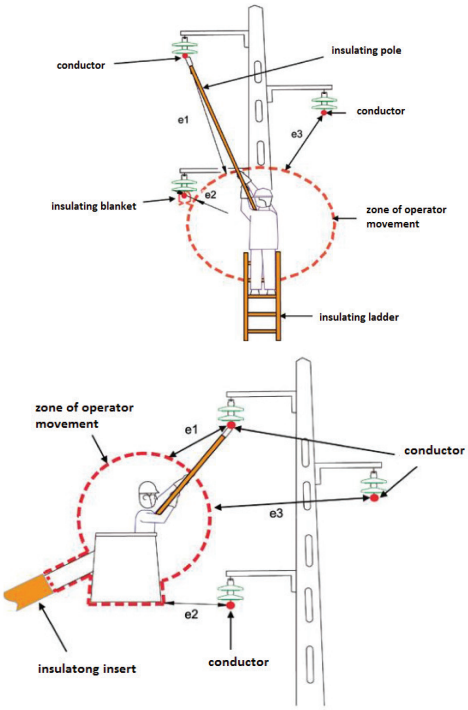

Figure 2: Method of working "at distance"

2.2. Method of working "IN TOUCH"

The operator uses, in addition to other protective equipment, rubber protective gloves, insulating shoes and insulated hand tools. The operator should cover all non-insulated parts that could be dangerous to life or could cause a short circuit with insulating blankets, caps, foils. [4]

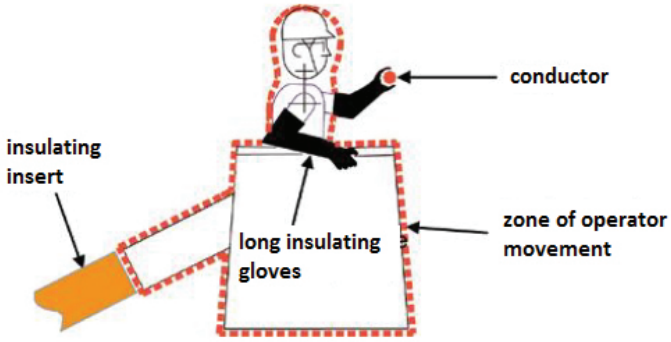

Figure 3: Zone of movement when working with the "in touch" method

2.3. Method of working "AT POTENTIAL"

The method of working "at potential" is most often performed at high and very high voltage. When working at the potential, the operator approaches the live part with an insulating ladder, an insulating platform or a basket suspended from the insulator. The protective clothing he wears contains metal mesh, which forms a kind of Faraday cage. It is necessary to connect the protective suit to the live part with a flexible conductor, to ensure that there is no potential difference. [8]

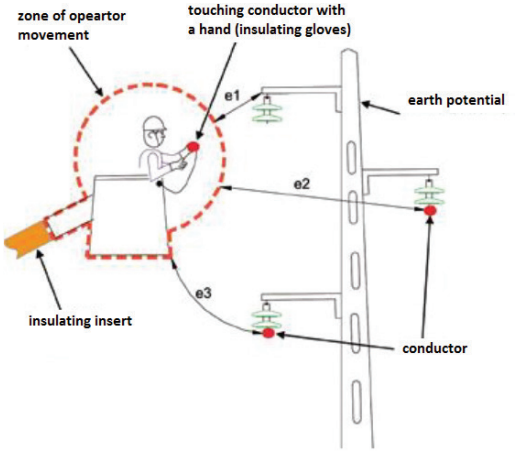

Figure 4: Method of working "at potential"

3. PERSONAL PROTECTIVE EQUIPMENT FOR LIVE LINE WORKERS

According to General Guidelines for Safety of Live Line Working, workers performing live line work should wear insulating protective appliances (insulating clothing or insulating shawls, insulating sleeves, insulating gloves, insulating shoes, insulating safety helmets, etc.), which we can see at figure 5. Workers performing live line connection or disconnection of leads should wear goggles and use safety belts having good insulating properties. Insulating protective appliances should not be taken off during live line working. [5]

All equipment used for working on overhead lines and apparatus shall be surveyed
every month by a responsible official and he shall take random checks on the equipment to satisfy himself that the equipment is in good condition, paying special attention to the safety equipment such as safety belts, gloves, ropes used for hoisting etc.
as per schedule. Any replacement due to wear and tear shall be made immediately. [6]

Basic personal protective equipment for live line workers: [7]

a) Hard hat – made from hard plastic with inner web suspension system; has universal slots to attach accessories such as ear protection. Extended brim protects face from falling debris. Factory-tested for dielectric strength.
b) Safety glasses – Nylon, one-piece frame. Worn to block hazardous sun glare, particularly when working on energized lines.
c) Ear protection – Mounts into hardhat slots and has replaceable foam cushions. Different types have different noise reduction ratings
d) Rubber sleeves – Dielectric-tested, seamless, vulcanized molded rubber that protects wearers arms from unintentional contact with energized power source
e) Safety harness and Hearing Protection – full body harness for working in elevated bucket. Harness attaches to truck boom with lanyard and locking snap hook.
f) Shirt – 55% Modacrylic/45% cotton flame resistant fabric and stitching with nonmetallic buttons. Protects from burns in event of contact. Bright color highly visible in high traffic areas
g) Rubber gloves – Dielectric-tasted, rubber insulated gloves for electrical protection. Glove thickness dictates the level of voltage line personnel may work.
h) Lanyard – Nylon strap with locking snap hooks connects to lineman`s safety harness (in back) to truck boom to prevent falling.

i) Rubber glove protectors – Leather gloves with Velcro tightening strap and attached orange vinyl cuff. Worn over insulated rubber gloves to reduce chance of puncturing or tearing from sharp objects.

j) Hot stick – insulated, dielectric-tested fiberglass tool for moving or adjusting live electrical equipment.

k) Jeans – 88% fire resistant cotton/12% Nylon with flame resistant stitching. Protects from burns in event of electrical contact.

l) Work boots – Lace-to-toe, steel or ceramic-toe leather boots with extra arch support for climbing.

Figure 5: Personal protective equipment for live line workers

3. CONCLUSION

Working under voltage requires special training as well as safety and protective equipment that have been tested according to current standards. Live line workers must follow all rules for live work and use all prescribed equipment to prevent injuries at work. The starting point for the development of live line work technology is educational centers, and Croatia has a high-quality educational center in Velika, which leads to the conclusion that it has a good foundation for the further development of live line technology. Along with constant technological development, a high level of professional training, the constant renewal of workers knowledge, the introduction of live work results in a significant reduction in

fatalities, a reduction in minor and serious injuries at work, and the preservation of workers health. Live line working also brings economic benefits to factories and electricity suppliers, due to the continuity of the power supply.

REFERENCES

[1] Ministarstvo rada, mirovinskog sustava, obitelji i socijalne politike: Pravila sigurnosti pri radu s električnom energijom, Rujan 2020, *Available from* *http://uznr.mrms.hr/wp-content/uploads/2020/09/VODI%C4%8C_ELEKTRI%C4%8CNA_ENERGIJA.pdf* *Accessed:2022-07-03*

[2] Ministarstvo rada i mirovinskog sustava: NN 88/2012, Pravilnik o sigurnosti i zdravlju pri radu s električnom energijom, Srpanj 2012, *Available from:* https://narodne-novine.nn.hr/clanci/sluzbeni/full/2012_08_88_2019.html *Accessed:2022-07-03*

[3] Hrvatska elektroprivreda, „Uvjeti izvođenja radova pod naponom na srednjem naponu metodom rada „na udaljenosti“ i kombinacijom metoda“, Bilten HEP-a br. 242, Zagreb 2011.

[4] Hrvatska elektroprivreda, “Uvjeti za izvođenje radova pod naponom – čišćenje na srednjem naponu“, Bilten HEP-a br. 243, Zagreb 2011.

[5] Tianyou L., Qiujin L., Genghuang C.: *Live-Line Operation and Maintenance of Power Distribution Networks*, John Wiley & Sons Singapore Pte.Ltd, ISBN 9781119055532, Singapore, (2017)

[6] YESCO-Youth Engineering System & Co.: Live Line Working Safety Manual, *Available from*

https://www.yescobd.com/youthsite/uploadfile/03_Live_Line_Working_Safety_Manual.pdf *Accessed:* 2022-07-06

[7] Access Energy Coopearative,: Safety Equipment, *Available from* https://www.accessenergycoop.com/safety-equipment *Accessed:* 2022-07-06

[8] Mušnjak J., Mjere sigurnosti kod tehnologije rada pod naponom, *Available from* https://urn.nsk.hr/urn:nbn:hr:128:920592 *Accessed:* 2022-07-02

3

PUBLIC HEALTH

BREASTFEEDING DURING COVID-19 PANDEMIC

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Abstract:
Introduction: *The emergence and spread of the emerging COVID pandemic 19 have changed all aspects of human life by imposing new habits and behaviors to reduce human-to-human transmission of the virus. At the beginning of the pandemic, it could not be said with certainty whether the Sars-CoV-2 virus was transmitted through breast milk to an infant.*
Aim of the study: *The main objective of this final paper is to examine the impact of the Covid-19 pandemic and social isolation measures on breastfeeding and the satisfaction of breastfeeding mothers with the support they received during breastfeeding during the Covid-19 pandemic.*
Methods: *The research was conducted through an online anonymous questionnaire that was shared via social media in interest groups that promote motherhood and provide support to breastfeeding mothers in the first days of motherhood.*
Results: *Before starting breastfeeding, 49% of mothers were informed about the transmission of the Sars-CoV-2 virus to the child through breast milk, while 51% of mothers did not ask for information about it. 48% of respondents believe that the Sars-CoV-2 virus is not transmitted through breast milk to the child, 40% of respondents do not know the answer while 12% of them believe that the virus is transmitted through breast milk.*
Conclusion: *At the time of the Covid-19 pandemic, breastfeeding mothers need to ensure a smooth stay with the newborn in the common area and be taught general epidemiological measures to combat the transmission of the virus to the child*
Keywords: *Covid-19 pandemic, breastfeeding*

1. INTRODUCTION

Breastfeeding is associated with positive effects on the physical and emotional health of the mother after childbirth, lactation, and the rest of her life. Epidemiological studies have shown that, compared to non-breastfeeding women, breastfeeding women are less likely to use health services, have a lower incidence of respiratory, cardiovascular, and gastrointestinal diseases as well as fewer emotional health problems (1). Several studies have highlighted the benefits of breastfeeding and its protective effect in reducing the risk of breast cancer as low estrogen levels during lactation reduce the rate of cell proliferation and differentiation. It has been estimated that the risk of breast cancer can be reduced by more than 4% for each year of breastfeeding (2). According to a study conducted by UNICEF in 2014, a 16% increase in the proportion of mothers breastfeeding for more than six months can reduce the expected global prevalence of breast cancer by 1.6% per year (3). A pandemic caused by the SARS-CoV-2 virus isolated in the Chinese city of Wuhan in late 2019 has disrupted the daily life activities of the population globally and caused major public health and economic consequences around the world. Given all the benefits associated with breastfeeding infants with suspected Covid-19 infection in mothers, according to the UNICEF recommendation of March 2020, it is advisable to start or continue breastfeeding with general protection measures (4).

2. AIM AND HYPOTHESIS OF THE RESEARCH

The main objective of this final paper is to examine the impact of the Covid-19 pandemic and social isolation measures on breastfeeding and the satisfaction of breastfeeding women with the support they received during breastfeeding during the Covid 19 pandemic.

The specific objectives of the research are:

- Determine the relationship between breastfeeding and the mother's level of education and age
- To determine the knowledge and attitudes of breastfeeding mothers about the impact of the Sars-CoV-2 virus and vaccines against it on the safety of breastfeeding.
- Determine the relationship between breastfeeding and the source of information on the impact of Covid-19 on breastfeeding
- To establish the connection between knowledge about the impact of the Covid-19 vaccine on breastfeeding

2.1. HYPOTHESES

- Hypothesis 1: Mothers of younger age will breastfeed to a greater extent than older mothers
- Hypothesis 2: The level of education has an impact on the frequency of breastfeeding
- Hypothesis 3: Source of information on the impact of Sars-CoV-2 virus on breastfeeding safety influences breastfeeding decision

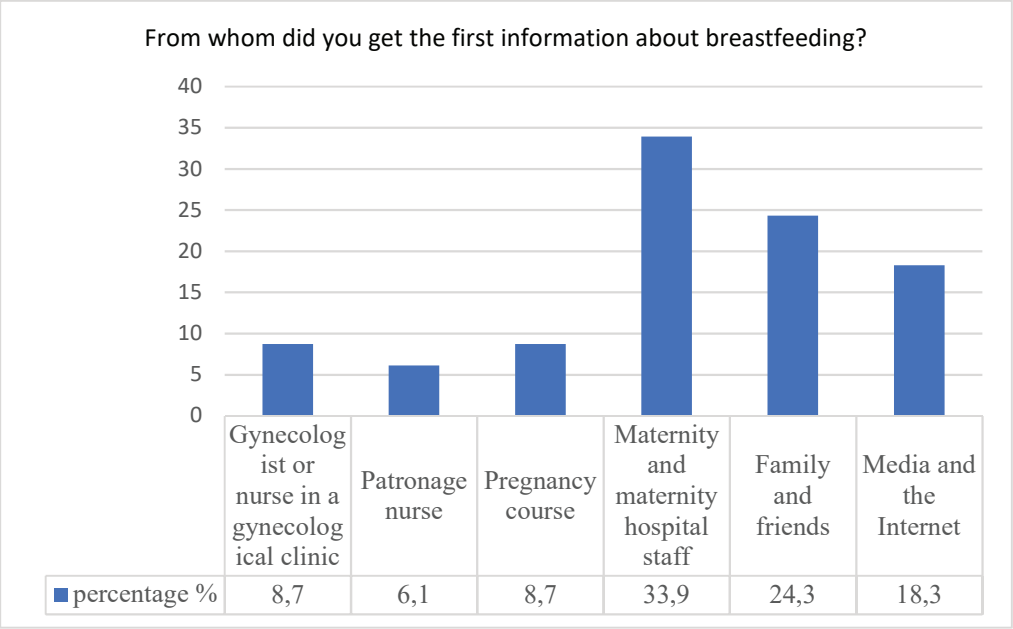
3. METHODS AND SUBJECTS

The research was conducted through an online anonymous questionnaire compiled in a Google forms form that is shared via social media in interest groups that promote motherhood and provide support to breastfeeding mothers in the first days of motherhood. The research lasted from 20.08. to 01.09.2021. years. A total of 115 respondents responded to the survey and completed the questionnaire correctly and completely. Participation in the study was completely anonymous. The Chi-Square Test of Independence determines whether there is an association between categorical variables

4. RESULTS

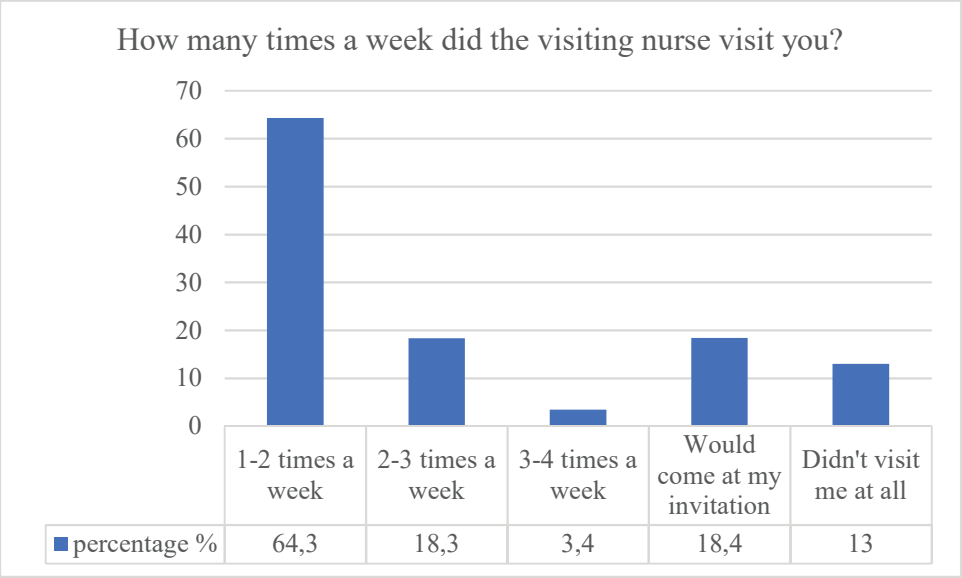
A total of 115 respondents with an average age of 30.8 (± 6.45) years participated in the study, the youngest was 20 years old and the oldest 50 years old. After the birth, the respondents received their first information about breastfeeding mostly from 39 (33.9%) birth and maternity hospitals, then from family and friends 28 (24.3%), from the media and social networks.

Figure 1: From whom did you get the first information about breastfeeding?



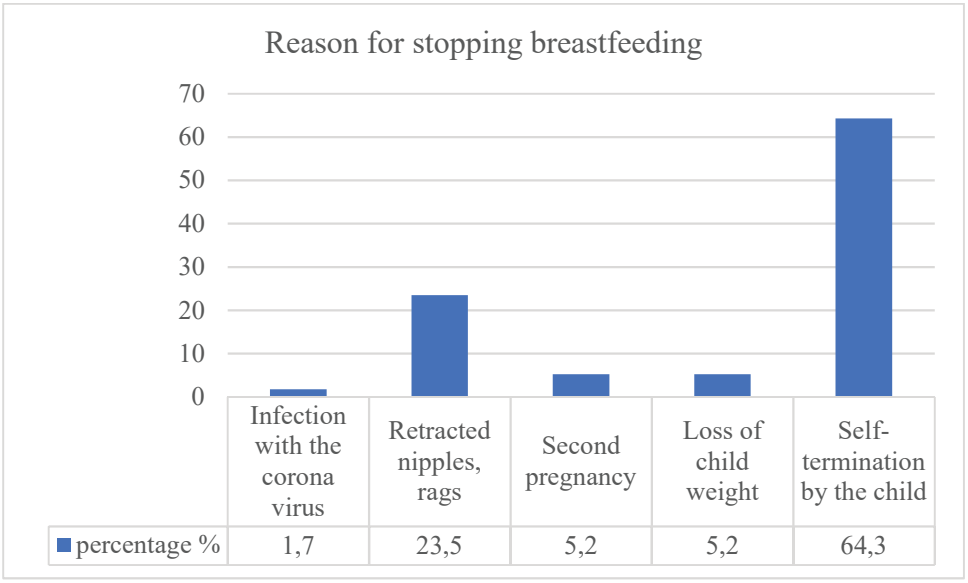
When there were problems with breastfeeding, the respondents mostly sought help from a close person 45 (39.1%), followed by a patronage nurse 27 (23.5%). Respondents in the smallest percentage turned to the breastfeeding support group 9 (7.8%). The largest number of respondents 54 (47%) were visited by a community nurse 1-2 times a week, 21 (18.3%) were visited by a community nurse, and 15 (13%) respondents stated that the community nurse did not visit them at all.

Figure 2: How many times a week did the visiting nurse visit you?



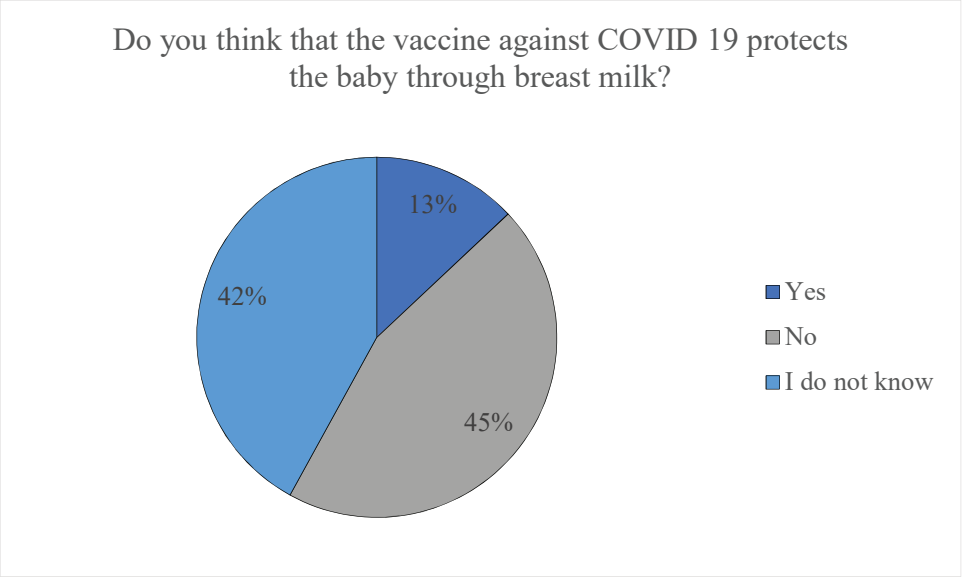
The reason for cessation of breastfeeding in most respondents 74 (64.3%) was an independent cessation of breastfeeding by a child, followed by 27 (23.5%) respondents with some problems with the breast, then in an equal number of respondents 6 (5.2%) second pregnancy and weight loss of the child. Only 2 (1.7%) respondents stopped breastfeeding due to Sars-CoV-2 virus infection.

Figure 3: Reason for stopping breastfeeding



In this research 63 (55%) respondents stated that they received all the necessary support and assistance with breastfeeding, 38 (33%) believe that they received partial assistance, and 14 (12%) respondents believe that they did not receive the necessary assistance and support related to with breastfeeding in the maternity ward.

Figure 4: Do you think that the vaccine against COVID 19 protects the baby through breast milk?



Respondents who believe that the vaccine against Covid-19 does not protect the child from the disease breastfed statistically significantly more often than other respondents (Table 5)

5. DISCUSSION

The main objective of this study was to examine the impact of the Covid-19 pandemic and social isolation measures on breastfeeding and the satisfaction of breastfeeding women with the support they received during breastfeeding during the Covid-19 pandemic. The ratio of respondents who breastfed their children with secondary and higher education was equal to those who did not breastfeed, while the ratio of respondents with higher education who did not breastfeed was 4% higher than those who breastfed. Statistical analysis of the results did not show a statistically significant difference among the respondents depending on their education. A study conducted on a sample of 1,219 breastfeeding women in the UK examined the impact of Covid-19 on the decision to stop breastfeeding. The majority of 70.3% of respondents attributed the decision to stop breastfeeding to a lack of face-to-face support, 20.9% were concerned about the safety of breastfeeding, and 6.5% of respondents attributed the development to infection. The results also showed that mothers with a lower level of education stopped breastfeeding earlier due to concerns

about the impact of breast milk on the health of the child (5). The analysis of the result proved a statistically significant difference in breastfeeding depending on the source of information. Respondents who sought information on the Internet breastfed statistically significantly more frequently than respondents who received information from family and friends and scientific research. The task of maternity health professionals, gynecologists, and community nurses is to follow the latest research on breastfeeding safety during a pandemic to be ready to offer the future mother and breastfeeding mother relevant information supported by scientific evidence and thus influence her possible fears. to the safety of the child. In the age of the internet, pandemic information is available to everyone, but it is sometimes difficult to distinguish information that is accurate from inaccurate.

6. CONCLUSION

Given all the benefits associated with breastfeeding infants in case of suspicion of the presence of Covid-19 infection in the mother, according to the latest research, it is desirable to start or continue breastfeeding with general protection measures. Before starting breastfeeding, it is the task of healthcare professionals to acquaint the mother with the known routes of virus transmission and possible risks related to the health of the infant. The decision to start or continue breastfeeding or to express milk should be made by the mother herself after receiving all relevant information. The task of health professionals is to teach the mother how to apply general protective measures before and during breastfeeding to avoid the transmission of the virus from mother to child as much as possible.

REFERENCES

[1] WebMED (Internet) Breast. Available at: https://www.webmd.com/women/picture-of-the-breasts ; Approach: 09.07.2022.
[2] Lawrence RA, Lawrence RM. Breastfeeding: a guide for the medical profession. 6th Edition. London: Mosby; 2005.
[3] Hartmann PE, et al. Breast development and the control of milk synthesis. Food and Nutrition Bulletin. 1996;17(4):292–302.
[4] Uvnas Moberg K. The neuroendocrinology of the mother-child interaction. Trends in Endocrinology and Metabolism. 1996;7:126–131.
[5] Hart SL, Jackson SC, Boylan LM. Compromised weight gain, milk intake, and feeding behavior in breastfed newborns of depressive mothers. Journal of Pediatric Psychology. 2011 Sep;36(8):942-950. DOI: 10.1093/jpepsy/jsr031. PMID: 21642337; PMCID: PMC3156587.

ASSESSMENT OF WORKING CAPACITY OF NURSES / TECHNICIANS IN HOSPITALS AND INSTITUTIONS FOR HOME HEALTH CARE

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Abstract: *The assessment of workability is very important for the employer and one of the ways to increase human resources. In the study on the assessment of working, capacity is included nurses/technicians who are employed in general hospitals and clinical hospital centers, and nurses/technicians working in health care facilities in a house. The assessment of work ability was carried out by WAI questionnaire. The results obtained through the research show that there is no significant statistical difference between the two examined groups in the assessment of work capacity.*
Diseases which are the subjects most often, or which might reduce work capacity are injuries in the accident, diseases of the muscle and skeletal system, heart and circulatory system, respiratory system diseases, and mental disorders.
Keywords: *nurse /technician: assessment of working capacity, WAI index*

1. INTRODUCTION

The profession of nurse is classified as a high-risk occupation in terms of back pain (1) - the most intense incidence of lower back pain (58%) was found among registered nurses (2). Musculoskeletal disorders are the most common reason for long-term sick leave of nurses in Germany (3). At the same time, "burnout" and psychological disorders are common among health professionals (4). Because of these interdependent factors, the focus is shifting to preserving the working capacity of health professionals. Accurate assessment of workers' working ability is very important for employers, it is one of the ways to increase human resource productivity (5). The notion of workability is the basis for planning and proper selection of staff for different jobs (6). The work ability index (WAI) was developed in Finland and is based on data collected from periodic health examinations and tests at the workplace. It aims to promote health and quality of working life. The use of WAI in research and

practice has expanded to several countries, with translation into 24 languages (7). Many workers have been shown to tend to underestimate their actual risk of developing the disease (8). Perceived self-efficacy in performing physical tasks and priorities in health and safety at work is important for health, safety, and workability (9).
The aim of this paper is:
• Compare nurses/technicians working in hospitals and in-home health care to assess the workability
• Examine which diseases occur most often in the respondents, i.e., which diseases could reduce their ability to work.

2. RESPONDENTS AND METHODS

For the research, 244 respondents aged 20 to 65 years were selected and were divided into two groups. The first group consists of nurses / medical technicians employed in health care institutions (132 respondents), while the second group consists of nurses employed in general and clinical hospital centers (112 respondents). The criterion for inclusion in the examination is the position of a nurse / medical technician of all levels of education and professional title. The survey was conducted in the period from November 20, 2021, to January 20, 2022.

2.1. Methods

The instrument used for the research was the Work Ability Index Questionnaire, a standardized questionnaire of the Finnish Institute of Occupational Medicine hereinafter referred to as the WAI. The questionnaire is used to test workability concerning job requirements. The Work Ability Index (WAI) is expressed numerically and is calculated according to the instructions of the Finnish Institute of Occupational Medicine. The range of points is from 7 to 49 points. A higher number of points means better working ability. According to the number of points, the working capacity index is categorized into four categories:

- bad (7 to 27 points)
- good (from 28 to 36 points)
- very good (from 37 to 43 points)
- excellent (44 to 49 points).

WAI is highly predictive of the retention of employees in a particular job. People who have been measured to have poor WAI do not stay in that job for more than five years. If people have bad or good WAI, certain measures need to be taken to accommodate the worker's capabilities and job requirements. Basic descriptive statistical parameters (arithmetic mean, standard deviation, minimum, maximum) are presented for all continuous variables, while percentages of individual values are calculated for categorical variables. The obtained numerical values of the results followed the data processing, and the software Microsoft Office Excel 2013 is used for the transformation of data from numerical to graphical form, as well as the final data processing. $\chi 2$ test. The results are shown in graphs and tables.

3. RESULTS

Table 1: Presentation of respondents by gender

	A		B		A+B	
	Institutes		Hospitals and KBC			
Respondents	Total number	Percentage %	Total number	Percentage %	Total number	Percentage %
	132	54,10	112	45,90	244	100,00
Respondents by gender						
Women	127	52,05	103	42,21	230	94,26
Man	5	2,05	9	3,69	14	5,74

The study involved 132 respondents from institutions and 112 respondents from general hospitals and clinical hospital centers. Out of the total number of respondents, 230 are female and 14 are male, i.e., 94% are women and 6% are men.

Table 2: Presentation of the age structure of the respondents

	A		B		A+B	
	Institutes		Hospitals and KBC			
Age groups	Total number	Percentage %	Total number	Percentage %	Total number	Percentage %
20-30	26	10,66	22	9,02	48	19,67
31-40	37	15,16	42	17,21	79	32,38
41-50	44	18,03	37	15,16	81	33,20
51-60	25	10,25	10	4,10	35	14,34
61-65	0	0,00	1	0,41	1	0,41

The most represented group consisted of 81 respondents and consisted of respondents aged 41 to 50 years, while the least represented group of respondents was aged 61 to 65 years and consisted of 1 respondent. The age group of 51 to 60 years is represented by 14% of respondents, while the age group of 20 to 30 years is represented by 20% of respondents. The age group of 31 to 40 years is represented by 32%.

Table 3: Division of respondents by education

	A		B		A+B	
	Institutes		Hospitals and KBC			
Qualifications	Total number	Percentage %	Total number	Percentage %	Total number	Percentage %

Nurse/technician	109	44,67	62	25,41	171	70,08
Bachelor of Nursing	23	9,43	50	24,59	73	29,92

The largest number of respondents, 171 (70%), are nurses / medical technicians, and 73 respondents (30%) are bachelors of nursing. Of the total number, 70% of respondents have a high school diploma, while 30% of them have completed the professional study of nursing.

Table 4: Division of respondents by workplace

	A		B		A+B	
	Institutes		Hospitals and KBC			
Working place	Total number	Percentage %	Total number	Percentage %	Total number	Percentage %
Hospital	0	0,00	62	25,41	62	25,41
Clinic	0	0,00	50	20,49	50	20,49
Institution	123	54,10	0	0,00	123	54,10

There are 132 respondents employed in health care and rehabilitation institutions, 50 respondents are employed in clinics, and 62 respondents in general hospitals. Of the total number of respondents, 54% are employed in care and rehabilitation institutions, 21% in clinics, and 25% are employed in general hospitals.

Table 5: Presentation of the type of work of the respondents

	A		B		A+B	
	Institutes		Hospitals and KBC			
Organization of work	Total number	Percentage%	Total number	Percentage%	Total number	Percentage%
in team	37	15,16	112	45,90	149	61,07
independently	95	38,93	0	00,00	95	38,93

Regarding the organization of work, the team consists of 149 respondents, while 95 respondents work independently. 61.07% of respondents work in teamwork, while 39% of respondents work independently.

Table 6: Display of type of duration of employment

	A	B	A+B
	Institutes	Hospitals and KBC	

Type of employment	Total number	Percentage %	Total number	Percentage %	Total number	Percentage %
definitely	16	6,56	8	3,28	24	9,84
indefinitely	116	47,54	104	42,62	220	90,16

According to the type of employment, 220 respondents were employed for an indefinite period, while 24 respondents were employed for a definite time. 90% of respondents are employed for an indefinite period, while 10% of respondents are employed for a definite time.

Table 7: Presentation of the working capacity index of all respondents

	A		B		A+B	
	Institutes		Hospitals and KBC			
WAI CATEGORY INDEX	Total number	Percentage %	Total number	Percentage %	Total number	Percentage %
BAD	1	0,41	1	0,41	2	0,82
GOOD	5	2,05	7	2,87	12	4,92
VERY GOOD	33	13,52	30	12,30	63	25,82
EXCELLENT	93	38,11	74	30,33	167	68,44

In the conducted research, 167 respondents have an excellent index of working ability, and 63 respondents are very good. Only 2 respondents have a poor work ability index, while 12 respondents have a good one. Excellent 68% of respondents have a working ability index, 26% have a very good working index, 5% have a good one, and 1% of respondents have a poor working ability index.

Table 8: WAI index of employees in health care and rehabilitation institutions

	HIPOKRAT MEDICA ZADAR	HEALTH INSTITUTION FLORENCE	HEALTH INSTITUTION TOBIO ZG	HEALTH INSTITUTION ZDRAVKA
M	43,60	46,67	42,56	47
SD	4,15	3,30	4,53	2,83
Max	49	49	49	49
Min	37	42	34	43
	HEALTH INSTITUTION HELENA SMOKROVIĆ	ZLATNE RUKE	ZNJ ZAGREB	HEALTH INSTITUTION KARLOVAC
M	45,4	44,53	45,00	44,92
SD	2,06	6,54	3,86	4,28

Max	49	49	49	49
Min	43	22	38	32

According to the WAI index, respondents employed in health care and rehabilitation institutions at home have the highest number of points 49, and only a small proportion of respondents have 22 points. Table 4 shows the arithmetic means and standard deviations by institution, as well as the minimum and the maximum number of points in the WAI questionnaire.

Table 9: WAI index of employees in general hospitals and clinical hospital centers

	THALASSOTHERAPY OPATIJA	THALASSOTHERAPY CRIKVENICA	OB PULA	KBC RIJEKA SURGERY AND ORTHOPEDICS
M	47,30	44,06	43,50	43,30
SD	1,73	5,74	5,22	5,05
Max	49	49	49	49
Min	44	29	32	34

	OPERATING HALL	ANESTHESIA	DIALYSIS	DIGESTIVE SURGERY	RAB
M	45,00	43,60	46,60	44,45	42,50
SD	1,54	4,64	4,37	4,03	7,5
Max	49	49	49	49	49
Min	45	38	34	37	22

According to the WAI index, respondents in general hospitals and clinical hospital centers have the highest score of 49 and the lowest of 22. Table 5 shows the arithmetic means and standard deviations by hospital sites, as well as the lowest and highest scores in the WAI questionnaire. By comparing the obtained values (Table 7), we tested the set hypothesis using the $\chi 2$ test, where the probability is $\alpha = 0.05$, the degree of freedom is 1, and the critical value is 3.84. The obtained $\chi 2 = 0.755795757$ leads us to the conclusion that there is no significant difference in the WAI index of workability between the examined groups.

4. DISCUSSION

Research has been conducted on the frequency of health problems of this profile of health professionals, which gives worrying results (10, 11, 12). Most nurses suffer from a specific disorder that results from lifting patients, pushing heavy equipment, moving patients, or holding heavy instruments in operating rooms (13). One of the first surveys in the Republic of Croatia regarding the assessment of working capacity was conducted in clinical, general, and special hospitals in the City of Zagreb, in the period from 2006 to 2008. The study included 2,380 respondents between the ages of 18 and 65 who work in the workplace of health professionals (nurses and technicians of secondary and higher education, doctors, and other highly educated people). The

results of this research showed that the examined health professionals in hospitals in the city of Zagreb have on average very good working ability (14). One of the factors that can influence the increase and maintenance of working capacity in health professionals in education. The research conducted on nurses in Croatian hospitals by the research group of the Medical Faculty of the University of Zagreb within the project of the Ministry of Science, Education and Sports Health at Work and Healthy Environment, no. 108-1080316- 0300, showed that higher education is significantly associated with the better working ability (15), which coincides with the results of studies conducted in other countries (16, 17). Therefore, it is necessary to provide education to employed nurses even after completing their formal education in high school or college, which would have a positive effect on the working ability of the largest group of health professionals, and thus on the quality of care for patients. In the examined sample, 171 respondents (70%) had only basic secondary education, while 73 respondents (30%) had completed the professional study of nursing (bachelors of nursing). In this study, a larger number of nurses with only a basic education, and despite this, the results in the assessment of working ability with the WAI questionnaire ranged from very good to excellent working ability. A specific problem is related to the education of nurses in Croatia. Institutions that provide health care services, as well as general hospitals and clinical hospital centers need highly educated nursing staff (which is provided by undergraduate and graduate nursing studies), but highly educated nursing staff often do not have systematized jobs and are not adequately rewarded according to education. it often acts degrading and demotivating. Both groups of respondents rate their ability to work concerning job requirements as very good. The current working capacity with the psychological requirements of work in health care institutions was rated from moderate to very good. This result can be associated with higher age of employees, increased job demands, daily routine, and possibly inappropriate interpersonal relationships. Most employees work in private institutions, so they probably feel insecure here as well, which is reflected in their mental state and the psychological demands of the job. They are entrusted with the care of patients who need continued health care outside the institution. Often these are patients who need palliative care and in whom the outcome of treatment and health care is uncertain, which greatly affects the ability to work according to the psychological requirements of the job. The results of this research can be an incentive for further research, which would be conducted on a larger number of respondents, over a longer period and in several different jobs that are in the competence of nurses/technicians of different levels of professional education.

5. CONCLUSION

Based on the obtained results we can conclude the following:

1. An excellent result was obtained in the assessment of the working ability of the respondents with the WAI questionnaire.
2. In the assessment of working capacity there is no significant statistical difference between the two examined groups.
3. Diseases that most often occur in respondents, or that could reduce their ability to work are the following: injuries in accidents, diseases of the

musculoskeletal system, diseases of the cardiovascular system, respiratory diseases, and mental disorders.

4. Diseases can have their causes in the physical and mental burden of health professionals of this profile.
5. Illnesses of health professionals are closely related to age, length of service, and organization of working hours in health care institutions as well as in general hospitals and clinical hospital centers.

9. LITERATURA

[1] Byrns G, Reeder G, Jin G, Pachis K. Risk factors for work-related low back pain in registered nurses, and potential obstacles in using mechanical lifting devices. J Occup Environ Hyg. 2004;1:11–21. doi: 10.1080/15459620490249992.

[2] d'Errico A, Viotti S, Baratti A, Mottura B, Barocelli AP, Tagna M, Sgambelluri B, Battaglino P, Converso D. Low back pain and associated presenteeism among hospital nursing staff. J Occup Health. 2013;55(4):276-83. doi: 10.1539/joh.12-0261-oa. Epub 2013 Jun 24. PMID: 23796597.

[3] Bödeker, W., & Zelen, K. (2007). Frühindikatoren für Langzeit-Arbeitsunfähigkeit - Entwicklung eines Vorhersage-Instruments für die betriebliche Praxis. *Chronische Krankheiten,* p. 187.

[4] Garrett C. The effect of nurse staffing patterns on medical errors and nurse burnout. AORN J. 2008 Jun;87(6):1191-204. doi: 10.1016/j.aorn.2008.01.022. PMID: 18549833.

[5] Habibi E, Dehghan H, Zeinodini M, Yousefi H, Hasanzadeh A. A Study on Work Ability Index and Physical Work Capacity on the Base of Fax Equation VO(2) Max in Male Nursing Hospital Staff in Isfahan, Iran. Int J Prev Med. 2012 Nov;3(11):776-82. PMID: 23189229; PMCID: PMC3506089.

[6] Van den Berg, T., Elders, L., de Zwart, B. and Burdorf, A. (2008) The Effects of Work-Related and Individual Factors on the Work Ability Index: A Systematic Review. Occupational and Environmental Medicine, 66, 211-220.

[7] Tuomi K, Huuhtanem P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. Occup Med. 2001;51(5):318–324.

[8] Ilmarinen J. The Work Ability Index (WAI) 2007 Occupational Medicine. 2007;57:160.

[9] Törner M: Safety climate in a broad context: what is it, how does it work, and can it be managed? SJWEH Suppl 2008, 34 : 5-8.

[10] Marks R, Allegrante JP, Lorig K: A review and synthesis of research evidence for self-efficacy-enhancing interventions for reducing chronic disability: implications for health education practice (part II). Health promot pract 2005, 6 : 148-156

[11] Legg, S. J. (1987). "Physiological ergonomics in nursing." Int J Nurs Stud 24(4): 299- 305.

[12] Marshall, D. E. and K. A. Worthington (1993). "Ergonomics: designing patient care to fit the nurse." Nurs Dyn 2(3): 5-8, 10

[13] Fragala, G. (1995). "An ergonomics system aimed at preventing back injuries in health care." J Healthc Risk Manag 15(2): 7-10.
[14] Corlett, N. (1992). "Ergonomics and back pain." Nurs Stand 6(32): 51.
[15] Knežević, Bojana, et al. "Očuvanje radne sposobnosti bolničkih zdravstvenih djelatnika." Acta Medica Croatica 64.5 (2014): 391-394.
[16] Golubic R, Milosevic M, Knezevic B, Mustajbegovic J. Work-related stress, education and work ability among hospital nurses. J Adv Nurs 2009
[17] Bobak M, Pikhart H, Rose R, Hertzman C, Marmot M. Socioeconomic factors, materialinequalities, and perceived control in self-rated health: cross-sectional data from seven post- communist countries. Soc Sci Med 2000;51:1343-50

OBESITY IN CHILDREN

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Abstract: *Obesity is a growing problem in the world. Obesity is also a big problem in Croatia, as we are the 5th country in Europe in terms of obesity. In this paper, I want to explain what exactly obesity is and why a healthy diet and exercise are important in obesity prevention. Obesity is increasingly occurring at an early age, in children and adolescents. Therefore, obesity prevention programs are implemented in pregnant women, because it is believed that obesity can occur as early as prenatal age. All of this is due to today's fast-paced, modern lifestyle, which leads to unhealthy foods and insufficient physical activity wich lead to obesity. In order to calculate obesity, it is necessary to calculate the body mass indexor BMI, and it is obtained by dividing body weight in kilograms by the square of body height in meters.*

Key words: *obesity, healthy diet, physical activity, children*

1. INTRODUCTION

Fatness is one of the greatest and most serious health problems of the 21st century. Excessive body mass, especially obesity is defined as too great of an amount of body fat that is dangerous for the health of children and adults alike. Obesity is a well known risk factor for the development of many chronic illnesses.[1] Fatness in children has taken epidemic proportions. Complications tied to obesity includes hypertensions, dyslipidemia, orthopedic and sleeping disturbances, sickness tied to gall-bladder and insulin resistance. Children with increased body mass are more likely to be obese as adults. Increased body mass of children is tied to bad eating habits, living environment, family lifestyle, physical inactivity and genes.

2. OBESITY

Fatness is not only an aesthetic problem but also a health problem which leads to the development of chronic illnesses such as of the heart, blood vessels and diabetes type 2. The number of obese people in the world is on the rise. The World health organization (WMO) claims that in 2025 50% of the world's population will

be overweight. Many people believe that obesity means that someone has too large of a body mass, but it means they have a great amount of body fats. People exist like body builders who have too large of a body mass because of the muscles but are not obese. Obesity is dangerous for adults and children especially. That is when you have to fight obesity. Child obesity is a factor in adult obesity. Obesity in children is easily observed by weighing them and controlling their body mass. The results are compared to the referent weight or height at that age. To state the value of adolescence simple and practical methods are used: define the body mass index (BMI), measuring the thickness of skin overlap and measuring the volume of the waist. [4]

2.1. BMI

Body mass index is calculated by dividing the body weight in kilograms by the square meter of height. Factors are also the age and child gender. When the BMI is calculated we compare it by graph, boys separate from girls to define the percentiles.[2] Overweight children are those whose percentile is between 85 and 95, obese are those over 95.[18]

2.2. MEASURING SUBCUTANEOUS FAT

The percentage of body mass we define by measuring the thickness of skin overlap. A caliper is used to measure a few places on the body and then the percentage of body fat is calculated. For men over 25% and women 30% body fat means they are obese. This method is precise and simple, you measure subcutaneous fat in the area of triceps and subscapularis.[2]

2.3. OBESITY IN CHILDREN IN CROATIA

Croats take 5th place of fatness in Europe, just behind Malta, Greece, Turkey and England. Obesity in Croatia is growing at the rate to worry about. Results of a survey in Croatia 2015/16 show that 35% of 8 and 9 years old are overweight which is in Europe's top 5. 31% of girls and 38,7% of boys. Today's way of life so called Modern way of life, does not help. Children spend too much time in front of TV, using mobile phones, tablets, computers, laptops and similar from the physical activity changed to sitting on a couch. A greater consumption of fast food and sweets subsidies for cooked meals and fruit.

3. HOW OBESITY OCURRES

When we speak of obesity the first reason that comes to mind is too great an intake of food and not enough physical activity. This leads to the energy from the food

being stored in fat tissue. There are also other factors for obesity like genetics, psychological, social and sometimes health. These factors of obesity in children are divided on environmental and genetics.

3.1. GENETIC FACTORS

It is scientifically proved that genetic factors make up 70% of obesity in children. Mostly on the metabolism for fats and regulating the hormone for appetite. Modern genetics confirmed a tie between gene mutation and obesity. Modern science helped to confirm the existence of a hunger/hormone (ghrelin) and satiety hormone (leptin). Ghrelin is found in cells of the stomach tissue and parts of the brain. It functions that when we are hungry the level of hormones is high stimulating the brain cells telling us to eat. After eating the level of hormones drastically falls. Leptin works differently, contrary. It sends the brain signals that you are full. An elevated level of this hormone causes you to lose appetite. A discrepant in these hormones is tied to obesity.[5] Inheritance is also a crucial factor in the development of obesity. 80% of a obese adults or children have obese family members. If one parent is obese the child is 5 times more at risk of becoming obese, or if both parents are 12 times more than a child whose parents are of normal body weight. There are also some genetic syndromes that can cause obesity like Pader-Willi, Laurence-Moon-Biedl, Cohen, Astrom and WAGR.[6]

3.2. ENVIRONMENTAL FACTORS

These factors include social, cultural and economic factors. Even though the genetic factor takes lead the environmental cannot be excluded because it influences obesity very much. This includes the parent's behavior, what they and the child eat and how much physical activity do they have. Another influence can be the low social-economic status of the parents. Children of that status eat less fruit and vegetables, consume more sweets, energetic drinks, fast food and food that is caloric and poor in nutrients. The environment influences physical activity in children. Parents have to be more involved with their children and have them play outside, do sports and such. These values they get as children stay for a lifetime.[19]

4. CLASSIFICATION OF OBESITY

The classification of obesity is founded on the values of BMI.[7] We divide it by cause and arrangement of fat tissue: android (centripeta) type-fat tissue collects in the abdominal area. Gynoid type- fat tissue collects around thighs and hips obesity by cause is divided in to primary and secondary obesity.

4.1. PRIMARY OBESITY

Primary or constitutional, monosymptomatic, idiopathic, simple. Primary obesity has mostly one leading symptom which is almost always the only one and that is the increasing of fat tissue in the organism. More factors like genetic, psychological, social, and environmental influence this type of obesity. 97% of obese children fall within this category.

4.2. SECONDARY OBESITY

Secondary or polysymptomatic, symptomatic, complex. With secondary obesity, overweight is a secondary symptom of another illness. In most cases these are monogenetic in hereditary illnesses or syndromes and congenital diseases of the central nervous system or endocrine gland.

5. PREVENTION OF OBESITY

Obesity is better to prevent than treat. To prevent obesity physical activity and healthy food are recommended. Objective diagnosis is the first step of prevention. In most cases the parents don't think the child's obesity is a health problem. Parents think that this is something that will pass by itself. They should be a good example nutrition wise and in physical activity because children learn and copy from them. Treating obesity is a long process that demands patients and perserverance from the patient, doctors, and parents. To implement a program for obesity prevention you must put together expert teams. These teams must include a doctor for children and you, a PE teacher, a psychologist, a nutritionist, and a district nurse. Prevention can be primary, secondary, and tertiary.[8]

5.1. PRIMARY PREVENTION

Primary prevention is focused on individuals but can also be focused on a population with normal weight for education, promotion and acceptance of healthy nutritional habits. Primary prevention focuses on preschool and school children and pregnant women. Risky periods for the development of obesity are prenatal, early youth and adolescence because then come changes in behavior and lifestyle. Pregnant women have to be educated in how the increase of their weight during pregnancy can influence obesity in the child. In preschool prevention is focused on adopting healthy nutritional habits, regular meals, water instead of juice, eat more non-fat meat, fish, fruits and drink milk. It is also important to restrict their time in front of a TV and encourage them to play outside with various types of physical activity. Primary prevention is seen as the most difficult type because it takes lengthy motivation, involvement of parents and experts with results seen in the future.[9]

5.2. SECONDARY PREVENTION

This type of prevention includes the identification of risky groups of people to develop obesity. This is its task. Targeted groups are children with the predisposition to become obese due to genetics or a lifestyle of sitting. These groups are educated on watching their body mass, importance of control as to prevent the development of chronic illness that can influence your quality of life. Children and youth that are at risk have their metabolic parameters clinically monitored. CPR, GUK, urine are some of parameters monitored that can point to the development of illnesses as result of obesity.[9][10]

5.3. TERTIARY PREVENTION

This applies to children and youths who have gotten an illness due to obesity. It is focused on those whose BMI is over 30 and who already have comorbidity. Comorbidities are illnesses or states that exist together with the main or primary illness of the patient. Tertiary prevention is focused on monitoring the deterioration of illnesses which frequently come with obesity. Many health workers are included in this: nephrologist, orthopedist, endocrinologist, radiologist, and others.

6. CONSEQUENCES OF OBESITY

If obesity develops at an early age, later can come illnesses that can end in death. Some of the illnesses can be cardiovascular diabetes, apnea, and many others.

6.1. HEALTH PROBLEMS

Obesity in children can result in the development of serious health complications as are:

- High blood pressure
- High cholesterol and triglycerides
- Arterial and heart sickness
- Sickness of bones and cartilage
- Sleeping problems (apnea obstruction)
- Carcinoma
- Stroke
- Respiratory problems
- Eating disorders (anorexia and bulimia)

- Liver illness
- Diabetes type 2 – most frequent result of obesity
- Other phycological disorders (depression, anxiety, social anxiety)[4]

6.2. DIFFICULT SOCIALISATION

Obese children are often made fun of and mocked. These children can feel discarded which can lead to depression which leads to sitting in front of a TV and overeating. An obese child will lose its self-confidence, close up and have no will to do anything which can lead up to lesser achievements at school. The child needs help to socialize, they need someone to stand by them and encourage them.[4]

7. HOW TO HELP AN OBESE CHILD

The best way to help an obese child is to be there for it, show that it is worthy and that its weight doesn't influence that. Parents have to be there for their child and support it because a child makes a picture of itself using a parent's opinion. If the child has problems or difficulties the parents have to encourage the child to share it with them. The child have to change its eating habits and not only the child but the whole family. It will be great benefit to increase physical activity and not to be on a diet to lose weight unless a doctor recommended it. All unhealthy food have to be slowly encouraged to physical activity in the form of a sport, council them on the harmfulness of alcohol, drugs and smoking. Healthy nutrition and physical activity should be a lifestyle and not something else that represents anguish and strain. Children should be educated about that and prepared for many falls along the way.[18]

8. PHYSICAL ACTIVITY

Physical activity is important for the correct development of a child and cuts the risk of obesity and diabetes. Regular exercise makes children more focused, sharp minded and helps their memory. Exercise is exceptionally good for the brain, children achieve better results in school and extracurricular activities, sleep and concentrate better.[13] Physical activity enlarges the blood circulation in the body and brain. This means that the brain cells are better connected. Advantages of that are: more self-confidence, better mood, and sleep. Preschool children should have the least 60 minutes to a couple of hours of physical activity with breaks of no more than 60 minutes unless they are sleeping. Children at the age of 6 need this hour.[16] It does not have to be at once. It can be before school, after homework and so. Like healthy nutrition, it is important that the whole family participates in physical

activities. This has to become a habit of the whole family, and this will stay with the child its whole life. You can plan family activities in the open or take a long walk. Walking is a basic human activity which is important for proper posture so children should be warned to keep their head up straight and not drag their feet. Families can play badminton, soccer, go swimming where the child will have fun and be active.[15] It is also important to cut the time children spend in front of a TV or computer. There are many exercises good for children: mild or difficult anaerobic exercises, exercise to strengthen muscles and bones.[11],[14],[17]

9. CONCLUSION

Children are not allowed to be on diets before the age of five. Diets in children is actually decreasing their energy intake 20-25%. Children are constantly growing and developing and that is why they need various nutritive components. A child shouldn't lose more than 250g weekly. If they lose more than that a pediatrician must be consulted. It is important that children acquire healthy eating habits while they are young. This will result with healthy eating habits throughout their lives. This is one of the reasons why we must encourage children from the earliest age to eat healthy. Another reason is that during growth and development it easier to keep up normal body weight. In this paper I analized obesity. It is a dangerous state that causes many other chronic illnesses like diabetes type 2, cancer, apnea, gall-bladder stones, stroke, osteoarthritis, heart attack and respiratory problems. Inactivity, unhealthy food, and genetics cause obesity. That is why children must have healthy nutritional habits and exercise. They also have to avoid food full of fats and sugar. Juices, sweets, and snacks has to be substituted by water, fruits, and vegetables. For a child's healthy growth and development, his family's way of life is important, and the parents have to show the child the way.

10. REFERENCES

[1] Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of comorbidities related to obesity and overweight; A systematicreviewand meta-analysis. BMC Public Health. 2009; 9.
[2] https://www.zdravobudi.hr/clanak/69/debljina-ili-pretilost
[3] https://repozitorij.foozos.hr/islandora/object/foozos%3A857/datastream/PDF/view
[4] https://www.krenizdravo.hr/mame-i-bebe/zdravlje-djece/pretilost-kod-djece-vrste-uzroci-posljedice-i-prevencija
[5] http://www.znanostblog.com/grelin-hormon-zbog-kojega-ne-uspijevate-smrsaviti/
[6] https://miss7zdrava.24sata.hr/dijeta/istrazili-smo-je-li-debljina-nasljedna-5970

[7] https://www.mychoicemylife.com/hr/pretilost-je-put-u-bolest/koje-su-izmjerene-vrijednosti-pretilosti.html
[8] http://hpps.kbsplit.hr/hpps-2016/PDFS/Ses%2036.pdf
[9] https://www.hzjz.hr/
[10] http://www.istrazime.com/zdravstvena-psihologija/prevencija-pretilosti/
[11] Prahović, M., (2013.), „Vodić za fitnes trening studenata“ Karlovac
[12] https://littledotapp.com/hr/blog/prehrana/zdrava-prehrana-djece
[13] https://bs.wikipedia.org/wiki/Dojenje
[14] Jelčić, J., (2014.), „Debljina: bolest stila života“ Zagreb, Algoritam
[15] https://www.centarzdravlja.hr/zdrav-zivot/majka-i-dijete/djecji-mozak-i-tjelovjezba/
[16] http://www.pjesmicezadjecu.com/zdravlje/tjelesna-aktivnost.html
[17] Baureis H., Wagenmann C., (2015.), „DJECA BOLJE UČE UZ KINEZIOLOGIJU - Savjeti i vježbe za lakše učenje i bolju koncentraciju“
[18] Pokrajac-Bulian A., „Pretilost: Spremnost za promjenu načina življenja“
[19] Juul, Jesper, (1996.), „Vaše kompetentno dijete: za nove temeljne vrijednosti obitelji“ Zagreb; Educa

Nanotechnology in the food industry: Nanofood safety and potential negative effects on human health

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Abstract: *Nanotechnology is a new technological branch that involves the use of molecular size substances, usually below 100 nanometres, that can be integrated with most technologies and applications, which has strong industrial potential for competitiveness and resource efficiency, but also a great impact on quality of life and sustainable development. It is increasingly used in the food industry to improve the properties of food (functional food) and materials that come into contact with food, in the control of food safety, and especially in food packaging processes. The term "nanofood" has been introduced for food grown, produced, processed or packaged using nanotechnology or with the addition of nanoparticles. The positive effects of nanotechnology in the food sector are generally well described, however, the risks and negative impacts that nanoparticles may have on biological systems have not yet been fully elucidated. The paper presents the latest achievements in the application of nanotechnology in the food industry, safety and potential risks and the impact of nanofood on human health.*

Key words*: nanoparticles, nanomaterials, food safety, nanofood*

1. INTRODUCTION

Pressure to meet consumer demands for safe, fresh, minimally processed and nutritious food, along with strict food safety regulations, is one of the biggest challenges the food industry has to face. Nanotechnology is a field of science and technology that involves the use of nano-sized particles, ranging from 1 to 100 nanometers in scale, of various materials for different applications [1]. It enables the production of materials with unique chemical, physical, and biological properties, otherwise not found at its macro level, to create new devices and techniques [2]. Due to their reduced size, the surface to volume ratio increases which makes them more biologically active and accessible to the human body but it also requires lesser amounts of incorporated material to achieve needed properties [3]. Nanotechnology has proven to be applicable in agriculture, functional food production, food packaging and food safety control [4].

2. APPLICATION OF NANOTECHNOLOGY IN THE FOOD SECTOR

Researchers have leveraged it to develop novel products with nanoscale ingredients that improve properties of food, enhance nutrient bioavailability, prevent microbial spoilage, remove contaminants, and increase the strength of packaging materials [2]. With the application of nanoparticles, it is possible to enhance food flavour and taste, but in the same time to reduce the use of additives such as sugar, salt, fat, preservatives, and emulsifiers in food products. For example, in the production of full-fat products, such as ice cream or mayonnaise, application of nanotechnology could produce a creamier and tastier low-fat alternative, and therefore offer healthier product to the consumer [4]. Considering the stated, there are lots of opportunities for using nanotechnology in the food sector.

2.1. APPLICATION IN FOOD PRODUCTION AND PROCESSING

In agriculture, farmers often encounter the problem of fresh products contamination, which reduces their yield and profit, and where the use of nanotechnology can be of great benefit. For example, application of nanoformulated agrochemicals (*e.g.* fertilizers, pesticides, biocides, veterinary drugs) requires lesser quantities, provide better efficiency and application control (target release pesticides) [5]. Using nanosprays and nanosensors is an effective way to detect the plant nutrient and water needs, presence of food contaminants and their toxic metabolites, and the use of filters with nanopores purifies water and soil from various pathogens [4]. Nanofilters could also be used in food processing aiming to purificate raw materials and to separate different food components (proteins, minerals, vitamins) in food [6]. In terms of improving product properties, nanoencapsulation masks unpleasant odours and tastes, boost flavour and colour retention, extends shelf life and improves safety, functionality, easier handling, appearance, availability, solubility and absorption of nutrients, and overall acceptability of the designed food product [7]. Recently, there are efforts in the production of different food machinery (nano-magnetic refrigeration, lubricants and rubber) which, in the long run, can reduce food production costs, reduce environmental pollution and extend the operating life of food process equipment [6].

Example: Polymeric nanoparticles in production of functional food are suggested to be suitable for the encapsulation of bioactive compounds, such as vitamins, and releasing them into an acidic environment (*i.e.*, human stomach).

2.2. APPLICATION IN FOOD PACKAGING AND SAFETY

Food items, potentially, could be packaged with a protective layer using nanoclays and nanofilms. These layers act as a barrier to external conditions keeping food products secure during transport, but also extending shelf life and freshness of food. Coatings with incorporated inorganic material, such as silver, zinc-, magnesium-, and calcium-oxide, have antimicrobial properties causing oxidative stress and microbial cell damage, and participate as an influencing component in the improvement of firmness and strength of food packaging materials [1]. Also, the use of biodegradable nanocomposite packaging has great potential in environmental protection. In order to

maintain a high food quality and safety, it is to prevent contamination with microbes, including pathogenic and spoilage microorganisms. One way is to use nanoscale edible coatings as an alternative to prevent microbial spoilage and in the same time to preserve quality and extend products shelf life. Application of antioxidant treatments in association with edible coating is the most common way to control browning of fresh-cut fruits, such as apples [8]. In application of such packaging methods, it is very important to minimize the migration of nanoparticles to a minimum, because otherwise it will not be accepted for safety reasons, and thus have a negative consumer perception [4].

Example: Modern food packaging methods include "Intelligent" and "Active" packaging that are based on monitoring the freshness of food, display information on quality (nanosensors), improve safety and convenience.

3. POTENTIAL EFFECTS OF NANOFOOD ON HUMAN HEALTH

3.1. POTENTIAL BENEFITS OF NANOFOOD

By incorporating nanoencapsulants into food, it is possible to produce functional food which, in addition to its basic functions, has proven health benefits due to the addition of superior compounds [9]. Many functional food ingredients such as unsaturated fatty acids, natural antioxidants, probiotics, vitamins and other bioactive compounds are unstable or have a repulsive taste and odour, and some of them show poor absorption due to their lipophilic nature which greatly limits their application [10]. Encapsulation and incorporation of olive oil, fish oil, chia seed oil, flaxseed oil, and cod liver oil into food play a significant role in health promotion and disease prevention due to their good source of essential fatty acids [11]. Application of polyphenols is gaining more attention in the production of functional foods due to their health benefits. One of their protective actions is against oxidative damage caused by free radicals and other oxidants. Polyphenols protect human body from the emergence and development of cardiovascular disease, cancer, neurodegenerative diseases and many other chronic diseases. In addition to that, they show antiarthritic, antithrombotic, antiviral, and antibacterial action [12]. Given that, and the fact that most phenolic compounds have unpleasant taste, incorporating them into a protective layer (nanocapsule) allows them to have a wider application in food products. Considering that a lot of beneficial food ingredients and nutrients degrade and lose their bioactivity in the stomach and intestine due to the low pH value, that way the nanoencapsulated sensitive food ingredients are protected. Although the potential

favourable effects, there are still certain concerns considering health risks associated with the nanofood manufacture and production and consumption.

Example: A typical product of this type of application would be a probiotic yoghurt, antioxidant rich cheese, breads and cereals, meat products enriched with essential fatty acids, protein enhanced sports drinks, etc.

3.2. POTENTIAL RISKS OF NANOFOOD

It is known that the positive, but also negative, biological properties of nanomaterials largely depend on their physicochemical parameters and administered dose [8]. In general, the toxicity of the nanoparticle is proportional of its size, which means that the smaller particles are more harmful in comparison to the large-sized ones of the same chemical composition [13]. In line with this effort, different nanoparticle characterization techniques have been developed by following parameters: nanoparticle size, shape, chemical composition, surface area, charge and chemistry, agglomeration, aggregation, purity and crystallinity of nanoparticle [1]. Although naturally occurring nanoparticles that do not have a detrimental effect on the body can be found in food, some scientific research suggests that intentionally altered nanoparticles can cross cellular barriers and lead to their damage [4]. Some studies have shown that small nanoparticles (<10 nm) act as gas particles and can easily enter human tissues and distribute in the lungs, liver, heart, and even the brain [13]. Potential consumer exposure to nanoparticles could be viewed through migration into foodstuffs, or ingestion of edible coatings [5]. Various nanofood additives, nanoencapsulation, nanoclays from food contact material, and other methods of nanopackaging could cause intolerance, allergies and other health risks with the potential release of heavy metals into the body [8]. Also, some nanoparticles may be released into the environment and present new challenges in their detection and evaluation. For that reason, monitoring of chronic food exposure in contact with nanomaterial should be critically evaluated, and a nanofood hazard assessment needs to be established to ensure safety before such products reach the global market [6]. It should be noted that every food product is a living system prone to change due to action of various internal and external factors. Taking into consideration pH value, osmotic pressure, physical forces, chemical composition of food, activity and metabolism of present microbes, altogether with the effect of nanomaterials and nanoparticles should be evaluated for risk assessment [8].

Example: Potentially toxic nanoparticles, such as copper- and zinc-oxide, inhaled or ingested with food, have ability to enter the bloodstream and accumulate in the liver and in the mononuclear phagocytic system which can cause dysfunctions and structural changes leading to immune system weakening and disease developing [14].

4. LEGISLATIVE

Despite the growing commercialization of nanotechnology in the world, we are not yet fully aware of the impact nanomaterials and nanotechnology have on humans in terms of toxicity and carcinogenicity [15]. In order to be able to assess the

hazardous properties of nanoforms and ensure their safety, regulations related to the safe use of nanomaterials have been introduced in the European Union, *i.e.* in the form of REACH and CLP regulations. The amendments of the REACH regulation to address nanoforms of substances establishes basic information on volumes and uses of nanoforms in food, particle size, shape and surface chemistry, performance of chemical safety assessment, documentation of information requirements on hazard assessment and application of adaptation possibilities, risk management, user obligations, etc. Since REACH applies to registration, evaluation, authorisation and restrictions of nanomaterials, CLP regulations refer to classification and labelling, as it would for any other food additive or substance. Considering that, there are other regulations and directives that could be applied to nanomaterials in food.

Regulation (EC) No. 258/97 refers on the novel foods or novel food ingredients placement on the market, it states that they must not present a risk for consumer, mislead them, or differ from original food or their ingredients they tend to replace. Only authorized and safety-evaluated additives are allowed into food [4]. In regards to that, *Regulation (EC) No. 1331/2008* establishes a common procedure for the evaluation and approval of food additives, enzymes, flavours and other additives intended for food incorporation, and *Directive 89/107/EEC* applies to food additives used during foodstuff manufacture or preparation, and are present in the final product, even in altered form. According to regulations of *Directive 2000/13/EC* and *90/496/EEC*, all food components, including nanomaterials, must be listed under the item "ingredients". Additives are not the only substances that can alter food properties. Different food packaging materials with incorporated nanoparticles intended to directly or indirectly come into contact with food could be controlled with *Regulation (EC) No. 1935/2004* that is based on consumer health protection by establishing rules applicable to packaging materials.

EFSA (European Food Safety Authority) has published two guidance documents to assist with the assessment of nanomaterials in the food and feed chain, *Guidance on risk assessment of nanomaterials in the food and feed chain: animal and human health,* and *Guidance on technical requirements for regulated food and feed product applications to establish the presence of small particles including nanoparticles*. These guides provide necessary information that can assist food producers in regards to permitted materials and additives when placing products on EU market.

5. CONCLUSION

Nanotechnology finds its application in biomedicine, electrical engineering, and in most cases in the food sector. With it, we can ensure the safety of drinking water, maintain sterile surfaces and devices, reduce food contamination, extend the shelf life of food products, reduce energy usage, protect the environment and human health. Advantages and limitations of nanomaterials in food depend on their specific characteristics as well as the composition of food. Nanotechnology can be used to enhance flavour and texture of food products, protect valuable but unstable food components, keep the product inside the packaging fresher which provides consumers with better and safer products, and food producers have greater profitability in the

long run. Benefits of nano-enriched food can be also seen in improving the health and functionality of the organism. However, adding nanomaterials into food is not without risks. The influence of nanocomponents in food is yet to be fully investigated, but what we do know is that they can affect the normal functioning of the human body depending on its physicochemical characteristics and the taken dose. Therefore, appropriate legislation is being established to regulate nanomaterials associated with food products that are being placed on the market.

ACKNOWLEDGEMENTS

This work has been supported by the Croatian Government and the European Union through the European Structural and Investment Funds - the Competitiveness and Cohesion Operational Programme (KK.01.1.1.04.) under the project "Modification of cheese ripening process and development of whey-based products—SIRENA". Project co-financed by the European Union from the European Regional Development Fund.

REFERENCES

[1] Khare, S., Williams, K., & Gokulan, K.: Nanotechnology, In *Encyclopedia of Food Microbiology*, **Vol. 2**, Elsevier Ltd., ISBN: 9780123847331, (2014), Pages 893–900

[2] Kuang, L., Burgess, B., Cuite, C. L., Tepper, B. J., & Hallman, W. K.: Sensory Acceptability and Willingness to Buy Foods Presented as Having Benefits Achieved Through the Use of Nanotechnology. *Food Quality and Preference*, **Vol. 83**, (2020), No. 103922

[3] Nazzaro, F., Fratianni, F., & Coppola, R.: Microtechnology and nanotechnology in food science. *Green Technologies in Food Production and Processing*, Food Engineering Series, Springer Science+Business Media, (2011), Pages 471-494

[4] Knežević, N., Šćetar, M. i Galić, K.: Possibilities of Nanotechnology Application in the Food Sector with Reference on its Consumers Acceptance. *Croatian Journal of Food Technology, Biotechnology and Nutrition*, **Vol. 7(1-2)**, (2012), Pages 126-131

[5] Chaudhry, Q., & Castle, L.: Food applications of nanotechnologies: An overview of opportunities and challenges for developing countries. *Trends in Food Science & Technology*, **Vol. 22(11)**, (2011), Pages 595–603

[6] Bai, H., & Liu, X.: Food nanotechnology and nano food safety. *IEEE Nanotechnology Materials and Devices Conference* (NMDC), ISBN:978-1-4673-9362-1, Anchorage Alaska, USA, 13-16th September 2015, IEEE, (2015)

[7] Pateiro, M., Gómez, B., Munekata, P.E.S., Barba, F.J., Putnik, P.; Kovačević, D.B., & Lorenzo, J.M.: Nanoencapsulation of Promising Bioactive Compounds

to Improve Their Absorption, Stability, Functionality and the Appearance of the Final Food Products. *Molecules*, **Vol. 26**, 1547, (2021)

[8] He, X., & Hwang, H.-M.: Nanotechnology in food science: Functionality, applicability, and safety assessment. *Journal of Food and Drug Analysis*, **Vol. 24(4)**, (2016), Pages 671–681, ISSN: 1021-9498

[9] Delshadi, R., Bahrami, A., Tafti, A. G., Barba, F. J., & Williams, L. L.: Micro and nano-encapsulation of vegetable and essential oils to develop functional food products with improved nutritional profiles. *Trends in Food Science & Technology*, **Vol**. **104**, (2020), Pages 72-83, ISSN 0924-2244

[10] Chew, S. C., Tan, C. H., Pui, L. P., Chong, P. N., Gunasekaran, B., & Nyam, K.: Encapsulation technologies: A tool for functional foods development. *International Journal of Innovative Technology and Exploring Engineering*, **Vol. 8(5)**, (2019), Pages 154-162, ISSN: 2278-3075

[11] Heidebach, T., Först, P., & Kulozik, U.: Microencapsulation of Probiotic Cells for Food Applications. *Critical Reviews in Food Science and Nutrition*, **Vol. 52(4)**, (2012), Pages 291–311, ISSN: 1040-8398 / 1549-7852

[12] Shivashankara K.S. &, Acharya S.N.: Bioavailability of Dietary Polyphenols and the Cardiovascular Diseases. *The Open Nutraceuticals Journal,* **Vol. 3**, (2010), Pages 227-241, ISSN: 1876-3960/10

[13] Bahadar H., Maqbool F., Niaz K., Abdollahi M.: Toxicity of Nanoparticles and an Overview of Current Experimental Models. *Iranian Biomedical Journal*, **Vol. 20(1)**, (2016) Pages 1–11

[14] Yao, Y., Zang, Y., Qu, J., Tang, M., & Zhang, T.: The Toxicity of Metallic Nanoparticles on Liver: The Subcellular Damages, Mechanisms, And Outcomes. *International Journal of Nanomedicine*, **Vol. 14**, (2019), Pages 8787–8804

[15] Aída María Ponce Del Castillo: The EU approach to regulating nanotechnology. *Working paper 2010.05*, European Trade Union Institute, ETUI aisbl, Brussels, (2010), ISSN 1994-4454

MILK AND DAIRY PRODUCTS SOURCE OF NUTRACEUTICALS: REVIEW

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Abstract: *Taking care of own health has encouraged people to consume food with bioactive ingredients (nutraceutics), which have a beneficial effect on health. Milk and dairy products are traditionally considered as foods that have adequate nutritional value and a beneficial effect on health as a valuable source of nutraceutics such as proteins, peptides, lipids and carbohydrates. These ingredients have a preventive effect on health and prevent the development of various chronic diseases such as diseases of the vascular system or diabetes. The aim of this paper is to present the nutraceuticals, bioactive components, present in milk and dairy products and to show their effect in health.*

Keywords: *dairy products, human health, milk, nutraceuticals.*

1. INTRODUCTION

Consumer care about their own health and the development of food technology, medicine, and our understanding of nutrition at large have led to the creation of specially designed food products and dietary supplements. These new food products, aside from their baseline nutritional value, have been designed to positively and satisfactorily influence one or more functions of the human organism, lowering the risks of certain diseases. This is why they are referred to as 'functional food'. Functional food can increase the general wellbeing of the whole organism, lower the risk of certain diseases or illnesses, and can be even used to treat certain conditions. The term 'functional food' also ties in the term 'nutraceutic'. This term is used to describe any substance or part of the food itself that has medicinal or health benefits including prevention and treatment of certain diseases. These products can come in a variety of forms such as purified and concentrated nutrients, food supplements, plant products or natural components of plants and processed foods [1].

Milk and dairy products represent a food source full of nutritionally beneficial components such as proteins, lipids, lactose, as well as other micro- and macronutrients. It is well known that milk itself represents a naturally wholesome source of food that is necessary for the development and growth of mammals. Aside from the naturally occurring components, milk can also be enriched during its processing or digestion by certain elements (such as the enzyme hydrolase) that can act as nutraceutics due to their health benefits [2].

Modern technology uses the bioactive ingredients from milk and dairy products as supplements to 'functional food' or for potential pharmaceutical use. Some of these bioactive ingredients are primarily present in the milk such as growth factors (epidermal growth factor, neuronal growth factors, vascular endothelial growth factors, erythropoietin, growth regulating factors) and certain substances connected to the immune system (immune cells, cytokines, chemokines) [2] [3].

The aim of this paper is to present the nutraceuticals, bioactive components, present in milk and dairy products and to show their effect on health.

2. BIOACTIVE COMPONENTS OF MILK AS NUTRACEUTICALS

2.1. Bioactive proteins and derivatives in milk

Milk proteins are classified as proteins of high biological value, good digestibility, and a good source of essential amino acids necessary for the human organism. Milk contains around 32 g / 100 g of proteins, which can be separated into two categories, casein (80%) and whey proteins (20%). The make up of amino acids is significantly different between these two categories, whey proteins are more rich in leucine, isoleucine, valine and lysine, while caseins are mostly rich in histidine, methionine and phenylalanine. The percentage of proteins in the milk is one of the factors that determine the purchase price of the milk since the production of cheese is directly tied to the percentage of casein present in the milk. Recent studies have shown that peptides activated through the digestion of milk have a protective role for the human health, while phosphorylated peptides are necessary for the transport and absorption of nutritional minerals such as zinc and calcium [4].

Table 1: The main bioactive peptides, their activities and structural properties [2].

Activity	Structural characteristics
Opioid	Tyrosine at N-terminus, connected with another aromatic residue (Phe or Tyr), in the 3rd or 4th position.
ACE inhibitory (Antihypertensive)	Hydrophobic amino acids or positive charge of Lys or Arg on the C-terminus.
Antithrombotic	Ile^{108}, Lys^{112} and Asp^{115} residues of casoplatelins (peptides derived from κ-casein)
Antioxidant	High amounts of His and hydrophobic amino acids.
Hypocholesterolemic	Low ratios of Met-Gly and Lys-Arg in proteins. High amount of hydrophobic amino acids.
Antimicrobial	Positively charged residues and hydrophobic region that contains Trp

Milk proteins are known for their high nutritional value and many of their macromolecules are tied to the various biological activities including: antimicrobial properties, mineral absorption, antilypidemic activity and antitumor properties. Besides that, peptides originating from the digestion of the milk in the digestive tract also have a biological activity since they are directly, positively, correlated to hypertension, inflammatory markers, diabetes, and osteoporosis[2]. The main bioactive peptides of the milk, structural properties, and their functions are shown in the table 1.

2.2. Carbohydrate component

Aside from lactose, oligosaccharides are also important carbohydrates in the milk, Human milk contains a large quantity of oligosaccharides in the colostrum (25 g/L) and in the mature milk (14 g/L). Cow milk contains 0,7 to 1,2 g/L of oligosaccharides in colostrum, while their mature milk contains 100 mg/L of oligosaccharides. Oligosaccharides in the milk contain, in their structure, lactose or N-acetil-lactoseamine on their reduction end and have monosaccharide remnants on the non-reductive galactosis. Researches have shown that oligosaccharides of the cow milk are structurally similar to oligosaccharides of the human milk and contain branching oligosaccharides with N-acetil-neuraminic acid and fucose. This structural similarity suggest that oligosaccharides of the cow milk have some similar biological functions with those found in the human milk. The inclusion of oligosaccharides in the human milk has directed researches to prove and determine their biological function in that type of milk. However, the similarities between their structure and structure of oligosaccharides found in the cow milk has expanded these researches. Even though oligosaccharides in the cow milk are present in a low concentration, a large portion of the available whey protein found in them has represented a large potential for getting these bioactive compounds in the food industry [5]. The significance of oligosaccharides in the human milk for the development of a newborn is represented in Table 2.

Tabe 2: Influence of oligosaccharides in human milk on infant health [6].

Effect of oligosaccharides	Mechanism of action
Prebiotic effect	Human milk oligosaccharides serve as a substrate for beneficial bacteria in the gut.
Transcriptional effects	Signaling via human milk oligosaccharides altere the gene expression of intestinal epithelial cells.
Antimicrobial effects	Attachment of human milk oligosaccharides to epithelial receptors in the gut prevents microbial attachment.
Immunomodulatory effects	Cytokine production and inflammatory cell infiltration are modulated by human milk oligosaccharides

2.3. Bioactive Properties of Lipids

Tabe 3: Milk fat composition and their main health effects [8].

Milk component	Concentration in 1 L whole milk	Health effects
Fat	33 g/L	Energy rich
Saturated fatty acids	19 g/L	Increase HDL, small dense LDL, and total cholesterol. Inhibition of bacteria, virus
Oleic acid	8 g/L	Prevent CHD, gives stable membranes
Lauric acid	8 g/L	Antiviral and antibacterial
Myrisitc acid	3.0 g/L	Increase LDL and HDL
Palmitic acid	8 g/L	Increase LDL and HDL
Linoleic acid	1.2 g/L	Omega-6 fatty acid
Alpha linolenic acid	0.75 g/L	Omega-3 fatty acid

Milk fat contains up to 400 different fatty acids that have an important nutritional role for the human organism. Most of the fatty acids are esterified with glycerol and are present in the form of triacylglycerides that make up around 95% of milk fat, while the rest is made up of 2% diacylglycerol, 1% phospholipids, 0.5% cholesterol and 0.5% free fatty acids [7].

Table 4: Conjugated linoleic acid isomer profile [4].

Isomer	Composition (g/100g CLA)		
	Bovine	Caprine	Ovine
cis-8, *trans*-10	< 0.01 - 1.70	< 0.01	NR
cis-9, *trans*-11	65.6 - 88.9	62.1 - 75.1	80.0 - 80.9
cis-11, *trans*-13	< 0.01 - 0.23	0.16 - 0.69	NR
cis-12, *trans*-14	< 0.01 - 1.06	0.00 - 0.13	1.69 - 1.83
trans-7, *cis*-9	2.63 - 9.49	4.57 - 11.7	5.96 - 6.08
trans-8, *cis*-10	< 0.01 - 2.33	1.85 - 3.48	NR
trans-9, *cis*-11	< 0.01 - 3.93	< 0.01 - 4.21	NR
trans-10, *cis*-12	< 0.01 - 1.61	< 0.01 - 0.90	0.55 - 0.57
trans-11, *cis*-13	0.06 - 9.33	0.22 - 0.48	2.14 - 2.38
trans-6, *trans*-8	< 0.01 - 1.40	0.12 - 1.91	< 0.01

trans-7, *trans*-9	0.02 - 2.80	0.42 - 1.08	0.40 - 0.42
trans-8, *trans*-10	0.19 - 0.67	0.36 - 1.47	0.34 - 0.42
trans-9, *trans*-11	1.31 - 1.40	2.99 - 5.77	1.40 - 1.60
trans-10, *trans*-12	0.31 - 1.40	0.76 - 4.16	0.53 - 0.85
trans-11, *trans*-13	0.89 - 6.00	0.58 - 1.14	3.04- 3.18
trans-12, *trans*-14	0.35 - 3.55	0.72 - 1.90	1.90 - 2.20
trans-13, *trans*-15	< 0.01 - 0.16	< 0.01	NR

Researches have shown that butyric acid (4:0) has anti-cancerogenic properties and it is a well-known gene modulator. Lauric acid (12:0) is the most important when it comes to antiviral and antibacterial effects and it can also serve as protection against cavities and plaque formation. Caprylic acid (8:0) has also been found to slow down cancer growth, and it also has an important antiviral role. Oleic acid, which is a mono-nonsaturated fatty acid present in the milk, could also have health benefits. Another important fatty acid in the milk is the conjugated linoleic acid, which can be found in a multitude of positional and geometric isomers and has become very interesting for research purposes. The most important isomer of the conjugated linoleic acid is cis-9, trans-22 which is made through bioconversion of multi non saturated fatty acid by anaerobic bacteria in the rumen which earned it the name of rumenic acid. It is known that the conjugated linoleic acid can be therapeutic, anti-cancerogenic, improve immune system, anti-diabetic, antihypertensive, anti-atherogenic, lower body fat and can influence obesity. Isomers of the conjugated linoleic acid and their representation in the varying types of milk are shown in Table 4. Butter is used to introduce bioactive lipids, such as polarized lipids found in the membrane of fatty acid globules, into the organism and which have been shown to have numerous health benefits. They positively influence digestion and can act anti-proliferative against ovarian cancer and colon cancer [9].

3. CONCLUSION

In the recent decade intensive researches have shown the effect of bioactive components in the milk on human health. These components found in the milk are safe for human consumption, can act preventative or even curative in certain health condition such as: stress, cardiovascular disease, obesity, and other conditions. Bioactive milk components have a high potential for improvement of different biological functions in the human body which can result in positive effects on the overall human health. Future researches in this field should focus on the development of technology that could be used to isolate these bioactive compounds and the study of the interaction of these compounds with other compounds in the food so that they could become commercially available through various food or pharmaceutical products. Through those researches, food with bioactive ingredients

found in the milk would become more available to the consumers that are concerned about their health and could be used to prevent or cure diseases.

REFERENCES

[1] Arai, S., Vattem, D.A., Kumaga, H.: Functional Foods—History and Concepts, In: *Functional Foods, Nutraceuticals and Natural Products*, DEStech Publications Inc., ISBN 978-1-60595-101-0, Lancaster (2016), pp. 1-18.
[2] Lisak Jakopović, K., Barukčić, I., Božanić, R.: Bioactive components derived from bovine milk, *Mljekarstvo*, **69** (2019) 3, pp. 151-161, ISSN 1846-4025.
[3] Giacometti, J., Buretić-Tomljanović, A.: Peptidomics as a tool for characterizing bioactive milk peptides, *Food Chemistry*, **230** (2017), pp. 91-98, ISSN 0308-8146.
[4] Minieri, S., Sofi, F., Mannelli, F., Gatta, D., Benvenuti, D., Buccioni, A.: New Trends in the Bioactive Compounds of Milk: a Review of the Functional Activities and Processing Effects, *SDRP Journal of Food Science & Technology*, **3** (2018) 4, pp. 378 – 388, ISSN 2472-6419.
[5] Lin, T.: Bioactives in bovine milk: chemistry, technology, and applications, *Nutrition Reviews*, **79** (2022), pp. 48–69, ISSN 0029-6643.
[6] Bode, L.: Human milk oligosaccharides: Every baby needs a sugar mama, *Glycobiology*, **22** (2012) 9, pp. 1147–1162, ISSN 0959-6658.
[7] Tratnik, Lj., Božanić, R.: *Mlijeko i mliječni proizvodi*, Hrvatska mljekarska udruga, ISBN 978-953-7472-06-1, Zagreb (2012).
[8] Haug, A., Høstmark, A.T., Harstad, O.M.: Bovine milk in human nutrition – a review, *Lipids in Health and Disease*, **25** (2007) 6, pp. 2-16, ISSN 1476-511X.
[9] Dhankhar, J., Sharma, R., Indumathi, K. P.: Bioactive lipids in milk, *International Food Research Journal*, **23** (2016) 6, pp. 2326-2334, ISSN 2231 7546.

VACCINATION HESITANCY IN HEALTHCARE WORKERS

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***Abstract**: Vaccine hesitancy is one of the main causes for poor vaccine coverage during ongoing COVID-19 pandemic and imposes significant occupational and public health threat. Vaccine acceptance among healthcare workers is highly influenced by perception of vaccine efficacy and safety where sociodemographic, health- and occupation-related differences seem to play a role. Therefore, the aim of the study was to present sociodemographic, health- and occupation-related determinants that may influence delay in acceptance or refusal of vaccination in healthcare workers. Acknowledging and understanding these differences may be beneficial in constructing effective vaccination strategies targeted towards vulnerable occupational groups potentially resulting in greater vaccine acceptance and optimal workplace vaccine coverage.*

***Keywords**: Vaccination Hesitancy, COVID-19, Health Behaviour*

1. INTRODUCTION

World Health Organization defines vaccination hesitancy as a delay in acceptance of vaccine or refusal of vaccination despite availability of vaccination services [1]. Vaccination hesitancy results in poor vaccine coverage in general population with significant impact on vulnerable occupational groups as well. Negative attitudes towards COVID-19 immunization resulting in delaying or refusing vaccination represent a challenge of a particular importance when in comes to healthcare workers. Being carriers of diagnostic procedures and treatment for COVID-19 patients, healthcare workers represent vulnerable occupational group in particular risk of SARS-CoV-2 infection [2]. Research suggests that healthcare workers may as well be a significant source of nosocomial SARS-CoV-2 infections [2]. Finally, being important source of information about importance of vaccination for patients and communities, healthcare workers with negative attitudes towards vaccination may negatively influence patients' attitudes towards vaccination as well.

Healthcare workers' attitudes and uptake of COVID-19 vaccine variates globally, with acceptance rate ranging from 27.7% to 77.3% [3] making overall vaccine acceptance of 51% [2]. According to available research, multiple sociodemographic, health- and occupation-related factors may influence acceptance of COVID-19 vaccine in healthcare workers. Therefore, in order to review current knowledge on aforementioned determinants of COVID-19 vaccine acceptance in healthcare workers present study was conducted.

Comprehensive literature search in PubMed data base was undertaken by querying MESH keywords: "Vaccination Hesitancy, "COVID-19" and "Health Behaviour". Only articles available in English language were considered. Available abstracts were examined independently by three authors and relevant articles were included in the present study. References of included articles were also reviewed to ensure complete inclusion of relevant literature.

2. SOCIODEMOGRAPHIC DETERMINANTS

2.1. Age and gender

Meta-analysis of available studies conducted by Luo et al. showed that age is a significant determinant for COVID-19 vaccine acceptance among healthcare workers [2]. Research suggests that younger healthcare workers are less likely to get vaccinated when compared with older colleagues. Likely explanation for such findings is low perception of risk for adverse COVID-19 outcomes when it comes to morbidity and mortality in younger individuals [4] related to proven high prevalence and mortality rates of COVID-19 in elderly individuals [5]. Secondarily, vaccination programs were initially targeted towards vulnerable groups in risk for adverse health outcomes in relation to COVID-19 (including elderly), providing older workers, among others, with more time and opportunity to be vaccinated [7]. Thirdly, younger workers are more likely to be exposed to variety of different on-line content that may not be supportive of vaccination as an effective preventive measure [8]. Fourthly, older individuals may have higher education and greater experience in healthcare settings making them more aware of vulnerability to COVID-19 infection and related mortality and morbidity [7].

Research suggests that vaccination intention varies with gender making male healthcare workers more prone to receiving COVID-19 vaccine when available [2, 9]. Possible explanation may lie in higher perception of risk for adverse COVID-19 outcomes in males compared to females due to reported higher risk for COVID-19 complications and mortality rates in males [5, 10]. Gender-based differences in prevalence of chronic cardiovascular and respiratory diseases which may influence health outcomes in COVID-19 seem to play a role in vaccine acceptance [11]. Vaccine hesitancy in female workers may be related to concerns about possible side effects that could make them unable to take care of families, as well as with fear of infertility or adverse pregnancy outcomes [7]. Pregnancy itself is shown to be associated with higher odds of being vaccine hesitant [12] which may be a result of

recommendations advising delaying vaccination for pregnant women at the beginning of vaccination programs.

2.2. Social background

Being married, having children as well as living with the family is shown to be an independent determinant in COVID-19 vaccination acceptance probably due to protective behaviors aimed towards vulnerable members of the family [13]. Similarly, vaccine hesitancy showed to be four-folds higher in single healthcare workers in comparison with ones having different forms of relationships [6]. However, research seems to be inconsistent, with available studies showing no significant difference in vaccination acceptance between single healthcare workers and ones in a relationship [14].

Research regarding racial and minority differences in responsiveness to SARS-CoV-2 vaccination acceptance is scarce. Vaccination hesitancy in general has shown to be more prevalent in ethnic and racial minority groups [15, 16]. Biswas et al. [7] and Shekhar et al. [17] suggest that Black race is more vaccine hesitant in comparison to Whites and Asians probably due to lack of trust in government and healthcare systems, distrust in vaccine efficacy and safety as well as other sociodemographic factors associated with ethnicity such as education level, religious beliefs etc. [4].

2.3. Education and income

Lower education is shown to be another factor of poor vaccine acceptance among healthcare workers [6, 7, 17]. Research conducted by Kara Esen et al. [12] showed that the risk of not receiving COVID-19 vaccine or delaying it increases by 1.78 times in nurses and midwives, 3.42 times in administrative staff and 4.11 times in patient attendants and cleaners when compared with doctors and faculty members. Possible explanation may lie in lower perception of risk from COVID-19 due to less available information obtained from quality scientific sources as well as greater tendency to believe in community myths [7] and various on-line content that may not be supportive of vaccination.

Related to education, in general population as well as in healthcare workers, low income is one of the negative predictors of vaccine acceptance [6]. Available research suggests that deprivation is related to lower vaccine uptake in general population [18] with low-income households being more vaccine hesitant when compared with higher income households [6]. Similarly, healthcare workers that earn less per year are more vaccine hesitant compared to higher-earning healthcare workers [6].

3. HEALTH-RELATED DETERMINANTS

Fares et al. showed that, along with age and gender, positive attitude towards vaccination in general and willingness to accept non-mandatory vaccine such as influenza vaccine is significant predictor of COVID-19 vaccine acceptance [20]. Research conducted by Kara Esen et al. [12] showed that hesitancy towards vaccines in general is the most important risk factor for COVID-19 vaccination hesitancy [12]. For example, healthcare workers who had not received influenza vaccine had an increased risk of refusing COVID-19 vaccine by 3.24 times [12] and research conducted by Gagneux – Brunon et al. [21] showed that vaccination against influenza is the most important predictor of COVID-19 vaccine acceptance. Receiving one of the hepatitis A, hepatitis B or tetanus vaccines was significantly more prevalent in COVID-19 vaccinated workers comparing with ones who had not receive COVID-19 immunization [12]. Potential explanation may be that healthcare workers who are more compliant with vaccination in general have more knowledge about benefits of vaccination and are generally oriented towards preventive health behaviors.

Having suffered from mild clinical courses of COVID-19 as well as being tested positive for SARS-CoV-2 when compared to ones who had not been ill or tested positive elevates the risk of not being immunized against COVID-19 od delaying it by 2.36 times [4, 12]. Healthcare workers tested positive for SARS-CoV-2 without any clinical symptoms as well as ones suffering from mild clinical course of COVID-19 have less concerns regarding COVID-19 morbidity and mortality, which, along with perception of acquired immunity, has significant impact on vaccination acceptance.

Suffering from chronic illness (cardiovascular, respiratory, etc.) is positively correlated with COVID-19 vaccine acceptance in healthcare workers [4, 12]. Reasons for such findings probably arise from increased perception of personal risk of adverse outcomes from COVID-19 shown to be more prevalent in COVID-19 patients with chronic illness.

4. OCCUPATION-RELATED DETERMINANTS

Available research is showing that healthcare workers working in clinical settings are more inclined to accept COVID-19 vaccine when compared with ones that are not employed in clinical setting [6]. Non-clinical staff is more likely to be vaccine hesitant due to reduced perceived susceptibility to infection and ability to contract SARS-CoV-2 in occupational setting [6]. Healthcare workers employed in clinical setting may have better access to quality scientific information about benefits of vaccination and therefore may be more inclined to accept vaccine. However, present studies show that there are differences in vaccine hesitancy even within the clinical setting. Front-line healthcare workers are more inclined to accept vaccine when compared with ones providing indirect healthcare [22]. Such findings

are likely due to higher perceived risk of contracting SARS-CoV-2 infection during direct contact with patients. Research suggests that there are differences among direct patient care providers as well, with nurses and respiratory therapists being more reluctant to vaccination in comparison to physicians [17]. Previously mentioned differences arising from different education and possible greater susceptibility to various on-line content that may not be supportive of vaccination may lead to lower perception of risk from COVID-19 morbidity and mortality in nurses and physical/respiratory therapists.

5. CONCLUSION

Strategies aimed to increase COVID-19 vaccination uptake should be directed towards specific causes of existing hesitation. Luo et al. suggest that aforementioned strategies in healthcare workers ought to be primarily directed towards young, female healthcare workers reluctant towards non-mandatory vaccination [2] since current evidence strongly implies age, gender and attitude towards non-mandatory vaccination as most important risk factors for poor COVID-19 immunization in healthcare workers. Furthermore, making accurate scientific information regarding risks that arise form SARS-CoV-2 infection and benefits of vaccination in prevention of severe morbidity and COVID-19 related mortality widely available as well as addressing workers' concerns regarding efficacy and safety of vaccine is crucial in managing vaccination hesitancy in healthcare. Identifying workers in particular risk of vaccine hesitancy in healthcare system and providing them with needed information on benefits of vaccination should be of benefit in managing current COVID-19 pandemic in occupational setting.

REFERENCES

[1] World Health Organization: SAGE Working Group on Vaccine Hesitancy: Literature Review, (2013):1-40.

[2] Luo, C., Yang, Y., Liu, Y., Zheng, D., Shao, L., Jin, J., & He, Q.: Intention to COVID-19 vaccination and associated factors among health care workers: A systematic review and meta-analysis of cross-sectional studies, *American journal of infection control*, 49(10) (2021):1295-1304.

[3] Li M, Luo Y, Watson R, Zheng Y, Ren J, Tang J, Chen Y.: Healthcare workers' (HCWs) attitudes and related factors towards COVID-19 vaccination: a rapid systematic review, *Postgrad Medical Journal*. (2021).

[4] Martin, CA., Marshall, C., Patel, P., Goss, C., Jenkins, DR., Ellwood, Barton, L.: SARS-CoV-2 vaccine uptake in a multi-ethnic UK healthcare workforce: A cross-sectional study, *PLoS medicine* 18, no. 11 (2021): e1003823.

[5] Team, Epidemiology: The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19)—China, 2020, *China CDC weekly* 2, no. 8 (2020):113.

[6] Amuzie, Chidinma Ihuoma, Franklin Odini, Kalu Ulu Kalu, Michael Izuka, Uche Nwamoh, Uloaku Emma-Ukaegbu, and Grace Onyike: COVID-19 vaccine hesitancy among healthcare workers and its socio-demographic determinants in Abia State, Southeastern Nigeria: a cross-sectional study, *The Pan African Medical Journal,* 40 (2021).

[7] Biswas, Nirbachita, Toheeb Mustapha, Jagdish Khubchandani: The nature and extent of COVID-19 vaccination hesitancy in healthcare workers, *Journal of community health* 46, no. 6 (2021): 244-1251.

[8] Mohammed, R., Teklehaimanot Mezgebe, N., Bruck Messele, H., Atalay Mulu, F., & Gebremedhin Beedemariam, G.: COVID-19 vaccine hesitancy among Ethiopian healthcare workers, *PloS one 16*, no. 12 (2021): e0261125.

[9] Saddik, B., Al-Bluwi, N., Shukla, A., Barqawi, H., Ali Hussain Alsayed, H., Saheb Sharif-Askari, N., & Halwani, R.: Determinants of healthcare workers perceptions, acceptance and choice of COVID-19 vaccines: A cross-sectional study from the United Arab Emirates. *Human vaccines & immunotherapeutics* 18, no. 1 (2022): pp: 1-9.

[10] Galbadage, T., Peterson, B., Awada, J., Buck, AS., Ramirez, DA., Wilson, J., & Gunasekera, RS: Systematic review and meta-analysis of sex-specific COVID-19 clinical outcomes, *Frontiers in medicine* 7 (2020): pp. 348.

[11] Jordan, RE., Peymane, A., Cheng, KK.: Covid-19: risk factors for severe disease and death, *British medical Journal* 368 (2020).

[12] Kara Esen, B., Gunay Can, BZP., Sumeyye, NA., Aysenur, O., Ilker & Nese, S.: COVID-19 vaccine hesitancy in healthcare personnel: A university hospital experience, *Vaccines*, no. 11 (2021): pp.1343.

[13] Kaplan, AK., Mustafa, KS, Hulya, P. & Isil, AG.: The willingness to accept the COVID-19 vaccine and affecting factors among healthcare professionals: a cross-sectional study in Turkey, *International Journal of Clinical Practice* 75, no. 7 (2021): e14226.

[14] Dror, AA., Netanel, E., Shahar, T., Morozov, NG & Eyal, S.: Vaccine hesitancy: the next challenge in the fight against COVID-19, *European journal of epidemiology* 35, no. 8 (2020): pp. 775-779.

[15] Stephanie, C.: Racial/ethnic differences in influenza and pneumococcal vaccination rates among older adults in New York City and Los Angeles and Orange Counties, *Preventing chronic disease* 15 (2018).

[16] Quinn, SC., Jamison, AM., Freimuth, VS., Ji, A., & Hancock, GR.: Determinants of influenza vaccination among high-risk Black and White adults, *Vaccine* 35, no. 51 (2017): pp. 7154-7159.

[17] Shekhar, R., Abu Baker, S., Upadhyay, S., Singh, M. & Suman, P.: COVID-19 vaccine acceptance among health care workers in the United States. *Vaccines* 9, no. 2 (2021): 119.

[18] Hungerford, D., Macpherson, P., Farmer, S., & Keenan, A.: Effect of socioeconomic deprivation on uptake of measles, mumps and rubella vaccination in Liverpool, UK over 16 years: a longitudinal ecological study, *Epidemiology & Infection* 144, no. 6 (2016): 1201-1211.

[19] Khubchandani, J., Sharma, S., Price, JH., Wiblishauser, MJ., Sharma, M. & Webb, FJ.: COVID-19 vaccination hesitancy in the United States: a rapid national assessment. *Journal of community health* 46, no. 2 (2021): 270-277.

[20] Fares, S., Elmnyer, MM., Mohamed, SS. & Elsayed, R.: COVID-19 vaccination perception and attitude among healthcare workers in Egypt. *Journal of primary care & community health* 12 (2021): 21501327211013303.

[21] Gagneux-Brunon, A., Detoc, M., Bruel, S., Tardy, B., Rozaire, O., Frappe, P. & Botelho-Nevers, E.: Intention to get vaccinations against COVID-19 in French healthcare workers during the first pandemic wave: a cross-sectional survey. *Journal of Hospital Infection* 108 (2021): 168-173.

[22] Dalal, Y., Abou-Abbas, L., Berry, A., Youssef, J., & Hassan, H.: Determinants of acceptance of Coronavirus disease-2019 (COVID-19) vaccine among Lebanese health care workers using health belief model. *Plos one* 17, no. 2 (2022): e0264128.

OAK PROCESSIONARY MOTH (*Thaumetopoea processionea*) IN THE POKUPSKO BASIN FOREST – HEALTH RISK AND CONTROL

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Abstract: *The oak processionary moth (Thaumetopoea processionea) is native pest in oak forests in Croatia. Its caterpillars will defoliate the oak trees leaving them vulnerable to other pests and diseases, and may cause decline of individual trees. The oak processionary moth raises particular concerns because of the potential risks the caterpillars pose to public and animal health via poisonous hairs that cause urticaria, which can result in severe allergic reactions, amongst other health problems. Control of oak processionary moth is carried out using mechanical, biological and chemical methods. In the period from 2017 to 2018, the Republic of Croatia recorded the highest number of oak processionary moth populations so far. The total recorded affected area of pedunculate oak forests in 2018 was over 7000 ha, of which 2173.31 ha was the area of the Pokupsko basin. Due to the significant damage caused by defoliation and the impact on the health of forestry workers, in 2018, aerochemical treatment of pests with biological insecticides was carried out in the Pokupsko basin. This method of pest control is often justified for the greater public good, including saving trees and associated biodiversity and protecting human health.*

Keywords: *oak processionary moth, pest control, health risk*

1. INTRODUCTION

The oak processionary moth (*Thaumetopoea processionea*) is a widespread thermophilic species native to central and southern Europe. It can be found on oaks (*Quercus* spp.) in natural habitats, nurseries, plantations and urban areas. Its range has been expanding northwards since the late 20th century. It is now established as far north as the Netherlands and northern Germany, and has occasionally been seen in Sweden. The expansion northwards has been aided by international trade of oak trees which might have oak processionary moth present on them, and also by a warming climate [1, 2].

The common and scientific names of *Thaumetopoea processionea* refer to the behaviour of the larvae to form long processions. The moth itself is harmless, but the larvae cause severe defoliation, reducing the viability of oak trees. They also pose a risk to both human and animal health because they shed poisonous hairs, which can result in severe allergic reactions, amongst other health problems [3].

The oak processionary moth is native pest in oak forests in Croatia that occurs regularly, although at a low population density [4]. For forestry, the moth is not of great importance, since it rarely causes severe defoliation, but recently more frequent appearance has been noticed, which raises concerns about the unwanted consequences it can have on the health of people and animals.

2. DESCRIPTION OF SPECIES

Understanding the biology of oak processionary moth can help with its control and management. The name oak processionary moth originates from the fact that the caterpillars march behind one another in chains with up to 20 parallel tracks when moving from one feeding area to another.

Figure 1. A procession of oak processionary moth caterpillars on the trunk of an oak tree (Picture: Henry Kuppen) [2]

The oak processionary moth has one generation per year. Adults are brownish moths with the wingspan of 25–35 mm, which mate and lay their eggs between late July and sometimes late September. Females lay between 30 and 300 eggs on smooth bark of the high branches and twigs. Eggs overwinter and larvae emerge between April and May. The caterpillar stage lasts for several weeks. After emerging from the eggs, they pass through six growth or developmental stages, known as instars, until the pupation stage. They develop the urticating, or irritating, hairs from about third instar. The caterpillars descend lower down the trees as they

get older and bigger, and excrete silky threads to build nests on the branches and trunks. Older caterpillars feed mainly at night and rest in their nests during the day. They appear mid-June and feed almost exclusively on oak trees. They pupate in dark grey cocoons in July, in nests on the tree trunk or at the tree base. The final, adult stage in the life cycle is the moth. The first moths emerge from their pupae about the middle of July, and the last ones late in September. Both sexes live for only three to four days as adults [1, 2, 5].

3. HEALTH RISKS OF OAK PROCESSIONARY MOTHS

The oak processionary moth itself is harmless, but the caterpillar's irritating hairs can cause problems. Older caterpillars develop barbed and very fine (diameter of 0.1-0.25 mm) hairs containing an irritating protein called thaumetopoein, from which the species derives part of its scientific name. These urticating hairs cause inflammations and pose threat to human and animal health. In the most extreme cases, they cause anaphylactic reactions [1].

Contact with the hairs can cause irritation of the eyes and respiratory tract. When the skin is exposed to the irritating hairs, the initial reaction is burning and severe itching. Then small red nodules appear, which remain for several days.

Figure 2. Effects of exposure - dermatitis on the lower leg (Picture: Rahlenbeck, Utikal) [6]

The risk of exposure to these hairs is highest in May and June. The caterpillars can shed the hairs when threatened or disturbed. Normally, thaumetopoein protects the caterpillar against its natural predators. The hairs can be blown by the wind, sometimes over long distances, and they accumulate in the caterpillars' nests, which can fall to the ground. They can stick to trunks, branches, grass and clothing as well as to equipment used by forestry workers. The hairs can persist in the environment and pose a health hazard for several years [2, 5]. Also, the infestation of trees in central areas of towns and communities with the oak processionary moth constitutes a serious threat to the health of the residents.

A survey in Germany for the period from 2011 to 2012 recorded following: almost everyone affected (98%) complained of itching, 15–20% of conjunctivitis, 10–12% of inflammation of the upper airways. Inability to work was certified for every third patient, but inpatient treatment was extremely rare (0.2–0.7%) [6].

4. METHODS FOR CONTROLLING OAK PROCESSIONARY MOTHS

Control of oak processionary moth is carried out using mechanical, biological and chemical methods. The health risk to humans is due to the fine hairs of the caterpillars from the third instar, so protective measures can only be applied up to the second instar.

Mechanical removal of the nests and caterpillars of the oak processionary moth (when the larvae have reached the third instar) is the only way that further contamination of the environment can be prevented. Burning of nests was also reported as a method of controlling in conjunction with chemical control. One of the methods is also treatment with biological agent which contains bacterium *Bacillus thuringiensis*. Nematodes have also been investigated as a control measure against the oak processionary moth. The nematodes develop in the body of the caterpillars and thereby kill them [3]. Chemical control agents not only kill harmful insects, but can also be lethal to other insect species, some of which are protected. That's why it's important to limit use to the minimum necessary.

Only exceptionally when the danger to human health is great, following protective measures should be considered:

1. Closing the paths of the roads on which there are caterpillars and placing signs indicating the danger,
2. Mechanical removal of nests,
3. Application of protective agents.

People carrying out protective measures must be fully equipped with protective clothing and masks. Nests are removed by first spraying them with water, then vacuuming or burning them [5].

5. AFFECTED AND TREATED AREAS IN THE POKUPSKO BASIN

Out of a total of 11.400 ha of Pokupsko basin, 2.173,31 ha or 19% of the area was affected by oak processionary moth in 2018. Of these 2.173,31 ha, 33% were Draganićki lugovi with 719.64 ha, 30% were Rečički lugovi with 652.33 ha, 22% were Jastrebarski lugovi with 468.01 ha and 15 % Pisarovinski lugovi with 333.33 ha [7]. On May 7 and 8, 2018, aerial treatment of early defoliators with the biological insecticide Foray 48B was carried out. The flights were made from Lučko airport, and the service was provided by the authorized company AIR TRACTOR d.o.o. from Osijek.

Since 2016, the appearance of the oak processionary moth (*Thaumatopoea processionea*) has been recorded in the area of lowland oak forests in the continental part of the Republic of Croatia, and the increase in population has continued. In 2018 the infestation was recorded on an area twice as large as in 2017. In 2018, control measures were prepared and implemented on 7.470 ha, using 22,096 L of Forey 48B. [8]. During 2019, there was a decrease in the attacked and treated areas, as well as a decrease in the intensity of attacks [9].

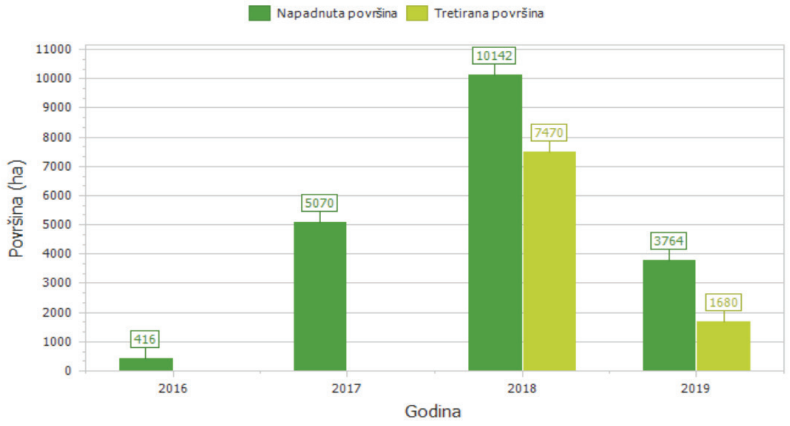

Figure 3: Areas attacked by oak processionary moth and treated areas in the Republic of Croatia from 2016 to 2019 [7]

6. CONCLUSION

Because of their human, forest stands and animal health hazards, the caterpillars of the oak processionary moth should not be left uncontrolled. The main focus of control is to prevent or limit further outward spread of the pest, and to minimise its population and impacts where it is present.

Management responses to tree pests and diseases are often justified for the greater public good including saving our trees and associated biodiversity and/or protecting human health [10].

REFERENCES

[1] Kavčič, A.: Oak processionary moth (*Thaumetopoea processionea*), *Available from* https://danubeforesthealth.eu/vrste_zapis.aspx?zapst=29 *Accessed:* 2022-05-27
[2] Anonymous: Oak processionary moth (*Thaumetopoea processionea*), *Available from* https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/oak-processionary-moth-thaumetopoea-processionea/ *Accessed:* 2022-05-27
[3] Beverley, C.: *Thaumetopoea processionea* (oak processionary moth), *Available from* https://www.cabi.org/isc/datasheet/53502 *Accessed:* 2022-05-27
[4] Matošević, D.: Hrastov četnjak (*Thaumetopoea processionea*), *Available from* https://stetnici.sumins.hr/Blog/hrastov_cetnjak_(thaumatoepoea_processionea)# *Accessed:* 2022-06-01
[5] Pernar, M.; Matošević, D.: Hrastov četnjak, *Available from* https://stetnici.sumins.hr/Blog/hrastov_cetnjak *Accessed:* 2022-06-01
[6] Rahlenbeck, S.; Utikal, J.: Eichenprozessionsspinner-Allergie: Raupen mit reizenden Brennhaaren, *Deutsches Ärzteblatt*, Vol. 114 (2017) No. 18, pp. 896-898
[7] Rožman, J.: Suzbijanje hrastovog četnjaka na primjeru gospodarenja šuma Pokupskog bazena 2018. godine, Završni rad, Veleučilište u Karlovcu, Karlovac, (2022)
[8] Anonymous: Izvještajno prognozni poslovi u šumarstvu za 2018/19. godinu, *Available from* http://stetnici.sumins.hr *Accessed:* 2022-06-01
[9] Anonymous: Izvještajno prognozni poslovi u šumarstvu za 2019/20. godinu, *Available from* http://stetnici.sumins.hr *Accessed:* 2022-06-01
[10] Marzano, M.; Ambrose-Oji, B.; Hall, C.; Moseley, D.: Pests in the City: Managing Public Health Risks and Social Values in Response to Oak Processionary Moth (*Thaumetopoea processionea*) in the United Kingdom, *Forests,* Vol. 11 (2020) No. 199, pp. 1-17

PROMOTING ACCESSIBILITY IN A COMMUNITY CONTEXT: FACILITATING OCCUPATIONAL PARTICIPATION AND HEALTH

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Abstract: *Promoting occupational health and participation, throughout life, is one of the fundamental bases of Occupational Therapy. The environment, as an external factor to the client, may facilitate or restrict occupational performance, with the occupational therapist assuming an extremely relevant role in the assessment and definition of the best intervention strategies that allow engagement in meaningful occupations. The bachelor's degree in Occupational Therapy of the Polytechnic Institute of Beja, Portugal, through a group of teachers and students, in the context of one of the courses and integrated into the teaching and learning process, developed two studies, in two consecutive academic year., These studies were about infrastructure, services and equipment of a shopping centre, in the southern region of the country, to improve the experience of people with several types of dysfunction. The accessibility study was operationalized, through a consultancy process, with the possibility of implementing inclusion measures seeking to optimize and harmonize the shopping centre's resources.*

Keywords: *accessibility, integration, shopping centre, occupational participation, health*

1. INTRODUCTION

One of the Occupational Therapy pillars is based on promoting health and participation, throughout life, of people, groups and populations through

involvement in occupation [1]. Health is supported and maintained when people are able to engage at home, at school, in the workplace and in community life. Therefore, occupational therapists are concerned not only with occupations, but also with the variety of factors that disrupt or empower those occupations and influence people's engagement and participation in positive health-promoting occupations [2]. There are a number of factors that can restrict occupational participation, and within the scope of this project we highlight the contexts and how they can affect people's access to occupations and the quality and satisfaction with performance. Understanding the contexts in which occupations can, and do, occur, provides occupational therapists with a comprehensive and integrated perspective of the influences of environmental and personal factors on involvement in occupations [1]. When people interact with the world around them, environmental factors can facilitate or restrict participation in meaningful occupations and can present barriers or supports and resources for service delivery. One of the occupational therapists' approaches, in the provision of qualified Occupational Therapy services, is the consultancy to community institutions, so that the natural and built environments can support occupational performance and engagement. In this sense, Occupational therapists provide the expertise to propose possible modifications, in accordance with the current legislation [1, 3].

A cooperation protocol was established between the Polytechnic Institute of Beja, Portugal, a higher education institution comprising four higher schools (School of Agriculture, School of Education, School of Health and School of Technology and Management) and the Ingka Centres Portugal, S.A, a company engaged, among other activities, in the development and management of shopping centres. On one hand, the School of Health is specifically aimed towards initial and continuous training in the area of health, also participating in own and cooperative research activities, in the constant enrichment of the theoretical and practical conditions of educational action. On the other hand, the Ingka Centres Portugal, S.A. built and developed a commercial complex in Loulé city, which includes the shopping centre "Mar Shopping Algarve", continuously seeking the optimization and harmonization of the shopping centres' operation, as well as the improvement of the reception and treatment of all its customers. This collaboration protocol follows the recognised interest of the relationship between the two organizations, namely the development of a cooperation model that allows the development of studies about the shopping centre's current infrastructures, services and equipment and the implementation of inclusion measures for people with reduced mobility and/or other cause of physical or mental disability. This cooperation model was thus assumed by the Technical-Scientific and Pedagogical Commission of the Bachelor's Degree in Occupational Therapy, integrated in the School of Health of the Polytechnic Institute of Beja, through its full-time teaching staff, together with the shopping centre management and more directly, with the community engagement leader. To this end, several formal contacts were established, diverse meetings were held and the role that each of the organizations would assume was defined.

It was agreed that the competences to be assumed by the Polytechnic Institute of Beja, namely through the Bachelor's Degree in Occupational Therapy, would include the diagnosis / needs assessment of the shopping centre, through the

respective plans and visits; offer consultancy services to make the shopping centre (in its common areas, as well as the numerous shops) inclusive in terms of accessibility, including also the indoor and/or outdoor leisure areas – this consultancy services involves, in practice, carrying out an in-depth study to identify the limitations/constraints of the shopping centre's common areas and the suggestion of adaptation and/or modification of specific materials and equipment or the environment; providing solutions for shopkeepers, in order to make their stores inclusive spaces; promote awareness actions and provide training to shopkeepers and employees of the commercial space. Due to the offered suggestions, through the consultancy services, meetings will be held with the necessary frequency to monitor the implemented changes and the possible need for new adaptations/modifications, if justified. On one hand, taking into consideration that one of the Occupational Therapy pillars is the promotion of health and occupational participation throughout life, it was assumed that the Bachelor's Degree in Occupational Therapy will be disseminated to the whole academic community of the Polytechnic Institute of Beja, as well as the local community, all activities developed within the scope of health and social inclusion measures. On the other hand, the competences to be assumed by the Ingka Centres Portugal, S.A. imply to promote to the local community the established partnership with the Bachelor's Degree in Occupational Therapy of the Polytechnic Institute of Beja; to monitor teachers and students in the development of diverse activities, in the context of visiting and assessing the different spaces of the shopping centre; to enable awareness-raising and training activities, not only for shopkeepers but also for employees, throughout the year.

The operationalization of this collaboration between the two organizations was carried out, in a first phase, through a consultancy process, by some of the teachers and the students of the VI Bachelor's Degree in Occupational Therapy, in the academic year 2017/2018; in a second phase, in the following academic year, 2018/2019, there was continuity of the work already developed, by the same professors and the students of the VII Bachelor's Degree in Occupational Therapy. In both phases, in the two consecutive academic years, teachers and students visited the shopping centre in order to analyse the different spaces previously defined by the management of this commercial space. In the 2017/2018 academic year, six sections of the commercial space were analyzed (five aspects: main entrance/exit and secondary entrances/exits, reception regarding support products, circulation in the shopping area, rest areas and information boards); lifts, escalators, stairs and moving walkways; WC and baby-changing facilities; access to restaurants, sitting area and balcony; children's areas (outdoor playground and Lego Space); parking (indoor and outdoor). In the 2018/2019 academic year other six distinct areas were analyzed, namely the administration space (a total of ten areas: the access; first aid room; female and male changing rooms; adapted bathroom for people with reduced mobility; dining room; administration reception; two meeting rooms; administration work space and cafeteria); movie theatres (three spaces: atriums; WC; lounges); medical clinic (thirteen spaces: clinic entrance, reception/waiting room, hallway; office 1 - permanent attendance, office 2 - nursing room; dental office; Computed Axial Tomography office and changing room; X-ray office and changing room; examination office; mammography office; ultrasound office and changing room;

adapted bathroom); pharmacy; restaurants (a total of eighteen); supermarket (a total of ten spaces: bakery, butchery and fish sections, fruit and vegetable shop, charcuterie, frozen food, hygiene products hallway, takeaway and pastries, grocery and drinks and payment checkouts). In both years, the students were previously distributed in working groups and a preparation was made, in a classroom context, in order to promote the necessary skills to analyze/evaluate each of these shopping centre spaces. The teaching and learning process involved getting acquainted with the portuguese current legislation on accessibility [3] and the construction of checklists about what to observe and assess in a real/community context.

2. RESULTS OF THE WORK

The operationalisation of this project involved carrying out two visits, in two consecutive academic years (2017/2018 and 2018/2019), to the shopping centre, by the third year students and some professors from the Bachelor's Degree in Occupational Therapy of the Polytechnic Institute of Beja. As previously mentioned, the students were previously distributed in working groups and each of them was assigned the task of evaluating a particular area. It is also important to highlight the fact that each of these student groups had the supervision of one of the professors of the referred Bachelor Degree. The observation and evaluation of each of these spaces was done in accordance with the current portuguese legislation and checklists, previously built in the classroom context, allowed this assessment to be as rigorous and objective as possible, ensuring a more effective teaching and learning process. For each of these specific spaces, all the aspects (positive and negative) that did not fully comply the current legislation were identified, in order to promote the inclusion of people with greater vulnerability in the most diverse areas (physical, motor and mental). On the other hand, taking in account the identification of the negative aspects, suggestions and recommendations for improvement were made. These included signposting; environmental modifications: furniture, replacing conventional doors for sliding doors, tables and chairs fixing in leisure areas; children's play areas with some entertainment reduced mobility, blind or deaf children; the suitability of furniture to the ergonomics of the employees; modification of slopes (inclination); placing handrails; amending the structure of counters and ATMs to allow wheelchair access; the height of toilets, washbasins, showcases or counters; the adaptation of menus in the catering area, in particular the brochure font size; increased colour contrast in product presentation; increasing the opening time of automatic doors; the use of an Ipad or mobile phone application that incorporates a GSP and allows orientation in space – for blind and partially sighted people; the implementation of a pathway with tactile flooring, with different textures, in order to differentiate between the different routes, thus enabling autonomous mobility for blind people.

All the information concerning the identification of the positive and negative aspects of each of the spaces evaluated and the various suggestions and recommendations for improvement were described in a clear, precise and objective manner, in an academic report format, sent to the management of the shopping

centre. Several photographs and data tables were presented in order to facilitate the identification of all these aspects for possible adaptations/modifications in terms of the environmental factors that may restrict the occupational participation of clients attending this commercial space. At the same time, the teaching staff demonstrated complete availability to articulate in case of doubts or whenever there was a need.

3. CONCLUSION

One of the service delivery approaches that occupational therapists can develop is the consultancy on community institutions, ensuring that the occupational needs of their clients, namely at the level of the person, group or population, are understood. Taking into consideration that environmental factors can facilitate or restrict occupational participation, it is essential to ensure people's access to occupations and to promote their quality and satisfaction with their performance. In this context, the development of collaboration models between organizations and the provision of qualified Occupational Therapy services is another opportunity, which allows the full potential of the work developed by occupational therapists to be expanded, in order to promote health and participation, throughout life, through involvement in occupation.

REFERENCES

[1] American Occupational Therapy Association: *Occupational Therapy Practice Framework: Domain and Process*, American Occupational Therapy, Bethesda, MD, (2020)
[2] Wilcock, A. A., & Townsend, E. A.: Occupational justice, In *Willard and Spackman's occupational therapy*, Lippincott Williams & Wilkins, Philadelphia, (2019), pp. 643-659
[3] Secretariado Nacional de Reabilitação e Integração das Pessoas com Deficiência (2006/2009). Guia de Acessibilidade e Mobilidade para Todos, Apontamentos para uma melhor interpretação do D.L. 163/2006 de 8 de Agosto. PAIPDI – Plano de Ação para a integração da Pessoa com Deficiência ou Incapacidade: Gabinete da Secretaria de Estado de Adjunta e da Reabilitação, *Available from* http://www.inr.pt/content/1/4/decretolei *Accessed*: 2022-04-20

STRESS MANAGEMENT AT WORK IN INTERNATIONAL, EUROPEAN AND NATIONAL LEGISLATION AND PRACTICE

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Abstract: *This paper presents the most important documents of international, European and Croatian legal regulations regarding the management of stress at work. In the practical part are presented the findings wich were obtained on the basis of data collected through web questionnaires. To compare with the obtained results was used a survey conducted in 2020. with the same topic. The research shows that the respondents are insufficiently acquainted with the regulations related to stress management at work. The data show that stress is relatively poorly managed in our companies. In most cases, even the minimum legally prescribed activities are not carried out such as psychosocial risk assessment, prevention of stress at work, consulting with employees and informing them about prevention.*

Keywords: *legislation, stress at work, psychosocial risks, prevention.*

1. INTRODUCTION

Managing stress at work is an area regulated by international agreements, European and national regulations. Some of these regulations do not explicitly mention stress at work, but contain general provisions on health protection at work, which certainly include psychosocial risks, i.e. stress at work, while certain legal acts specifically refer to stress in their provisions. As a part of the legal sources related to stress, in addition to the legally binding ones, a whole series of guidelines and recommendations are adopted, which can help employers and workers in eliminating these increasingly present risks in the workplace.

The international organizations that are most important in the area of regulating stress at work are the United Nations, the World Health Organization, the International Labor Organization and the Council of Europe is also included in the international framework.

Within the framework of the United Nations, the Universal Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights should be mentioned. According to Article 3 of the Universal Declaration of Human Rights, everyone has the right to personal security, which (although the article deals with issues of freedom in more detail) in the broadest sense includes safety at work, which must also take care of mental health and stress prevention. For the management of stress at work in the broadest sense, Article 5 is also important, according to which no one may be subjected to inhuman or degrading treatment, so this can also apply to work procedures and interpersonal relationships at work, which can be a source of stress for the worker. Article 23 defines everyone's right to work, including the right to fair and appropriate working conditions. [1] In Article 7 of the International Covenant on Economic, Social and Cultural Rights, it is written that the signatory states of the Covenant recognize everyone's right to fair and favorable working conditions, and one of the assumptions that must be ensured at work is mentioned in paragraph b), which refers to safe and healthy working conditions. Furthermore, according to Article 12, everyone is granted the right to enjoy the highest possible standard of physical and mental health, and in paragraph c) prevention, treatment and control of occupational and other diseases is also stated as a way to realize this right, which in our opinion must include stress at work, which can be the cause of various health problems and diseases. [2]

The European Convention for the Protection of Human Rights and Fundamental Freedoms in Article 3 prohibits inhuman and degrading treatment, so this is important in the context of work behavior and taking care within the framework of protection and safety at work. Article 5 defines the right of everyone to personal security. The European Court of Human Rights is responsible for ensuring compliance with the obligations arising from this convention. [3]

The European Social Charter, a document of the Council of Europe, emphasizes in the first part that all employees have the right to appropriate, safe and healthy working conditions. In the second part, in Article 2, the right to appropriate working conditions is elaborated in more detail, thus the obligation to eliminate the risks inherent in dangerous and unhealthy occupations is written down. In Article 3, the right to safe and healthy working conditions is elaborated, so states are obliged to adopt and regularly review national policies in the field of safety, health of employees and the working environment, and the main goal of these policies is to improve safety and occupational health. According to Article 22, state regulations will allow employees or their representatives to contribute to the establishment and improvement of working conditions, work organization and working environment, health and safety protection and supervision of compliance with regulations in these areas. In terms of managing stress at work, Article 26, which establishes the right to dignity at work, is also important. In this part, the signatories undertake to consult with organizations of employers and employees and to promote awareness, information and prevention regarding sexual harassment, illegal or extremely hostile

or aggressive actions directed against employees, and to take appropriate measures to protect employees. [4]

Within the framework of the activities of the International Labor Organization, when we talk about managing stress at work, the legislative framework in the broadest sense is the Convention on Safety and Health Protection at Work and on the Working Environment (ILO Convention No. 155), adopted in 1981. ILO Convention no. 155 obligates the involved members to establish, implement and periodically revise the national policy of safety and health protection at work in social dialogue with the aim of preventing accidents and injuries at work so as to reduce the patterns of danger inherent in the working environment. In that convention, stress at work is not explicitly mentioned as one of the potential health hazards, but it is included in Article 5 (b), which prescribes considering the "relationships between the material elements of the work and the persons who perform or supervise the work, and adapting machines, equipment, working hours, work organization and work processes to the physical and mental abilities of workers."[5]

The Treaty establishing the European Economic Community (EC Treaty) from 1957 is considered to be the beginning of labor law in the European Union. Article 118 stipulates that the Commission is in charge of encouraging cooperation between member states and assisting in the coordination of their activities in all fields of social policy, within which the area of occupational injury and disease prevention and occupational hygiene is also set aside. Accordingly, the Commission, in cooperation with the member states, conducts research, publishes opinions and arranges consultation on problems at the national level as well as those within the scope of international organizations. With a Single European act that entered into force in 1987, the Commission undertook to start from a high level of protection in recommendations on health and safety, while on the other hand, member states will encourage improvements in the working environment, safety and health of workers. Member states must harmonize the conditions, but at the same time preserve the improvements already achieved. The Treaty of Nice defined how, in the form of directives, the European Commission prescribes minimum requirements that member states can leave in place or prescribe their own, i.e. stricter measures to protect working conditions. It established a Single act, and the Treaty of Amsterdam confirmed the obligation to encourage social dialogue, as a specific process of consulting employers and workers. The Treaty of Lisbon, i.e. the Charter of Fundamental Rights of the European Union, gives it the same legal force as the founding treaties, which is very important, because it establishes that safety and health at work and the dignity of workers are a single entity, and human dignity is inviolable and must therefore be respected and protected. [6]

The fundamental legal act of the European Union that regulates all aspects of safety and health at work, including the management of stress at work, is the Framework Directive 89/391/EEC on the safety and health of workers at work [7]. This Directive, according to its general provisions, encourages the introduction of preventive measures in order to improve conditions in the working environment. It guarantees minimum health and safety requirements at the level of the European

Union, and member states can maintain or introduce stricter measures than the minimum prescribed by this directive. [6]

The Report on the implementation of the Framework Directive in national practices states that psychosocial risks are only implicitly represented in the Framework Directive and are not effectively represented. [8] This type of risk has proven to be an important cause of absenteeism (OSHA), and stress at work is recognized as one of the most frequently mentioned health-related problems in the European Union. According to the Report on the Implementation of the Framework Directive in national practices, the need of employees for designed trainings is observed so that they can perform their duties well in terms of taking care of their own safety and health at work. It has been shown that most of the training of workers in the framework of safety and security at work includes traditional topics such as fire protection and prevention of accidents at work. Contemporary topics such as violence, stress at work, discrimination and the like are less often covered in such trainings. [8] In the latest European Commission Report, 40% of companies expressed the need for additional information on assessing psychosocial risks. More than half of employees believe that stress is present in their workplace, and four out of ten workers think that stress is not managed well in their workplace. [9] Almost 80% of managers expressed concern about stress at work. [10] In addition to the unwanted impact on the health of employees, knowledge about the impact of stress on work efficiency is not negligible. Stress reduces work performance and can lead to up to five times more accidents at work. Around a fifth of job or employer changes are related to stress at work, with half of the lost working hours related to sick days due to stress, while absences due to stress are usually longer than due to some other illnesses. [9]

In addition to the Framework Directive, a number of individual directives have been adopted that deal with special aspects of safety and health at work, including psychosocial risks and stress at work.

The European Agency for Safety and Health at Work (EU-OSHA) launches various campaigns in which it raises awareness of various topics of safety and health at work. It also conducts various researches, and one of them shows that about half of the employees consider the problem of stress at work to be a common occurrence at their workplace. The most common causes of this type of stress are job reorganization or job insecurity, long working hours or excessive workload, harassment and violence at work. One of the goals and activities of this Agency is to publish information on the latest data and research results related to stress in the workplace and its effect on safety and health. [11]

The EU Strategic Framework on Occupational Safety and Health 2021-2027 should also be emphasized, which defines key priorities and activities for improving the health and safety of workers and offers solutions for sudden changes in the economy, demography and working methods. [12] Among other things, it emphasizes psychosocial risks. [13]

The occupational safety and health system in Croatia are governed by the Occupational Safety and Health Act [14], which is harmonized with the Framework Directive 89/391/EEC. In article 3, paragraph 1, item 28, stress at work is defined as "health and psychological changes that are the result of the accumulative impact of

stressors at work over a long period of time, and are manifested as physiological, emotional and cognitive reactions and as changes in the behavior of workers." Chapter 10 of that Act specifically deals with the topic of stress at work or in connection with work. Article 51 defines the employer's obligations regarding the prevention of stress caused at work or in connection with work. It follows from that article that the employer must implement the prevention of stress at work, and this especially applies to the following factors: work content, work organization, work environment, poor communication and interpersonal relations. The goal of prevention is to minimize the need for workers to overcome difficulties due to long-term exposure to intense pressure, and to eliminate the possibility that these pressures will reduce the worker's work efficiency or worsen his health. When there are signs of stress at work, the employer must pay special attention to the organization of work and work procedures, working conditions and environment, communication and subjective factors. Within the framework of work organization and work procedures, optimization refers to working hours, degree of independence, matching between worker's skills and job needs, workload and more. Working conditions and the environment that can represent a stressful load for the worker are exposure to violent behavior, noise, heat, cold, dangerous chemicals and others. Communication is especially important when it comes to uncertainty about what is expected from the job, what are the prospects for keeping the job, communication related to upcoming changes, and the like. Subjective factors that the employer must pay attention to are emotional and social pressures, a feeling of powerlessness, the feeling that the employee does not have enough support, and the like. Article 52 defines the obligations of workers and their representatives. Workers must cooperate with the employer and act in accordance with instructions to prevent, eliminate or reduce stress at work.

If the Occupational Safety and Health Act is analyzed through the prism of stress at work, other elements important for stress management can be found in it, for example in the definition of work-related illness from Article 3, paragraph 2, in the definition of prevention from the same article, in regulating the general principles of prevention from Article 11, in the general obligations of the employer in connection with the organization and implementation of safety at work from Article 17, paragraph 5, in the employer's obligation to assess risks at work, in accordance with Article 18, and in other provisions, including provisions on inspection supervision and misdemeanor provisions. [14]

An important act in the context of managing stress at work is the Ordinance on risk assessment. [15]

Legal regulation can be the basis for effective health protection at work, as well as with regard to the risk of stress at work. Through two studies, the authors wanted to study data on stress management at work, and the results are presented in further chapters of this paper.

1.1. Goals and hypotheses

In the empirical part of the work, we want to investigate the situation in 2020 and 2022, and we are interested in:

1. To what extent are people informed about regulations related to stress management at work.
2. Are there differences in information about regulations related to the management of stress at work between men and women.
3. To what extent do employees consider stress at work as a problem.
4. What experiences do employees have regarding managing stress at work in their work environment.

We assume that the situation in 2020 and 2022 is similar, and that:

1. Employees have a poor knowledge of regulations related to stress management at work.
2. There are no significant differences in the knowledge of regulations related to stress management at work between men and women.
3. Employees consider stress to be an important problem in Croatia, and most of them have had personal experience of stress at work.
4. Employees have insufficient experience with stress management activities and do not know well the activities carried out in their companies.

1.2. Methodology

In 2020, 130 respondents between the ages of 23 and 67 took part in the survey, of which 77 were female (59.2%) and 53 were male (40.8%), and in 2022, 101 respondents aged from 24 to 75 years old, of which 46 are female (45.5%) and 55 are male (54.5%). The average age of the participants is 39.24 years. Almost all respondents have a registered residence in Primorje-Gorski Kotar County (91.5% in 2020 and 88% in 2022).

The structure of the respondents' education in 2020 and 2022 is similar: in 2020, 94 (72.3%) of the respondents completed higher education or a master's degree, 33 (25.4%) completed secondary school, and three (2.3%) have a doctorate. In 2022, 78 (77.2%) of the respondents have completed higher education or a master's degree, 20 (19.8%) have completed high school, two (2%) have obtained a doctorate, and one (1%) has completed elementary school.

According to employment status, in 2020, 110 (84.6%) and in 2022, 94 (93.1%) participants are employed. In 2020, ten (7.7%) and in 2022, two (2%) of them work occasionally (student work, etc.), in 2020, four (3.1%) and in 2022, three (3%) are retired, In 2020, three (2.3%) and in 2022, one (1%) are unemployed, and three (2.3%) of them in 2020 and one (1%) in 2022 stated another status (in 2020, one self-employed and two officials, and in 2022 one on parental leave).

68 (52.3%) included in 2020 and 48 (48%) included in 2022 work in the quaternary sector (education, science, health, culture, public administration), followed by 40 (30.8%) employed in 2020, respectively 29 (29%) employed in 2022 in the tertiary sector (trade, transport, hospitality, banking, tourism), 12 (9.2%) employed in 2020 and 19 (19%) in 2022 in the secondary sector (industry, construction, mining, energy, shipbuilding, production crafts), and one (0.8%) respondent in 2020 and 2 (2%) respondents in 2022 work in the primary sector (agriculture, animal husbandry, fishing, forestry).

Data were collected through a web questionnaire. The web questionnaire consists of short instructions and 13 questions. At the beginning, there are six closed questions with which we collect demographic data (gender, age, employment status, work sector, county of residence and education). We check the spread of the problem of stress through the statements that respondents evaluate on a Likert-type scale. Knowledge of the regulations is checked with a closed question and the selection of one correct answer and a series of statements for which the respondents choose the answers "yes", "no" or "I don't know". We check the stress management practices and the experiences of the respondents through statements, which the respondents evaluate on a Likert-type scale, to which the answer "I don't know" is added, a question to which they answer with "yes", "no" or "no". I know" and by selecting an activity from the list. At the end, an open question was added, so that respondents could provide additional information about stress management at work in their company. The data was collected in August 2020 and again in May 2022.

2. RESULTS AND DISCUSSION

The collected data were statistically processed with the SPSS program. Basic descriptive analyzes were performed.

2.1. Awareness of regulations related to the management of stress at work

The first goal of this research is to determine how informed respondents are about the regulations related to the management of stress at work in 2020 and 2022. We assumed that employees are poorly acquainted with the legal regulations and are not aware of their rights and obligations of employers and workers when it comes to stress at work.

Our data show that between 2020 and 2022, there are no significant changes in employee awareness: approximately a quarter of respondents are aware of the fact

that stress at work is legally regulated, and more than three quarters of those involved do not.

In the following, we checked whether employees are aware of the employer's specific obligations prescribed by the Occupational Safety and Health Act, as well as the rights and obligations of employees when it comes to stress at work.

Knowledge of specific regulations has not changed from 2020 to 2022. Approximately half of the participants are familiar with the individual segments of the regulations.

Based on the collected data from 2020 and 2022, we confirm the hypothesis that employees have a poor knowledge of the regulations related to the management of stress at work. Namely, it was determined that the majority (more than three quarters) of the participants in our research were not aware of the fact that stress at work is regulated under the Occupational Safety and Health Act. Between 44% and 65% of participants know the individual obligations stipulated in that law, which in our opinion is too small a share for employees to be able to exert pressure and demand from employers strict adherence to prescribed activities.

In the second objective, we wanted to investigate whether there are differences in the knowledge of regulations between the sexes. According to the results for the year 2020, based on the conducted hi-square test ($\chi2=0.567$; df=2, p=0.753), we conclude that there are no statistically significant differences between men and women. We conclude the same for the year 2022 based on the conducted hi-square test ($\chi2=0.207$; df=2, p=0.902), which is in accordance with our second hypothesis.

2.2. The problem of stress at work

One of the goals of the research is to find out to what extent employees consider stress at work as a problem. On average, the participants mostly agree with the statement that stress at work is a big problem in Croatia and that the situation has not changed significantly in the last two years. Also, on average, they mostly agree that in the last six months they were personally burdened by stress at work. On average, we find the strongest agreement with the statement that they know at least one person who suffered health consequences due to stress at work. And that average is within the majority of agreement.

Based on the data we can conclude that stress at work is present in the work environment and represents an important problem that is worth investigating. A more detailed analysis of the data reveals a similar situation in 2020 and 2022. We learn that in the past six months, slightly less than two-thirds of respondents were burdened with stress at work (as many answered that they mostly or completely agreed with the statement). The percentage of respondents who know at least one person who suffered health consequences due to work stress is even higher. In our sample, as many as 70% of participants agree with this statement (mostly or completely).

From the messages that the participants could leave at the end of the questionnaire, three out of eight comments are relevant in the context of assessing

the extent to which stress at work is a problem. One participant says that the problem of stress at work is much more serious than it is being talked about. At least 50% of acquaintances and friends said that even coming to work is stressful for them, and another points out that stress has become an integral part of life, a silent killer, which is not recognized enough, and job insecurity, loans, etc. they only increase the above.

Our findings are in line with other research. Petričević and Medarić [16] found, for example, among employees in science and education, service industries and healthcare, that slightly less than a third of workers are constantly under stress at work, and sometimes stress at work is experienced by more than half of the participants. 89% of the involved workers believed that stress at work affects their health. [16]

Similarly, stress at work proved to be an important risk factor in terms of safety and health, as 53% of respondents in the European survey cited it as a problem [8]. In a recent report by the European Commission, more than half of the employees believe that stress is present in their workplace [9].

Based on the collected data, we confirm the third hypothesis and conclude that the respondents consider stress as an important problem in Croatia, with the majority having personal experience of stress at work.

2.3. Experiences of employee with the management of stress at work

For the fourth goal of the research, we asked ourselves the question, "What experiences do employees have regarding the management of stress at work in their work environment", so below we present the results of our findings. The questions in that part of the questionnaire were answered only by respondents who are currently working. For the calculation of the average agreement with individual statements, we excluded respondents who answered "I don't know".

Data collected in 2020 and 2022 show an almost identical picture. They least agree with the statement that, as employees, they are regularly informed about activities within the framework of stress management at work. Respondents generally do not agree with the statement that employees receive adequate help from their employers in case they suffer from the consequences of severe or long-term stress at work. Based on these data, we can conclude that stress is relatively poorly managed in companies. Most often, even the most necessary and minimal activities prescribed by law are not carried out, and therefore not even the activities necessary for quality stress management.

We asked the employees which activities are carried out in their companies. From the list offered, they could choose all that they noticed, and it was also possible to add some other activities that were not mentioned in the list. 28% of participants in 2020 and 26% of participants in 2022, who otherwise filled out all the questions in this one, did not choose a single activity, which means that none of the above is implemented in their companies in order to prevent or reduce the harmful effects of stress on work. To them we add six more included (the same in both

covered years), who entered "nothing" under the option "other". From the data analysis, we learn that in a third of the companies, where the respondents of our research work, there is no stress prevention practice that would include activities from our list.

Most often, in about a third of the examples in both years covered, the work is adapted to the needs of the workers, and in slightly less than a third of the companies in 2020, team building was carried out. In 2022, teambuildings are conducted in a quarter of companies. The decrease in the frequency of this activity may be the result of measures to prevent the spread of the Coronavirus. In more than a quarter of the examples in 2020 and in 2022, changes in the organization of work are used to reduce the psychological burden on workers, and in slightly less than a fifth of companies they train managers (for effective ways of organizing work, appropriate communication, etc.). In 11% of cases in 2020 and 15% in 2022, respondents state that in their company they have the opportunity to talk to an expert about stress at work, and one respondent stated that among other possibilities, in his company, one can always talk to the manager and colleagues even regarding some private problems. Trainings for more effective combating stress (meditation, mindfulness, etc.) are rarely used in the companies of our respondents.

According to the general principles of prevention, written in Article 11 of the Law on Occupational Safety, employers are obliged to conduct regular appropriate training for their employees. We investigated whether employees are informed about the issue of stress at work as part of these trainings. Our results support findings at the level of the European Union [8] where the majority of employee training in the framework of safety and security at work includes traditional topics (e.g. fire protection and prevention of accidents at work), while stress at work and other contemporary topics are less frequently represented. On the other hand, there is a need for employees for designed trainings so that they can perform their duties well in terms of taking care of their own safety and health at work.

Based on the collected data, we confirm the fourth hypothesis and determine that employees have insufficient experience with stress management activities and do not know well the activities that are carried out in their companies. We assumed that the respondents have a poor knowledge of the regulations related to the management of stress at work.

3. CONCLUSION

Stress at work is regulated by the regulations of international and European law, which is also respected by Croatian legislation. In the Republic of Croatia, stress at work is explicitly regulated by the Law on Occupational Safety, which, on the one hand, prescribes the employer's obligation to prevent stress at work and the obligation of workers who must cooperate with the employer and act in accordance with the instructions for prevention, elimination or reduction stress at work on the

other hand. The employer must assess the risks to the life and health of the workers and must consult in this process and inform the employees about the activities.

In the first objective, we were interested in the extent to which respondents were informed about the regulations related to the management of stress at work. According to the collected data, both in 2020 and in 2022, more than three quarters of respondents are not familiar with the legal regulation of stress at work, of which almost more than half do not know what the regulations are, and less than half think that stress is not legally regulated at all. Only less than a quarter of respondents are aware of the fact that stress at work is mentioned in some law. We also checked the respondents' knowledge of the individual obligations of employers and employees regarding stress at work and found out that slightly less than two-thirds of the respondents were aware of the employer's obligation to assess risks at work, and slightly more than half of those included were also aware of the obligation of employees who must cooperate with the employer and act in accordance with the instructions for preventing, eliminating or reducing stress at work. Based on these findings, we confirm the first hypothesis and conclude that the respondents have a poor knowledge of the regulations related to the management of stress at work.

In the second objective, we were interested in whether there are differences in information about regulations related to the management of stress at work between men and women. We assumed that there are no significant differences in the knowledge of regulations related to managing stress at work between men and women, which the data collected both in 2020 and 2022 supports, and on this basis we confirm the second hypothesis.

The third objective of the research asks to what extent employees consider stress at work as a problem. We assumed that stress at work is an important problem in Croatia and that most employees had personal experience of stress at work. On average, the survey respondents mostly agree with all the above statements that point to the problematic nature of stress at work in 2020 and 2022. On the basis of the collected data, we confirm the third hypothesis and conclude that the respondents consider stress to be an important problem in Croatia, with the majority also having a personal experience of stress at work.

In the fourth objective, we checked what experiences employees have related to managing stress at work in their work environment. Our assumption was that employees have insufficient experience with stress management activities and do not know well the activities carried out in their companies. The data show that the respondents on average do not agree with any of the statements that indicate stress management practices in the company. According to the collected experiences of employees, we can conclude that stress is managed relatively poorly in companies. Most often, even the most necessary and minimal activities prescribed by law are not carried out, and therefore not even the activities necessary for quality stress management.

This paper could be useful and relevant for employers, who can find information about basic legislative documents, become aware of employees' experiences, and compare their own stress management practices at work with the practices that are most common in companies according to our data. Another group that could be

interested in this work are employees and trade unions. We believe that they should also be aware of the lack of information and take the necessary measures. Namely, regulations by themselves cannot protect workers. Especially at the beginning of the process of respecting some rights, it is important to warn about violations of regulations and to demand that the competent services consistently punish violators. Only in this way, high-quality and responsible stress management at work will become part of business etiquette and everyday life.

REFERENCES

[1] Decision on the publication of the Universal Declaration of Human Rights, OG-IA, 12/09; The Universal Declaration of Human Rights (UDHR), 10 December 1948, *Available from* https://www.un.org/en/about-us/universal-declaration-of-human-rights *Accessed:* 2022-05-19.
[2] International Covenant on Economic, Social and Cultural Rights, 16 December 1966, *Available from* https://www.ohchr.org/en/instruments-mechanisms/instruments/international-covenant-economic-social-and-cultural-rights *Accessed:* 2022-05-21.
[3] The Convention for the Protection of Human Rights and Fundamental Freedoms, OG-IT, 18/97, 6/99, 14/02, 13/03, 9/05, 1/06, 2/10; European Convention on Human Rights, 3 September 1953, *Available from* https://www.echr.coe.int/pages/home.aspx?p=basictexts *Accessed*: 2022-05-19.
[4] European Social Charter, Revised, Social Policy Review, Vol. 4 No. 1, Zagreb, 1997. p. 41-53, *Available from* https://hrcak.srce.hr/29857 *Accessed:* 2022-05-23
[5] ILO Convention no. 155: Convention on Safety and Health at Work and on the Working Environment (No. 155, 1981), *Available from* https://tinyurl.com/y2q7spow *Accessed:* 2022-05-27.
[6] Šokčević, S.: Međunarodno i europsko pravo sigurnosti, IPROZ, Zagreb, 2014.
[7] Council Directive of June 12, 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (89/391/EEC) (OJ L 183, 29/06/1989)
[8] DG Employment, social affairs and inclusion, Evaluation of the practical implementation of the EU Occupational Safety and Health (OSH) Directives in EU member states, 2015, *Available from* https://tinyurl.com/yyegnr2t *Accessed:* 2022-06-01.
[9] European Commission, Communication from the commission to the European parliament, the council, the European economic and social comitee and the comitee of the regions, Safer and Halthier work for all - Modernisation of the EU occupational safety and health legislation and policy, Brussels, 2017, *Available from* http://ec.europa.eu/social/BlobServlet?docId=16874&langId=en *Accessed:* 2022-06-18.
[10] European Commission, Commision staff working document, Ex-post evaluation of the European Union occupational safety and health Directives (REFIT

evaluation), Brussels, 2017, *Available from* http://www.ec.europa.eu/social/BlobServlet?docId=16875&langId=en *Accessed:* 2022-06-18.
[11] Psihosocijalni rizici i stres na radnom mjestu, *Available from* https://osha.europa.eu/hr/themes/psychosocial-risks-and-stress *Accessed:* 2022-06-12.
[12] Strateški okvir EU-a o sigurnosti i zdravlju na radu 2021.-2027. *Available from* https://osha.europa.eu/hr/safety-and-health-legislation/eu-strategic-framework-health-and-safety-work-2021-2027 *Accessed:* 2022-06-18.
[13] Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions EU strategic framework on health and safety at work 2021-2027 Occupational safety and health in a changing world of work, COM/2021/323 final, Bruxelles, 28.6.2021., *Available from* https://eur-lex.europa.eu/legal-content/HR/ALL/?uri=CELEX:52021DC0323 *Accessed:* 2022-06-12.
[14] Occupational Safety and Health Act (OG, 71/14, 118/14, 94/18, 96/18)
[15] Ordinance on risk assessment (OG, 112/14, 129/19)
[16] Petričević, A.; Medarić, D.: Pravo radnika na dostojanstven rad i radno okruženje bez stresa, *Pravni vjesnik*, Vol. 30 (2014) No.2, pp. 405-419, ISSN

THE ROLE OF SPORTS AND PROPER NUTRITION IN PROTECTING AND PRESERVING HEALT

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Abstract: *The aim of the study was to show the multiple benefits of sports and physical activity and to explain the importance of proper nutrition and adequate representation of macronutrients and micronutrients. Physical inactivity and poor eating habits can cause the development of chronic non-communicable diseases, which are a leading public health problem in all developed countries. Sport and physical activity improve cardiovascular abilities, strengthen bones and joints, raise self-esteem and self-confidence, reduce stress and improve an individual's socialization, while proper nutrition provides the nutrients necessary for proper growth, development and health.*

Key words*: sport, physical activity, proper nutrition, health*

1. INTRODUCTION

Health is a state of total body, spiritual and social bliss. It is the basic human right and is influenced by biological, environmental, social and economic factors such as sex, age, constitution, inheritance, education, financial security, nutrition, physical activity, smoking, alcohol, place of living and other. Greater control over the state of your health is secured by the process of upgrading your health. Science confirms that incorrect nutrition and inactivity risk factors for incontiguous chronic illnesses whose death rate is 65% in the world. With a little work and some information, every person can help prevent the development of many illnesses. Sport is a physical activity that needs the activation of physical, psychological and social dimensions of man, while correct nutrition implies moderate and various intake of all needed nutrients. Variety secures the correct intake of a combination of nutrients and moderation of a sufficient amount.[1]

1.1. OBJECT AND GOAL OF THIS PAPER

The goal of this paper is to show the multiple benefits of sports and physical activity and explain the importance of correct nutrition and the required representation of macro and micronutrients.

2. SPORT AND HEALTH

Sport and physical activity are essential for the health and wellbeing of people. Regular physical activity and sport give people, man and women of all ages and states, also invalids a wide specter of physical, social and mental benefits and represents a powerful mean in preventing illness.[2]

Advantages of regular physical activity, sports and active games are:

- Cuts risk of early death
- Cuts risk of doing from heart disease or stroke
- Cuts risk of developing heart disease, colon cancer and diabetes type 2
- Helps prevent and reduce hypertension which ales 1/5 of the adult population of the world
- Helps prevent osteoporosis and reduce hip fracture in women
- Reduces the risk of pain in the lower back, can help in healing painful states like back and knee pains
- Helps build and keep bones healthy, muscles and joints
- Helps psychological welfare, reduces stress, anxiety and depression
- It helps in preventing and controlling risky behavior, especially with children and youths like smoking, drinking alcohol or other substances, unhealthy nutrition or violence

A great part of the benefit for your health comes from 30 minutes of mild physical activity everyday like walking to work, climbing steps, gardening, dancing and many other fun and recreational sports. Additional benefits for your health can come from mild to strong physical activity of a lengthier duration where children and youths need an additional 20 minutes 3 times a week. For weight control you need at least 60 minutes of mild to strong physical activity every day.[2]

3. THE INFLUENCE OF PHYSICAL ACTIVITY ON THE MAIN BODY ORGANS

Success in physical activity is defined by muscle ability which is defined by power, strength and stamina during work. Muscle power is defined from its mass, while

strength is the amount of work a muscle does during a time period. Stamina depends upon the muscle being supplied by nutrients and mostly by the amount of glycogen stored in the muscles before work.[3] For normal muscle function the key is functioning of the respiratory and cardiovascular systems because muscles use oxygen to work which is brought into the organism by breathing and to the cells by blood. The sun's energy turns into chemical energy of plants by photosynthesis which humans absorb and store in their organisms. When muscles work chemical energy from nutrients turns into heat and mechanical energy which is set free and manifested at physical activity. It also turns into electrical energy transferred by nerve impulses. For basic life function in a state of inaction a man needs to use 360 liters of O2 or about 1600Kcal.[4]

4. PHYSICAL ACTIVITY AND MANS MENTAL HEALTH

Physical activity has an important role in preserving and improving mental health and is also used as a therapeutic means in many psychological disorders. Physical activity lifts self-esteem and confidence, improves an individual's cognitive functions and socialization. It is efficient with anxiety, depression, stress, psychotic disorders, dementia and so on. It has a direct impact on the hormone system and increases the level of serotonin, endorphin and dopamine in the organism. Significant positive changes are made in an individual's health. It increases life quality, physiological and biochemical changes in the organism, a change in the way you see yourself and your environment.[4]

Physical activity enables the development of positive moral and social characteristics such as teamwork, solidarity, righteousness, determination, lucidness, perseverance, discipline, responsibility, honesty, modesty, optimism, respect. All these characteristics are very desirable in the modern way of life for takin on everyday work and life problems as also dealing with stressful situations.[5]

4.1. THE INFLUENCE OF PHYSICAL ACIVITY ON ANXIETY AND STRESS

Anxiety is defined as a feeling of discomfort, concern, tension, great stress, panic and fear, an irrational bad feeling and the awakening of the nerve system. When we speak of anxiety stress is often noted even though it is a much wider term defined as an individual's body reaction to different life conditions, the organism's incorrect adjustment to the same and an imbalance between the environment and the individual.[6]

Physical activity helps fight anxiety and stress because it suppresses the stress hormone cortisol which has a bad effect on many organs including the brain. Stress has a very negative influence on the organism if a stressful event lasts over a longer period or the level of stress is extremely high and there are no periods of settling down so the organism can recuperate. Research shows that sports and physical activity in the long term ease the impact of stress and reduce the sensitivity to it.

At the beginning of exercising people with anxiety will feel it elevated which happens due to the activation of the sympathic nerve system and they can have uneasy reactions like palpitation, sweating, loss of breath. Because of this reaction many people stop exercising thinking they increased their symptoms of anxiety.[5]

4.2. THE INFLUENCE OF PHYSICAL ACTIVITY ON DEPRESSION

Depression is a mood disorder which is defined as a feeling of worthlessness, guilt, great sorrow, helplessness and hopelessness where the individual pulls back from others. Research shows that people with greater psychological problems or are clinically depressed have the most benefit from physical activity. The excretion of serotonin and dopamine are reduced in depressed people and physical activity helps increase this. Scientists state the aerobic and anaerobic exercise positively influences the decrease of depression symptoms. For optimal results perseverance is of importance of exercising from a middle to high intensity. Exercising with groups of people helps the individual socialize. Exercise can be combined with cognitive therapy and by drugs. Medicaments for depression are on the base of serotonin so by exercising you can decrease the therapy. Many countries have 30 minutes of mandatory exercise within psychiatric facilities and after a few months a positive reaction was confirmed, and therapy decreased.[4]

4.3. ADDICTION TO EXERCISING

Problems can occur from too often and forced exercising, rapt interest with your body. Fitnessomania can become bigorexia (muscle dysmorphia) where you have a distorted picture of your body. Indications of the disorder are obsessive exercising which becomes life's priority, constantly checking your looks in a mirror, strict nutrition regime (can cause bulimia) and using steroid anabolics. This occurs in people that identify themselves as exercisers, have low self-confidence, are impulsive, anxious and extrovert. Addiction to exercising has negative effects on social and emotional health as also other addictions.[5]

Over exercising causes anemia, amenorrhea, metabolic and immuno-system disorder, and injuries from fatigue (stress fractures, tendinopathy). If people with

this addiction must change their exercise schedule for some reason or must exercise less due to injury, they will feel guilt or symptoms like unrest, anxiety, loss of concentration and sleep. This problem cannot be taken easily because it can develop some form of anxiety or obsessive-compulsive disorder and depression. Therapeutical action must be taken which relies on cognitive-behavioral psychotherapy and treatment by anxiolytics and anti-depressives.

5. SOCIALIZATION AND SPORT

Socialization is a complex process in which an individual interacts with his environment, develops, molds, and learns socially relevant forms of behavior (attitudes, beliefs, values, habits, and customs). The role of socialization is to integrate every individual into society and enable coherent attitudes and values, integration in society and transferal of cultural patterns. It also includes processes of change and outcomes that are not always acceptable to society (a misfit and diligent behavior). Through socialization an individual builds and makes an identity or personality. Factors that influence this are: personal structure, family, school, peer groups, media, work environment and free time.[7] Socialization is divided into three phases that differ by goals and mechanisms: primary, secondary, and tertiary.

Primary socialization is base or core socialization in the first years of your life in a family where children learn basic communication skills, language, roles in society and form its primary identity.

Secondary socialization takes place at the age of 4-16 where an individual learns skills within a group of peers, school, religious institution, and extracurricular activities (like sports). The main goal of this phase is to adopt norms that define social and work roles (work habits, responsibility, and social control). The success of this phase depends on intrinsic efforts and personal involvement of the individual and of the quality of those that teach them (professors, coaches, peers).

Tertiary socialization is a process that goes on for the rest of your life and its goal is to adjust to new situations in life later. Adults enter roles that previous socializations did not prepare them for (worker, spouse, parent). Sport is one of the ways you socialize within a group. Through sport individuals learn to work together, take upon a specific role and define themselves within a group. Children in team sports can develop many social skills such as leadership, communication, team building which will help them their entire lives in school, work or personal relationships. Team sport teaches individuals how to communicate with their peers and adults as coaches, referees, managers, and fans.[8] Socialization through sports has a goal to develop motorical skills, social competence and adopt social norms.[9]

In sports factors that influence socialization are degree of cooperation between individuals, quality of management, competitor spirit, importance of winning, part of individual activities and freedom of deciding. Sports prompt collective integration of individuals, teach cooperation and honesty. An individual assimilates a whole array of knowledge, attitudes, skills and moral rules needed for social life within a community developing imagination and creative capacities. Sports also enable the development of team spirit and feeling of belonging can help youths dragging them away from addictions and socially unacceptable behavior.[8]

5.1. SOCIAL DEVELOPMENT OF A CHILD THROUGH SPORT

Most sports can be looked at as playing and that is what attracts children. One of the most important characteristics of playing is that it's fun, entertaining and relaxing. Starting sports at an early age and systematic activity are of great importance for achieving a high degree of integration which leads to harmony between reaching your potential and achievements, successful integration within a society, respecting the needs of others and accepting basic behavioral norms and the basic values of the individual society.[10]

The type of sports activity is not relevant for the process of socialization. What is relevant is that the activity is repeated often enough and of high intensity. The effectiveness of the activity depends on the individual engagement and is important for developing creativity, positive feistiness, properly experience winning, learn how to behave on the field, learn what is good and positive behavior and what is bad and negative. Group sports activity can satisfy a child's need to belong to a group in which he learns to adapt to his peers. A family has an important role in forming a child's personality and needs to secure conditions for proper psychophysical development, stimulate the child's personality development and be a support on the way to independence. Coaches and parents must have good communication, so the child develops a positive attitude towards sporting competitions, accepts his own responsibility for success and tries no matter what the result.[10]

6. NUTRITION AND HEALTH

“Everything our organism intakes through food builds us and changes, our strength, health and lives depend on it “. Hipócrates statement should make every person choose food that protects and positively impacts your health. Food has an important role in the quality of life, in prevention, treatment and healing many illnesses.

The increase of chronic noncontagious illnesses is directly tied to global nutrition patterns which characterize high levels of fats and processed meats, saturated fats, refined grains, salt and sugar. The WHO recognized the importance of nutrition in the risk of illness and is launching a global plan to prevent and control noncontagious illnesses. Its plan is to solve unhealthy nutrition patterns by reducing other risk factors like physical inactivity, smoking, drinking alcohol.[12] With illnesses such as cancer, diabetes, high blood pressure, heart disease and osteoporosis substances like vitamins, minerals and phytochemicals are a protective factor, whereas some chemical substances from food can slow down ageing.[11]

6.1. IN GENERAL, ABOUT PROPER NUTRITION

Nutrition must secure all nutrients needed for proper growth, development, and health preservation. Nutrients needed for the organism come from food. Food has macronutrients, vitamins, minerals and hundreds of other natural substances like carotenoids, flavonoids and isoflavones.[13]

Properly balanced nutrition characterizes:

- controlled energetic intake – it is adapted according to sex, age, height, and daily physical activity
- adequateness – the possibility of fulfilling the organisms need for nutrients and energy
- balance – adjusting the intake of energy to its use
- nutritive density – intake of high-density nutrients which secure significant amounts of micronutrients and are low on calories
- diversity – intake of various nutrients from diverse groups
- moderation – limited intake of nutrients that can have negative implications on your health if taken more than needed. This includes salt (not more than 5 or 6 grams a day), alcohol (not more than one beverage per day for women, two for men), saturated (not more than 10% of daily calorie intake) and trans-fat acids (not more than 1% of daily calorie intake), cholesterol (not more than 300mg per day) and sugar (not more than 10% of daily calorie intake).

Nutritional guidance instructs picking quality sources of fat (olive oil), greater consummation of whole grains and a daily intake of five or more portions of fruit and vegetables and three servings of milk or milk products. Nutrients in food can be essential and nonessential. Essential are those the organism cannot synthesize and must be introduced through food like vitamins, minerals, amino acids, some carbohydrates. Nonessential the organism synthesizes itself. A healthy adult need 45-60% carbohydrates, 20-35% fats and 10-35% proteins from the whole amount of daily energy.[13]

6.2. MACRONUTRIENTS AND THEIR ROLE IN HEALTH

Macronutrients are nutritious substances that by their degradation ensure energy and essential nutrients needed for growth, functioning and activity of the organism. This group includes carbohydrates, fibers, fats, and proteins that make up most of an individual's nutrition.[14]

7. CONCLUSION

Man was predisposed to move and keep up psychometric qualities but with industrialization and the appearance of modern technology his life drastically changed. The degree of physical activity fell steeply. Sport and proper nutrition have a significant role in protecting and improving health. Daily physical activity and balanced nutrition can slow down or prevent a whole number of risky illnesses and lessen the death rate. Physical activity ensures multiple physical, psychological, and social benefits such as preventing hypertension, diabetes, cardiovascular illnesses, enhances digestion and muscle strength and stamina, maintains motoric and cognitive functions, prevents stress and lifts self-confidence. “Food can be your remedy and your remedy can be your food.” is Hippocrates' well-known statement which shows that food can prevent and heal many illnesses. Diverse and balanced nutrition is needed for normal development, growth and reproduction of organisms and for optimal degrease of activity and work efficiently, the organism's immunity toward infection and sickness and the ability to recuperate after injury. Non-sufficient or lack of intake of specific nutrients or too large an intake of uniformed food can cause chronic illnesses.

8. REFERENCES

[1] Alibabić V., Mujić I.: „*Pravilna prehrana i zdravlje*“, Veleučilište u Rijeci, Rijeka, (2016.), ISBN: 978-953-6911-89-9.
[2] World health organization: „*Health and Development Through Physical Activity and Sport* “, WHO, Geneva, Switzerland, (2003.).
[3] Guyton A. C., Hall J. E.: „Medicinska fiziologija“, 13. izdanje, Medicinska naklada, Zagreb, (2017.), ISBN 978-953-176-785-9. *Matematičko-fizički list*, 66 (2015.), 2, 109-114.
[4] Marić I., Lovrić F., Franjić D.: „Utjecaj rekreacijskih aktivnosti na mentalno zdravlje“, *Zdravstveni glasnik*, 6 (2020.), 105-114.
[5] Grošić V., Filipčić I.: „Tjelesna aktivnost u poboljšanju psihičkog zdravlja“, *Medicus*, 28 (2019.), 2, 197-203.
[6] Bungić M., Barić R.: „Tjelesno vježbanje i neki aspekti psihološkog zdravlja“, *Hrvatski športskomedicinski vjesnik*, 24, (2009.), 2, 65-75.

[7] Socijalizacija. Hrvatska enciklopedija, mrežno izdanje. Leksikografski zavod Miroslav Krleža, pristupljeno:14.6.2021.
[8] Kregar J., Sekulić D. i dr.: „Uvod u sociologiju“, Pravni fakultet, Zagreb, (2008.), ISBN 978-953-270-0275.
[9] Pomohaci M., Sopa I. S.: „The importance of socialization through sport in students group integration “, Revista Academiei Fortelor Terestre, 21, (2016.), 2,151-160.
[10] Sindik J., Brnčić B.: „Psihološke dobrobiti sporta za djecu“, *Zbornik radova Međimurskog veleučilišta u Čakovcu*, 3, (2012.), 2, 91-94.
[11] Vezilić M.: *Osnovne informacije o pravilnoj prehrani*, pristupljeno: 21.6.2021.
[12] Cena H., Calder P. C.: „Defining a Healthy Diet: Evidence for The Role of Contemporary Dietary Patterns in Health and Disease *“, Nutrients*, 12 (2020.),334, 1-15.
[13] Jirka Alebić I.: „Prehrambene smjernice i osobitosti osnovnih skupina namirnica“, *Medicus*, 17 (2018.), 1, 37–46.
[14] Vranešić Bender D., Krstev S.: „Makronutrijenti i mikronutrijenti u prehrani čovjeka“, *Medicus*, 17 (2018.), 1, 19–25.

The process of employment among persons with disabilities in the Republic of Croatia

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Abstract: *Persons with disabilities in the context of employment belong to a special vulnerable group of workers in the labor market in the Republic of Croatia. The employment of persons with disabilities is regulated by legislative and institutional frameworks with the aim of increasing the integration of persons with disabilities into the labor market. The process of employment of persons with disabilities as well as their professional rehabilitation have a significant role in acquiring the status of active members of society by exercising the right to work and consequently the possibility of earning a living. The aim of this paper is to determine the rights and opportunities as well as the problems encountered in the process of hiring groups of workers from the aspect of persons with disabilities, employers and the entire community. Cooperation and continuous education of the involved participants is needed to improve the status of persons with disabilities in the working environment.*

Keywords: *persons with disabilities, professional rehabilitation, working environment, vulnerable group*

1. INTRODUCTION

There are various definitions of persons with disabilities in use. In this paper, we will use the definition from the Convention on the Rights of Persons with Disabilities since it was signed by 164 countries worldwide. Said Convention states that persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which, in interaction with various barriers, may hinder their full and effective participation in society on an equal basis with others. [1]

When it comes to employment, persons with disabilities face many prejudices about their ability to work, as well as misconception about difficult and costly workplace adaptation. Both the process of employment of persons with disabilities and their professional rehabilitation have a significant role in acquiring the status of active members of society by exercising the right to work and

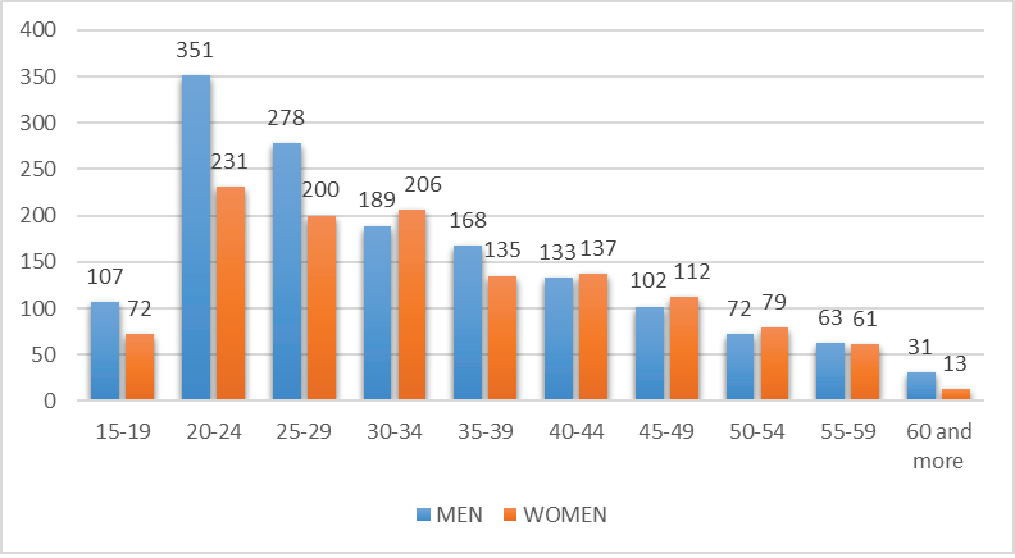
consequently, the possibility of earning a living [2]. This paper will explore the rights and the difficulties encountered in the employment process of persons with disabilities.

2. CURRENT STATUS OF PERSONS WITH DISABILITIES IN THE LABOUR MARKET IN THE REPUBLIC OF CROATIA

Statistics are necessary to better comprehend the problem of employment of persons with disabilities. According to the September 2021. Report on persons with disabilities, they make up about 14.4% of the total population of the Republic of Croatia. The most common types of impairment in persons with disabilities are multiple damages, damage to the locomotor system and damage to other organs [3].

When we look at the distribution by age, 45% of persons with disabilities are of working age (20-65 years), while 11% are children with disabilities. Data presented on the website of the Croatian Employment Service show that in 2021. the proportion of employed persons with disabilities in the total number of employees was only 1.8%. The majority of persons with disabilities in 2021. were employed in the processing industry (15.9%), followed by the activities of providing accommodation and food service (12.9%) and the public administration and defence; obligatory social security (11.1%) [4]. The table below shows the distribution of newly employed persons with disabilities by age group in 2021.

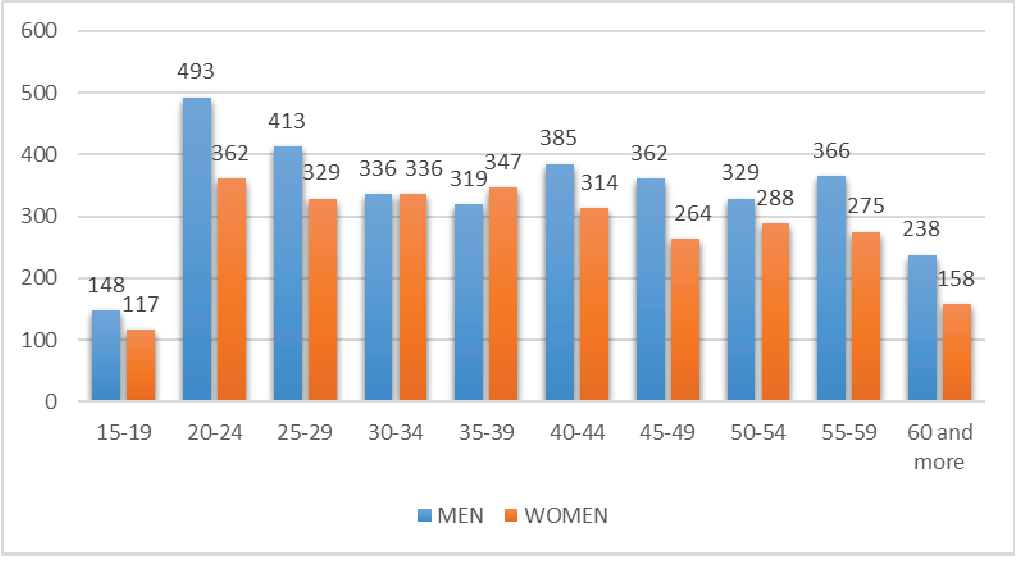
Table 1. Distribution of newly employed persons with disabilities by age group. (Croatian Employment Service)



Source :

Persons with disabilities make up 4.9% of the total population of registered unemployed persons. Despite the fact that young persons with disabilities make up the majority of newly employed persons with disabilities, they are also the most numerous groups among the unemployed persons with disabilities. As presented in the Table 2, 855 of 6179 unemployed persons with disabilities (13.8%) are in the group between the ages of 20 and 24, followed by the group between 25 and 29 years of age (758/6179 [12%]) and the group between 40 and 44 years of age (699/6179 [11.3%]) [4].

Table 2. Distribution of unemployed persons with disabilities by age group. (Croatian Employment Service)



The majority of unemployed persons with disabilities registered in the records of the Croatian Employment Service have completed secondary school (4,689/6179 [75.9%]). Persons with intellectual disabilities are the largest group in the total number of unemployed persons with disabilities (29.3%). The Croatian Employment Service regularly publishes current statistics of persons with disabilities on the labor market in order to correctly select target policies and point out problems in the employment of persons with disabilities [4].

3. LEGISLATIVE AND INSTITUTIONAL FRAMEWORKS ABOUT EMPLOYMENT OF PERSONS WITH DISABILITIES IN CROATIA

As we showed in the previous chapter, the largest proportion of persons with disabilities is of working age, while the largest proportion of the unemployed is among young people between 20 and 29 years of age.

Therefore, it is necessary to direct our efforts at multiple levels in order to enable a better and more efficient access to the labor market for all persons with disabilities, with a special focus on the young unemployed population. With the ratification of the Convention on the Rights of Persons with Disabilities Croatia accepted the obligation to improve public policies for the employment of persons with disabilities [5]. Legislative and institutional frameworks are the basis for creating national programs and policies. They are most important for the protection and harmonization of rights of persons with disabilities without discrimination in any respect. The rights of persons with disabilities in Croatia are defined through laws, regulations and the Declaration. In our context, the most important is *Law on professional rehabilitation and employment of persons with disabilities* (NN, 44/14, 2/15). This law regulates: the rights of persons with disabilities to professional rehabilitation, the methods of rehabilitation, their employment and work, and incentives for their employment. This law also defines employment under general conditions and employment under special conditions. The general conditions of employment mean according to general regulations which regulate the open market of work, while the special conditions of employment mean employment in an established institution or trading company for the purpose of employment of persons with disabilities in protective workshops [5]. Furthermore, a register of employed persons with disabilities is defined by the *Rulebook on the content and method of conducting the register of employed persons with disabilities* (NN 75/2018) [6]. The procedure of professional rehabilitation, organization and work of the Center for professional rehabilitation (CPR), scale for the assessment of the degree of disability in relation to work are detailed in the *Rulebook on professional rehabilitation and centers for professional rehabilitation of persons with disabilities* (NN 75/2018).

In March 2021., the European Commission passed the *Strategy on the rights of persons with disabilities for the period 2021-2030.* The goal of the strategy is to ensure that all persons with disabilities in Europe, regardless of gender, race, ethnicity, religion, belief, age or sexual orientation enjoy their human rights, have equal opportunities and equal access to participation in society and economy. The goal includes the rights to decide where, how and with whom they want to live, to move freely in the EU regardless of their support needs and to no longer be exposed to discrimination [7]. Lastly, the *Law on to the ombudsman for persons with disabilities* (NN 107/07) defines the role of the Office of the Ombudsman for persons with disabilities as the link between persons with disabilities, society and institutions that can systematically solve the potential problems of persons with disabilities [8].

4. THE PROCESS OF EMPLOYMENT FROM THE PERSPECTIVE OF PERSONS WITH DISABILITIES

Entering the labor market is often challenging for persons with disabilities. They face many prejudices and difficulties, which often results in dissatisfaction and discouragement. Ability to work is one of the fundamental human rights [2]. The right to work and consequently the possibility of earning a living improves satisfaction with life overall. In order to avoid discrimination and improve the status of persons with disabilities, employment opportunities in Croatia are defined by the aforementioned laws and regulations. As mentioned earlier, persons with disabilities can be employed through the open labor market or under special conditions with the obligation to ensure reasonable adjustments to the workplace (*Law on professional rehabilitation and employment of persons with disabilities* [NN, 44/14, 2/15]). In the open market persons with disabilities can be employed with or without using financial or professional support. Under special conditions of employment, a person with a disability may be employed in an institution or company established for the purpose of employing persons with disabilities who cannot be employed through the open labor market (integrative workshop) and in protective workshops [5]. In some state institutions, persons with disabilities have priority in employment if they submit all the evidence of fulfilling the required conditions, as well as proof of disability [7]. Persons with disabilities also have the possibility of self-employment, they can establish a trading company or an association in which they will be employed, they can perform crafts, domestic crafts, professional activities and forestry and agricultural activities (*Act on Professional Rehabilitation and Employment of Persons with Disabilities,* [NN 157/13, 152/14, 39/18, 32/20]). The persons with disabilities who are unemployed and registered in the Croatian Employment Service have the right to professional rehabilitation as well as the right to financial aid and compensation for travel expenses during education according to the *Law of work.*

They also have more rights when it comes to paid vacation and minimum duration of the notice period. For example, they have the right to a paid vacation for the duration of at least five weeks for each calendar year, and to a minimum duration of the notice period which is increased by one month in regards to general regulations on work, unless the dismissal was concealed by that person [7].

5. THE PROCESS OF EMPLOYMENT FROM THE PERSPECTIVE OF EMPLOYERS

Unfortunately, there is still a lack of awareness about the capabilities of persons with disabilities because the emphasis is on what they cannot do. Therefore, employers are the target group of incentive policies aimed at increasing the employment of persons with disabilities. It is extremely important to inform employers about the capabilities of persons with disabilities, the possibilities of

adapting the workplace, as well as the incentives offered to them for employing persons with disabilities. Employers who employ more than twenty workers have an obligation to employ a quota, i.e. they are obliged to employ a certain proportion of persons with disabilities in the total number of workers, with certain exceptions, as it is defined by the *Regulation on determining the quota for employment of persons with disabilities* (NN 75/18, 120/18, 37/20, 145/20). The employed persons with disabilities are registered in the Record of Employed Persons with Disabilities maintained by the Croatian Pension Insurance Institute. If an employer does not fulfill this requirement it is obliged to pay monetary compensation, which is later used for the purpose of paying monetary incentives and rewards for the employment of persons with disabilities and their promotion. If they hire more persons with disabilities than the prescribed quota they can get a financial reward [5,9,10]. The employer and the self-employed person also have the right to regular incentives as well as special incentives. Employment incentives include the following measures: wage subsidy, co-financing of education costs, co-financing of workplace adaptation costs, co-financing of the costs of adapting working conditions, co-financing of interest on credit funds intended for the purchase of machines, equipment, tools or accessories necessary for the employment of a disabled person, co-financing of professional costs support and special funds for innovative employment programs for persons with disabilities [7].

6. THE PROCESS OF EMPLOYMENT FROM THE PERSPECTIVE OF COMMUNITY

In today society, social awareness still primarily focuses on the limitations of the persons with disabilities, not their potential and capabilities. Persons with disabilities are often exposed to social isolation and worse socio-economic conditions, as well as increased dependence on the care of others, which consequently makes it difficult for them to be actively included in society.

Nevertheless, positive progress has been made in raising awareness and sensitizing society to persons with disabilities. Some studies show that employed persons showed significantly greater involvement in the life of the local community, cultural events, have a wider social network, are more involved in political life and perceive their environment as more supportive [11]. Also, from the financial aspect, investing in professional rehabilitation and employment programs can reduce the costs of social welfare, health care and other similar social benefits and increase the national income. As society we are slowly, but firmly, raising awareness that persons with disabilities can achieve professional success, just like other members of the community.

7. CONCLUSION

In conclusion, over the past few decades, policies, laws and regulations have tried to regulate and increase the employment of persons with disabilities. However, their involvement in the labor market is still lower than desired. The cooperation of all involved parties, both legislative and institutional, is essential for the improvement of the status of persons with disabilities in the labor market. The awareness of employers and society about the capabilities of persons with disabilities and how they can help the entire community as equal members of the community, is slowly growing. We hope that in the near future, with the further advancement of society, technology and social awareness, persons with disabilities will become equals in the labor market.

REFERENCES

[1] Zakon o potvrđivanju Konvencije o pravima osoba s invaliditetom i Fakultativnog protokola uz Konvenciju o pravima osoba s invaliditetom, Narodne Novine, NN 6/2007
[2] Leutar, Babić: *Pravo na rad i osobe s invaliditetom u Hrvatskoj*, Sociologija i prostor : časopis za istraživanje prostornoga i sociokulturnog razvoja, Vol. 46 No. 2 (180), 2008.
[3] Benjak, Izvješće o osobama s invaliditetom u Republici Hrvatskoj – stanje 09./2021, Hrvatski zavod za javno zdravstvo; September 2021.
[4] Izvješće o aktivnostima Hrvatskog zavoda za zapošljavanje u području zapošljavanja osoba s invaliditetom u razdoblju od 1. Siječnja do 31. Prosinca 2021. Godine, Zagreb, January 2022.
[5] Zakon o profesionalnoj rehabilitaciji i zapošljavanju osoba s invaliditetom, Narodne novine, 157/13, 152/14, 39/18, 32/20, March, 2020.
[6] Pravilnik o sadržaju i načinu vođenja očevidnika zaposlenih osoba s invaliditetom, Narodne novine, NN 75/2018, August 2018.
[7] Mogućnosti i prava – *Priručna brošura namijenjena osobama s invaliditetom – stradalima od minskoeksplozivnih sredstava*, HZJZ, March 2022.
[8] Zakon o pravobranitelju za osobe s invaliditetom, NN 107/07
[9] Pravilnik o poticajima pri zapošljavanju osoba s invaliditetom, NN 145/2020, December 2020.
[10] Odluka o načinu ostvarivanja poticaja pri zapošljavanju osoba s invaliditetom, NN 8/2008 , January 2008.ž
[11] Babić; Leutar; *Položaj osoba s invaliditetom na tržištu rada Republike Hrvatske*, Soc. ekol. Zagreb, Vol. 19 (2010.), No. 2

ASSESSMENT OF PSYCHOSOCIAL RISKS IN THE WORK OF HEALTH PROFESSIONALS IN THE PSYCHIATRIC WARDS OF THE GENERAL HOSPITAL KARLOVAC AND THE GENERAL HOSPITAL DR. JOSIP BENČEVIĆ, SLAVONSKI BROD

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Abstract :
Everyday work with patients in psychiatric wards is a great challenge for health professionals who in their work encounter many beautiful but also ugly events that can lead to many adverse events. Stress as a natural defense function puts the body in flight or fight mode.Any event in the workplace that an individual is unable to cope with, resolve, or there is imbalance between an individual's needs and ability to make a particular adjustment can cause stress as well as adverse events. Work in the psychiatric ward is specific and requires knowledge and experience in the application of de-escalation techniques and the types and methods of applying coercive measures against persons with severe mental disorders. For the purposes of this paper, the Questionnaire for Psychosocial Risk Assessment (PHI), the original questionnaire of general sociodemographic characteristics of respondents, the original questionnaire of architectural and safety characteristics of psychiatric wards, and the implementation of the legal obligations of the employer on education for the application of coercive measures according to the Ordinance on the application of coercive measures against persons with mental disorders. The questionnaire was distributed online via google form, and 48 health professionals participated in the survey. For the implementation of the research, the approval of the ethics committees of the mentioned hospital institutions was obtained, and the results indicate some significant differences between the mentioned institutions but also within the same institutions.
Keywords: *psychosocial risks, health workers, psychiatric ward*

1. INTRODUCTION

1.1. WORKPLACE STRESS

A model of physiological stress was set up by Selye, in the 1930s when he found that a wide range of different stimuli causes the same physiological changes. He introduced the name stressors for stimuli that cause stress. If there is no recovery period between stressful stimuli, but stressful events follow one another, chronic stress occurs, which can lead to serious health consequences for the body [1]. After long-term exposure to stressful situations, there is an increased secretion of corticosteroids, enlargement of the adrenal cortex and atrophy of the thymus and other lymphatic structures. He described these bodily responses as a general adaptive syndrome. Stress is recognized in the modern world as an important factor affecting health [2]. There are an extremely large number of circumstances that can be related to stress, and when the characteristics of the individual are added to this, the diversity of stressors becomes even greater, so there is a clear need to try to systematize the sources of stress. Stressors are divided into three groups:

- Physiological stressors – exposure to loud noise, great heat or cold or severe pain.
- Psychological stressors – caused by interpersonal misunderstandings and conflicts with family members, neighbours, colleagues and managers at work.
- Social stressors – when it comes to conflicts, crises and disasters that shake almost all people in a society such as economic crises, wars, sudden changes in social relations... [3].

  People whose part of their daily work is the provision of care services to others, such as health professionals, and especially employees employed in psychiatric wards are exposed to a number of stressors at work on a daily basis. The more complex the care services they provide, and the greater the potential for failure and the severity of the consequences, the greater the exposure to stress at work [4].

1.2. WORKPLACE AGGRESSION

Any behavior that poses a threat to one's own or others' integrity and the destruction of property is a problem in psychiatry, whether verbal or physical. It may or may not be associated with a specific psychiatric diagnosis[4]. The results of research in the United States have shown that only 3-5% of the risk of violence can be attributed to mental disorders, while socio-demographic and economic determinants are attributed significantly more [5]. Most incidences in those patients are associated with acute psychotic episodes, alcohol and psychoactive substance intoxication associated with some personality disorders, and abstinence crisis. In somatic diseases it can be present

as a result of traumatic head injuries and bodily pain. Understanding the cause of aggression in a particular patient, in a given situation, is a decisive step in the further sequence of interventions. Psychologically, aggression can be influenced by the patient's personality traits, i.e. the way he perceives a certain situation, as well as the way he copes with stress. It has its own sensory component that needs to be taken into account when in contact with such a patient. It is often preceded by a strong sense of humiliation, helplessness and injustice. Frightened patients have a special tendency to aggressive outbursts. With their violent behavior, they try to overcome their own feeling of fear and hide it from the environment [6]. Since the prevention and reduction of an aggressive incident are very demanding procedures, it is important to pay attention to the education of the staff who carry them out. By educating nurses, it is possible to act on the prevention and reduction of the number of aggressive outbursts. It refers to the improvement of communication/de-escalation techniques, detection of early signs of aggression, risk assessment, implementation of coercive measures in accordance with standards and elaboration of measures of safe call for help. In addition to learning skills, it is important to understand why aggression occurs at all, and to recognize the impact of one's own attitudes and reactions in the form of countertransference [4]. De-escalation procedures do not always guarantee successful prevention of aggressive outbursts. In that case, restrictive measures are sought, which include human restraint and human seclusion. Both must not be used at the same time [6]. Due to all the above, it is extremely important to have educated staff for the prevention of aggressive behavior, in accordance with the Ordinance on the types and manner of application of coercive measures against persons with mental disorders. It is necessary to organize regular training for nurses/medical technicians in communication skills and application of de-escalation techniques for dealing with crisis situations, training of basic self-defense techniques and techniques of physical restraint of patients, organization of "intervention" teams for dealing with crisis situations, arranged system of calls for help from technology to competencies [7], but also to provide security architectural possibilities when arranging closed Psychiatric Departments (ground floor, protective grilles on windows, balconies, locking system, security surveillance system, patient separation rooms...)

2. RESULTS

The purpose of the research was to examine whether there are differences in the assessment, i.e. the experience of exposure to psychosocial risks at the workplace of healthcare workers of the Karlovac General Hospital and Dr. Josip Benčević General Hospital, Slavonski Brod. 48 healthcare workers from two general hospitals took part in the research, of which 19 healthcare workers from Dr. Josip Benčević General Hospital, Slavonski Brod, and 29 healthcare workers from Karlovac General Hospital. Psychosocial risks were examined with the Questionnaire for the assessment of psychosocial risks, which consists of seven categories of sources of stress at work

with the corresponding statements, which are: work requirements, interpersonal relations, control in operation, lack of support from superior, lack of support from coworkers, work role and lack of awarenessof changes. The result is interpreted individually for each of the mentioned categories or subscales as the arithmetic mean of the results presented on a Likert scale from 1 to 5, where 1 means never, 2 rarely, 3 sometimes, 4 often and 5 always, and as the total average result of all 35 statements. The assessment of psychosocial risks determined which risks are the most pronounced and which represent a risk for health, injuries, or reduced work efficiency. Table 1 shows the arithmetic means and standard deviations of the results on the psychosocial risks and 7 subscales variables.

Table 1: Descriptive data

	Total		Karlovac GH		Slavonski Brod GH	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Psychosocial risks	115,78	13,25	114,89	11,10	117,17	16,31
Work requirements	20,17	6,32	18,79	6,62	22,33	5,29
Interpersonal relations	9,35	3,51	8,69	2,88	10,37	4,18
Control in operation	20,75	7,43	19,41	3,57	22,79	10,83
Lack of support from superior	17,60	5,23	18,93	5,09	15,58	4,87
Lack of support from coworkers	15,52	3,69	16,59	3,29	13,89	3,77
Work role	21,98	3,26	21,69	3,31	22,42	3,22
Lack of awareness of changes	10,19	2,72	10,93	2,56	9,05	2,61

The results of the assessment, i.e. the experience of exposure to psychosocial risks at the workplace of healthcare workers at the Karlovac General Hospital and Dr. Josip Benčević General Hospital, Slavonski Brod, indicate the existence of a high level of exposure to psychosocial risks at the workplace among healthcare workers of both hospitals, which indicates the existence of high exposure to stress at workplace (m= 115.78, sd= 13.25). With the T-test for independent samples, we tested whether there is a difference in the assessment, i.e. the experience of exposure to psychosocial risks at the workplace, between the healthcare workers of the two hospitals. No statistically significant difference was obtained, which did not confirm our hypothesis that the healthcare workers of Karlovac GH will have a greater experience of exposure to

psychosocial risks (t= -0.56, df= 44, p>0.05). With the T-test for independent samples, we also tested the existence of differences in the assessment, i.e. the experience of exposure to psychosocial risks by subscales, and a statistically significant difference was obtained in three of the seven subscales. Healthcare workers of Karlovac GH have a greater experience of exposure to stress on the subscale Lack of support from superior (t= 2.27, df= 46, p< 0.01), on the subscale Lack of support from coworkers (t= 2.61, df= 46, p< 0.05) and on the Lack of awareness of changes subscale (t= 2.46, df=46, p< 0.05), which partially confirmed our hypothesis. Table 2 shows the results of the T-tests.

Table 2: Differences in the assessment, i.e. the experience of exposure to psychosocial risks of health workers of two general hospitals

	t	df	Sig.
Psychosocial risks	-0,56	44	0,58
Work requirements	-1,91	44	0,06
Interpersonal relations	-1,65	46	0,11
Control in operation	-1,56	46	0,13
Lack of support from superior	2,27	46	0,03
Lack of support from coworkers	2,62	46	0,01
Work role	-0,76	46	0,73
Lack of awareness of changes	2,46	46	0,02

3. CONCLUSION

More than twenty years of research shows that stressful hospital work environments are associated with burnout among medical staff. Psychiatric nurses, as a professional group that provides care for people with mental disorders, are exposed to a high level of stress and thus exposed to burnout at work [8]. When deciding on strategies for dealing with stress in the workplace, we first need to define how we want to act - individually on the employee or on the workplace itself, and whether this action will

be preventive or curative. Depending on this, we will choose primary, secondary or tertiary prevention strategies. Interventions aimed at the employee work immediately and efficiently, but do not represent a long-term solution, while interventions aimed at the workplace are often not sufficiently individualized [9]. The limitations of this research are the small number of respondents and the differences in the number of respondents according to the place of work, but the results indicate that there are differences, and also the negative consequences of exposure to psychosocial risks. A suggestion for further research is to include more respondents and more institutions in order to have more relevant data.

REFERENCES

[1] Selye H.: A Syndrome Produced by Diverse Nocuous Agents, *Nature,* 1(1936) 1., 32.

[2] Cigrovski A: Pregled intervencija ciljanih na smanjenje stresa na radnom mjestu u medicinskih sestara koje rade na psihijatrijskim odjelima, Available from https://urn.nsk.hr/urn:nbn:hr:105:576200 Accessed: 2022-06-20.

[3] Havelka, M.; Havelka Meštrović, A.: *Zdravstvena psihologija,* Naklada Slap, 978-953-191-933-3, Jastrebarsko, (2002)

[4] Štrkalj Ivezić, S; Jukić, V & Buzina, N.: Smjernice za prevenciju agresivnog ponašanja i primjena mjera prisile u području psihijatrije. Available from https://www.psihijatrija.hr/site/prihvacene-smjernice-za-prevenciju-agresivnog-ponasanja-i-primjene-mjera-prisile-u-podrucju-psihijatrije/ Accessed: 2022-06-20.

[5] Jukić, V.: *Hitna stanja u psihijatriji*, Medicinska Naklada, 978-953-176-936-5, Zagreb, (2018)

[6] Vedriš, S.: Agresija prema medicinskim sestrama na odjelu psihijatrije. Available from https://zir.nsk.hr/islandora/object/unin%3A3386/datastream/PDF/view Accessed: 2022-06-20.

[7] Ministarstvo zdravstva. Pravilnik o vrstama i načinu primjena mjera prisile prema osobama sa duševnim smetnjama. Available from https://narodne-novine.nn.hr/clanci/sluzbeni/2015_02_16_303.html Accessed 2022-06-20.

[8] Shapiro, S.; Astin, J.; Bishop, S. & Cordova, M.: Mindfulness- based stress reduction for health care proffesionals: results from a randomised trial , *Int J Stress Manag,* 12 (2005); 1, 164–176, 1072-5245

[9] Cooper, CL. & Cartwright, S.: An intervention strategy for workplace stress. *J Psychosom Res*. 43 (1997), 1, 7-16, 0022-3999/97

TESTING OF ALCOHOLICITY OF WORKERS AT WORK WITH THE Alcotest 7000

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Abstract: *According to safety at work regulations, the employer is obliged to prohibit the abuse of alcoholic drinks and addictive substances at the workplace by appropriate measures, in particular to prevent the consumption of alcoholic drinks and other addictive substances during work and to prohibit their introduction into workplaces. The Dräger Alcotest® 7000 sets new standards in alcohol test devices. Alongside the classic test using a mouthpiece, the Alcotest 7000 enables tests to be carried using a funnel attachment. The funnel-based test gives an initial indication as to whether or not alcohol is present in the subject's breath. If the answer is positive, one simply presses a button to switch over to the mouthpiece-based test mode. The following test then shows the actual level of alcohol in the subject's breath. This enables to complete a large number of alcohol tests in a very short time span, and is therefore time-saving, cost-effective and hygienic.*

Key words: *alcoholic drinks at work, alcotest, level of alcohol, safety at work.*

1. INTRODUCTION

As it is justifiably considered that safety at work is an integral part of the organization of work and the execution of the work process, it is understandable that the problem of alcoholism at work had to be included in its framework, which causes great damage to the economy of the Republic of Croatia as a whole, as well as individually to employers and workers - as a result of injuries at work, damage to workers' health, occurrence of early disability, disruption of interpersonal relationships and long absence from work. Alcoholism at work also causes economic problems because of the reduction of working capacity, drop in productivity and loss of the company's reputation. The legal regulation in many countries, including Croatia, prohibit bringing alcoholic beverages and other addictive substances into workplaces, or using them.

The prohibition of the use of alcohol and other addictive substances at the workplace is required according to legal regulation and implemented by the employer. The

employer is obliged to prevent the use of such substances at work, to determine the level of alcohol intoxication of workers and to implement other measures provided for by regulation.

2. EFFECT OF ALCOHOL ON THE ORGANISM

Ethyl alcohol (ethanol), chemical formula C2H5OH, is a colorless and easily volatile liquid. This chemical compound has a harmful effect on all cells in the body, and its effect depends on the dose. Its frequent consumption can lead to addiction, illness and even death. Due to its wide availability, it has become the most commonly used psychoactive agent.

Our nation has been drinking since ancient times, and the enjoyment of alcohol is favored, and a part of all major festivities within the family and society. Alcohol is identified with good company, joy and fun. The norms of social drinking in Croatian society dictate that one drink even when one does not want to, that one drink out of respect for others who have been invited to drink, and also that one treat others with a drink and that the drink is drunk in their honor, regardless of whether one is drinking to someone or not [1].

Alcoholic drinks affect the body depending on the amount of alcohol consumed, namely:

- A concentration of up to 0.5 ‰ of alcohol in the blood, which can be called light intoxication with alcohol, it is characterized by reduced concentration, reduced reaction to stimuli and reduced visual acuity.
- An alcohol concentration of 0.5 to 1.5 ‰ in the blood, which is called an inebriated state, makes the person is unable to control their own movements and behavior, speech is difficult, their concentration, balance, and vision are disturbed.
- Alcohol concentration of 1.5 to 2.5 ‰ in the blood represents a drunken condition and causes alcohol to start inhibiting certain parts of the brain system, consciousness is narrowed, the person is sleepy, speech is difficult to the point of incomprehensibility, vomiting as well as uncontrolled urination often occur.
- With an alcohol concentration higher than 3.5 ‰, fainting and coma occur, and above 5 ‰ death may also occur [2].

The most dangerous doses of alcohol are those of 0.5-1.5 ‰ – of a drunken state, because self-criticism is lost [3]. The person then overestimates theirself, misjudges situations and facts in thinking that they can act better than in a sober state, while putting themselves and others in danger.

3. PROHIBITION OF THE USE OF ADDICTIVE SUBSTANCES

3.1 Legal regulations for testing employees for addictive substances

Provisions on the prohibition of drinking alcohol and taking other addictive substances and the procedure, devices and means for determining the intoxication of workers at work are prescribed in the Occupational Health and Safety Act of the Republic of Croatia (N.N. 71/14, 118/14, 154/14, 94/18, 96/18).
Employees shall not be under the influence of alcohol or other addictive substances during work time and they shall not bring them to the workplace.
The employer shall implement appropriate measures prohibiting the abuse of alcohol and addictive substances in the workplace, and shall in particular:
1) inform employees of the harmful effects of addictive substances and their impact on work ability
2) cooperate with the authorized officer, occupational health and safety specialist, specialist in occupational medicine and employees' commissioner for occupational health and safety, when implementing the measures which prevent the abuse of addictive substances
3) prevent the consumption of alcohol and other addictive substances during worktime and implement measures prohibiting that such substances be brought to the workplace and work areas
4) implement programs of addiction prevention in the workplace, in line with identified needs
5) establish, in writing, a procedure for testing employees for alcohol and addictive substances (carrying out the procedure with the consent of the employee, the method of testing, the type of test or devices, recording methods and methods for verification of results, the procedure in the event that an employee refuses to be subjected to testing) and shall effectively implement the established procedure. [4]
The disciplinary procedure and disciplinary measures are carried out in accordance with the written acts established by the employer. Work under the influence of alcohol or other addictive substances during work time represents a serious violation of work duties. As the most severe measure, the employment contract can be terminated with a worker who works under the influence of alcohol.

3.2 Testing employees for addictive substances

An employee shall be deemed under the influence of alcohol if the blood alcohol content is higher than 0.0 g/ kg, or higher than 0.0 milligrams per litre of breath sample, or if the blood alcohol concentration is higher than that allowed based on the risk assessment for the tasks performed by that employee. [4] Testing the employees for alcohol or other addictive substances shall be conducted by using a breathalyzer or other suitable device, procedure or means. Persons who are most commonly allowed to conduct employee testing for addictive substances are the employer or their authorized officers, business managers, occupational health and safety experts and other authorized persons. Where the employee refuses to undergo

the test, they shall be deemed under the influence of alcohol or other addictive substances. The employer shall instruct the employee under the influence of alcohol or other addictive substances to leave the workplace for as long as they remain under such influence. Where the employee refuses to leave the workplace, the employer shall call the competent security personnel to escort the employee from the premises.

3.3 Procedure for testing employees for alcohol and addictive substances

The employer must establish, in writing, in their regulations on occupational health and safety or by special decision, a procedure for testing employees for alcohol and addictive substances. The procedure must contain the method of testing (in breath, blood or urine) , the type of test or devices, recording methods and methods for verification of results, and the procedure in the event that an employee refuses to be subject to testing. The employer shall then effectively implement the established procedure. Persons who are allowed to conduct employee testing should be authorized and trained for handling alcohol test devices in order for the tests to be conducted professionally, competently, and responsibly.

4. TESTING WORKERS' ALCOHOL INTOXICATION AT WORK WITH THE Alcotest 7000

The Dräger Alcotest 7000 sets new standards in alcohol test devices. Its benefits include a wider temperature- and measuring range, low maintenance requirements and various networking options. In addition, the device can perform alcohol tests via both a mouthpiece and a funnel. Reliable alcohol tests have never been so fast, simple and efficient.

4.1 Two measurement methods in one device

Alongside the classic test using a mouthpiece, with the Alcotest 7000 can tests can also be carried out using a funnel attachment. This enables to complete a large number of alcohol tests in a very short time span, therefore making it time-saving, cost-effective and hygienic. The funnel-based test gives an initial indication as to whether or not alcohol is present in the subject's breath. If the answer is positive, one simply presses a button to switch over to the mouthpiece-based test mode. The following test then shows the actual level of alcohol in the subject's breath. With the Alcotest 7000 reliable measurements can be taken even in extreme temperatures. The tester's patented heating system and high-quality materials ensure dependable results in temperatures ranging from -10 °C to +55 °C. The increased performance capacity of the Alcotest 7000 also includes its measurement range. The maximum blood-alcohol limit that can be set with this alcohol testing device is as high as 6‰. If this measurement range limit is exceeded, it will show on the display.

4.2 The Alcotest Hygiene

Hygiene is an increasingly important part of our everyday lives. Dräger Alcotest breath-alcohol detection devices use non-invasive measuring technologies with a high degree of hygiene – for the user as well as the test subject.

Benefits of the replaceable funnel attachment are no body contact with the test subject and blocking the backflow of the test subject's own exhaled air, which prevent intake of potential pathogens from previous test subjects.

4.3. Prerequisites for use

It should be used at least 15 minutes after consuming alcohol, and this wait time cannot be shortened by rinsing the mouth with water or non-alcoholic drinks.

Residual mouth alcohol or flavored drinks (e.g. fruit juice), breath sprays containing alcohol, medicinal juices and drops can distort the result.

Belching and vomiting can distort the result. Drafts and climatic conditions such as wind, moisture and dust can distort the result when performing measurements using the funnel. The seal must not be damaged. [5]

4.4 Preparations for use

Ensure that the rechargeable battery is charged or that the batteries have been inserted. Press the button for 2 seconds to turn on the device. A self-test is carried out. When the device is ready for measuring: wait for the display to indicate that the device is ready. Before sampling, the subject must breathe calmly and steadily. The subject should be able to provide the minimum volume of breath (≥1.2 L) required for sampling. By default, the device is set to measuring using the mouthpiece. The measuring mode must be changed before measuring if using the funnel. [5]

4.5 Taking an automatic breath sample using a mouthpiece

Use a new mouthpiece for each measurement. Do not expose the sensor to high alcohol concentrations, e.g. by rinsing the mouth with alcoholic drinks with a high alcohol proof shortly before the measurement, as doing so shortens the life span of the sensor. Before taking the breath sample, ensure that the correct measuring mode has been selected.

Remove the mouthpiece from its packaging. For hygiene reasons, keep the mouth contact area covered by the packaging to protect it until the mouthpiece is firmly attached to the device. Position the mouthpiece at an angle with the serrated marking facing upward and push it up and into the mouthpiece receptacle

The mouthpiece audibly clicks into place. The mouthpiece can be used from the left or right side. Fully remove the packaging. Blow evenly and without interruption into the mouthpiece. A circular progress bar indicating progress as a percentage value is displayed. To remove the mouthpiece, push it out of the mouthpiece receptacle in an upward motion and dispose of it. [5]

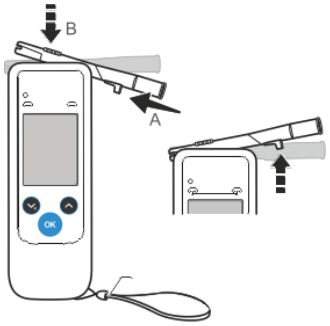

Figure 1: Position the mouthpiece

4.6 Taking an automatic breath sample with the funnel

Always maintain a distance of 2–3 cm from the subject or object to be tested. Do not touch excretions, surfaces or a subject's skin with the funnel. Avoid direct contact with substances to be tested. Replace contaminated funnels.

Remove the funnel from its packaging. Hold the funnel using the grip areas on the sides and attach it firmly to the top of the device (it can only point in one direction). Ask the subject to blow evenly and without interruption into the funnel without touching it. A continuous tone signals a sufficient flow of air. While the sample is being taken, an animated circular progress bar that also indicates progress as a percentage value is displayed. If sampling was successful, the tone ends with a clear, audible click. The display shows a spinning progress bar during an ongoing analysis process. The result is displayed after a few seconds and stored by the device. To remove the funnel, hold it using the grip areas on its sides, pull it out of the device in an upward motion and dispose of it. [5]

Figure 2: Position of the funnel

4.7 Reading the result

Three types of results are possible.

● No alcohol detected. In addition, the green LED lights up. The device is ready for use again after 2 seconds.

● Low level of alcohol detected. In addition, the yellow LED lights up. Press the button to proceed with the next measurement.

● Alcohol detected. In addition, the red LED lights up. Press the button to proceed with the next measurement.

Once the sensor's recovery time has elapsed, the display indicates that the device is ready for measurement. [5]

5. CONCLUSION

It was found that the work performance of alcoholics is about 2.5 times lower than the performance of other workers. It has been proven that alcohol, even at a blood concentration of 0.5 per thousand, reduces muscle strength by about 16%. The work of alcoholics is uneven, mistakes are frequent, and injuries at work are 3.5 times more frequent than with other workers. Each and every slowness or inappropriate reaction in emergency situations, any underestimation of danger or overestimation of own possibilities - which are reduced under the influence of alcohol, can endanger not only the life of each individual worker, but also the safety of others. [6] Constant testing for alcohol intoxication of employees at work along with the prevention of alcohol consumption is the most important tool for preventing the consumption of alcohol in the workplace. The Dräger Alcotest 7000 sets new standards in alcohol test devices with two measurement methods in one device,

enabling a large number of alcohol tests to be carried out in a very short time span, making it time-saving, cost-effective and hygienic.

REFERENCES

[1] Torre R.: *Alkoholizam: prijetnja i oporavak*. Profil knjiga d.o.o. Zagreb, 2015
[2] Dijagnostičke i terapijske smjernice za liječenje alkoholom uzrokovanih poremećaja. Hrvatsko psihijatrijsko društvo, Hrvatsko društvo za alkoholizam i druge ovisnosti Hrvatskog liječničkog zbora. *Available at*: http://www.hlz.hr/download/dijagnosticke-i-terapijske-smjernice-za-lijecenje-alkoholom-uzrokovanih-poremecaja/
[3] Gruber E. N. *Vještačenje stupnja alkoholiziranosti*. In: Golik-Gruber V, ur. Zbornik stručnih radova alkohološkog glasnika: priručnik. Hrvatski savez klubova liječenih alkoholičara, Zajednica klubova liječenih alkoholičara Zagreb. Zagreb, 2003
[4] Zakon o zaštiti na radu (NN 71/14, 118/14, 154/14, 94/18, 96/18)
[5] Dräger Alcotest®7000 *Instructions for use*: https://www.draeger.com/hr_hr/Safety/Alcohol-Breathalyser
[6] Škrinjar, A., Torre R.: *Utvrđivanje alkoholiziranosti radnika na radu,*. IPROZ. Zagreb, 2014

IMPACT OF COVID 19 ON THE NUMBER OF WORK-RELATED INJURIES

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Abstract: *Working from home became a necessity in 2020 to suppress the COVID 19 pandemic. Since people worked from home, it is to be presumed that the number of work-related injuries decreased in the same year. The aim of this paper is to determine the existence of a statistical difference in the number of work-related injuries in 2020 compared with the previous five-year period. The analysis includes the number of sick-leave days, the number of sick-leave days used for work-related accidents, the number of sick-leave days used for illnesses and the number of sick-leave days used for nurturing family members.*

Key words: *work-related injuries, COVID-19, T-test, number of sick-leave days [1, 3]*

1. INTRODUCTION

In November 2019, when the virus was first identified in Wuhan in China, the new corona virus or COVID 19 spread across the world, and the World Health Organisation (WHO) declared a pandemic. The preventive measures consequently harmed people's lives, economy, organisations, workers and employment both in the world and in Croatia, forcing agencies to switch to work from home (WFH) business model to provide business continuity.

The measures taken to suppress COVID 19 reflected on every activity in Croatia. Many workers were forced to work from home, and some were completely deprived of that option. The Croatian Bureau for Statistics (DZS) did not publish the data which show to what extent and how long working from home lasted. The papers [1, 3] investigate the impact of the measures on business in general. The purpose of this research is to explore the impact of these measures on work-related injuries. The paper analyses and compares the rate of work-related injuries of 1000 workers (hereinafter rate) during the pandemic year of 2020 compared with the rate from five years before.

During the writing of this paper, no relevant analyses of work-related injuries during the COVID 19 pandemic have been published for the Republic of Croatia. Notwithstanding, in his paper [7] Aurer Jezerčić concluded the number of these

injuries decreased in 2020. The reason of the decreased number work related injuries can be attributed to lower work and traveling intensity in certain business activities during the COVID crisis. However, the number of fatal injuries increased in 2020.

2. INPUT DATA FOR ANALYSIS

The source of data used for analysing work-related injuries are the data which were published by the Croatian Institute for Public Health (hereinafter HZJZ) in documents [3, 4, 8, 9, 10, 11], and according to the parameters they comply with the methodology of the European Statistics on Accidents at Work (ESAW methodology).

According to DZS, the number of active workers has been increasing since 2015, from a total of 1,466. 654 to a total of 1, 599,311 in 2019, resulting in a total increase of 9,05%. In 2020, the number of active workers dropped 1,5% in relation to the previous 2019. The hypothesis requiring further investigation is whether the lower number of active workers in 2020 was caused by the COVID 19 pandemic and its suppression measures. At the same time, the number of sick-leave days during the analysed period 2015-2020 has been growing continuously. A noticeable drop in the number of sick-leave days due to work related injuries was recorded in 2020 compared with the previous period. The data on the number of active workers, sick-leave days and total number of cases is presented in Table 1.

Table 1: Health insurance - Health insurance benefits

	2015	2016	2017	2018	2019	2020
Number of active workers	1.466.654	1.497.178	1.522.335	1.564.677	1.599.311	1.575.192
Sick-leave days, '000	14.754	14.261	16.420	17.775	18.391	18.549
Due to work-related injuries	860	870	820	833	824	737
Due to to illness	13.401	13.894	15.078	16.370	16.955	17.264
Due to family member care	493	497	522	572	642	548
Number of cases	12.815	11.116	11.082	23.737	20.286	20.023

Source: DZS. [5,6]

The number of reported injuries and the rate of injuries of 1000 workers employed in Croatian counties in 2019 and 2020 is presented in Table 2. The presented data point to a decreased rate of work-related injuries on 1000 workers in 2020, which is expected. The rates of work-related injuries on 1000 workers in the counties of the Republic of Croatia were analysed.

Table 2: The number of reported injuries and the rate of injuries of 1000 workers employed in the counties in 2019 and 2020 (complying with ESAW methodology)

County	2019		2020	
	Total work-related injuries	Rate of total WRI of 1000 workers	Total work-related injuries	Rate of total WRI of 1000 workers
Primorsko-goranska	1495	16,64	1186	11,19

Ličko-senjska	190	16,52	121	8,5
Zadarska	509	12,77	389	7,84
Šibensko-kninska	315	13,16	302	10,31
Splitsko-dalmatinska	1453	12,4	1096	7,78
Istarska	906	13,67	697	8,51
Dubrovačko-neretvanska	314	9,36	217	5,3
City of Zagreb	4386	10,76	3337	7,63
Zagrebačka	1236	17,18	1097	12,87
Krapinsko-zagorska	515	17,9	433	12,13
Varaždinska	790	14,32	707	11,04
Koprivničko-križevačka	354	14,13	257	8.31
Međimurska	481	14,48	423	11,22
Bjelovarsko-bilogorska	367	14,81	319	10,43
Virovitičko-podravska	263	17,47	221	10,9
Požeško-slavonska	318	20,96	222	11,96
Brodsko-posavska	376	13,02	326	9,18
Osječko-baranjska	1455	20,39	1166	13,97
Vukovarsko-srijemska	612	17,59	429	10,15
Karlovačka	391	13,19	364	10,29
Sisačko-moslavačka	645	20,04	530	13,82

Source: HZJZ.

3. RESULTS OF STATISTICAL ANALYSIS

The analysed data provided by DZS on total number of sick-leave days in Croatia in four of the observed categories (Sick leave, '000 days, Due to accident at work, Due to illness, Due to family member care) are presented in Charts 1, 2, 3 and 4.

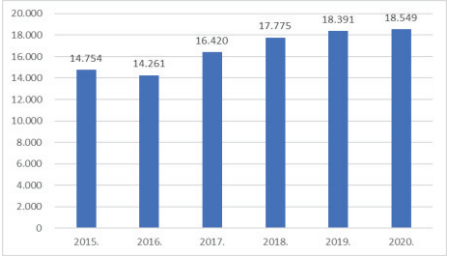

Chart 1 Sick leave, '000 days

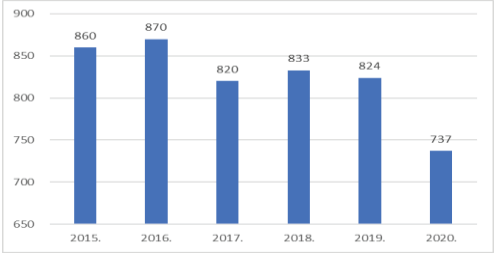

Chart 2 Due to accident at work

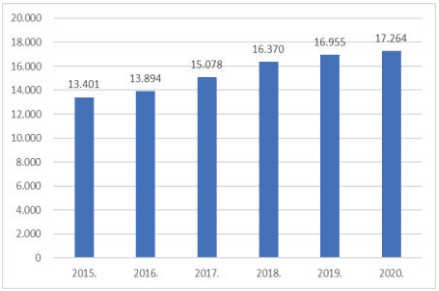

Chart 3 Due to illness

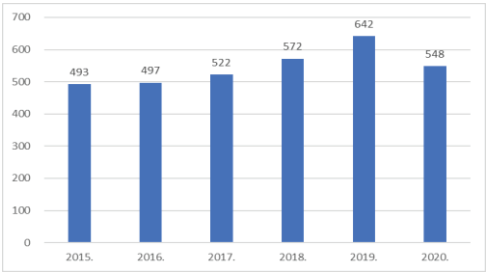

Chart 4 Due to family member care

Based on the data provided by DZS, the number of sick-leave days in Croatia has been growing continuously. Therefore, the number of sick-leave days in 2020 is on the same level as in 2019, totaling 18,349,000 days, and this is visible in Chart 1. The average number of sick-leave days '000 attributed to accidents at work from 2015 to 2019 totals 841,400 compared with 2020 when it totaled 737,000, which is a 12,4% drop compared with the previous five-year period, and this is visible in Chart 2.

The number of sick-leave days '000 and attributed to illness and the number of sick-leave days used for family member care (also '000) presented in Charts 3 and 4 and relating to 2020 are on the level of the previous five-year period. The basic descriptive statistics of the presented data is shown in Table 3.

Table 3: Statistical indicators of the number of active workers and sick-leave days 2015-2020

	Number of active workers	*Sick-leave, '000*	*Sick-leave days '000 due to accident at work*	*Sick leave days '000 due to illness*	*Sick-leave days '000 due to family member care*	*Number of cases*
Mean	1537558	16692	824	15494	546	16510
Median	1543506	17098	829	15724	535	16419
Standard Deviation	50705	1857	47	1622	56	5496

The rates of work-related injuries on a total of 1000 workers for each county were analysed for the period of 2015-2020. The average rate for the period of 2015-2020 is 15,27 compared with 2020 when it was 10,16, which is 33,46% drop in 2020 compared with the previous five-year period. The statistical indicators are provided in Table 4.

Table 4: Statistical indicators of the rate of work-related injuries on 1000 workers per Croatian counties

	2015-2019.	in 2020

Mean	15,27428571	10,15857143
Standard Error	0,680972194	0,480386395
Median	14,48	10,31
Standard Deviation	3,120606626	2,201407018
Sample Variance	9,738185714	4,846192857
Kurtosis	-0,527963464	-0,171728603
Skewness	0,187401156	-0,164560143
Range	11,6	8,67
Minimum	9,36	5,3
Maximum	20,96	13,97

T-test was used for comparing the number of the reported injuries and the rate of injuries on 1000 workers in Croatian counties in 2019 and 2020, and the numbers are presented in Table 2. Difference between means: M1-M2=15.27-10.16=5.11, sd=4.5079; se=0.8295, 95% CI of difference:3.4291 <5.11< 6.7909 (Wald), t-difference: 6.16, df-t: 29; p= 1, (left p: 0; two sided: 0).

The result was a statistically significant difference in the rate of work-related injuries on 1000 workers in the counties of Croatia in 2020 (10,61) in relation to 2019 (15,27).

4. CONCLUSION

The analysed data confirm that COVID 19 pandemic had a significant impact on the decreased rate of work-related injuries in the pandemic 2020 in other observed categories, statistically significant difference in 2020 was not confirmed.

The analysed data of the number of sick-leave days, the number of sick-leave days due to illnesses and the number of sick-leave days used for family member care in 2020 are on the level of the same numbers as in the previous five-year period.

The average number of sick-leave days expressed in thousands and attributed to accidents at work in 2020 is 12,4% in relation to the previous five-year period.

There is a statistically significant difference in the rate of work-related injuries on 1000 workers per Croatian counties in 2020 (10,61) compared with 2019 (15,27).

REFERENCES

[1] Dr. Akanksha Jaiswal, Dr. C. Joe Arun. Unlocking the COVID-19 Lockdown: Work from Home and Its Impact on Employees, 12 June 2020, PREPRINT (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-34556/v1]

[2] Patanjali S, Bhatta NMK. Work from Home During the Pandemic: The Impact of Organizational Factors on the Productivity of Employees in the IT Industry. Vision. January 2022. doi:10.1177/09722629221074137

[3] Analiza ozljeda na radu za 2020. godinu, Hrvatski zavod za javno zdravstvo – služba za medicinu rada, Zagreb 2020. http://www.hzzzsr.hr/wp-content/uploads/2022/08/Analiza-ozljeda-na-radu-za-2020.pdf
[4] Analiza ozljeda na radu za 2019. godinu, Hrvatski zavod za javno zdravstvo – služba za medicinu rada, Zagreb 2019. http://www.hzzzsr.hr/wp-content/uploads/2020/06/1UKUPNA_Analiza-ozljeda-na-radu-za-2019.pdf
[5] Statističke informacije 2021. Državni zavod za statistiku, Zagreb 2021. https://podaci.dzs.hr/media/erdfes4y/statinfo2021.pdf
[6] Statistički ljetopis Republike Hrvatske 2018. Državni zavod za statistiku, Zagreb 2018. https://web.dzs.hr/Hrv_Eng/ljetopis/2018/sljh2018.pdf
[7] I. Aurer Jezerčić, Ozljede na radu, Sigurnost i zaštita na radu, Kem. Ind. 70 (9-10) (2021) 622–625, https://hrcak.srce.hr/file/382938
[8] Analiza ozljeda na radu za 2018. godinu, Hrvatski zavod za javno zdravstvo – služba za medicinu rada, Zagreb 2018. http://www.hzzzsr.hr/wp-content/uploads/2019/06/Analiza-ozljeda-na-radu-za-2018..pdf
[9] Analiza ozljeda na radu za 2017. godinu, Hrvatski zavod za javno zdravstvo – služba za medicinu rada, Zagreb 2018. http://www.hzzzsr.hr/wp-content/uploads/2016/11/1UKUPNA_ANALIZA_ONR_2017WEB.pdf
[10] Analiza ozljeda na radu za 2016. godinu, Hrvatski zavod za javno zdravstvo – služba za medicinu rada, Zagreb 2018. http://www.hzzzsr.hr/wp-content/uploads/2016/11/analiza_onr_2016.pdf
[11] Analiza ozljeda na radu za 2015. godinu, Hrvatski zavod za javno zdravstvo – služba za medicinu rada, Zagreb 2018. http://www.hzzzsr.hr/wp-content/uploads/2016/11/ANALIZA_ONR_2015.pdf

CORRELATION ANALYSIS OF WORK-RELATED INJURIES IN THE CITY OF ZAGREB FROM 2010 TO 2020

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Abstract: *The procedure of correlation analysis is based on the determination of direction and strength indicators between the observed phenomena or variables. Correlation analysis, in addition to determining the numerical indicator (linear correlation coefficient), includes a graphical representation (scatter diagram) from which it is seen whether or not there is a connection of the observed phenomena and if so, what is the shape, direction and strength of this connection. The paper also describes the procedure for conducting a test of the significance of the calculated linear correlation coefficient. Based on statistical data, the relationship between the number of sick days and the number of injuries at work in the City of Zagreb in the period from 2012 to 2020 was analyzed.*

Keywords: *correlation analysis, linear correlation coefficient, scatter plot, significance test.*

1. INTRODUCTION

The primary task of the implementation of occupational safety is determined by the *Occupational Safety and Health Act* (NN 71/14, 118/14, 154/14, 94/18, 96/18) [13] is to prevent any form of injuries at work, occupational and other diseases related to work and protection of the working environment One of the indicators of the state and development of occupational safety in the Republic of Croatia is the number of received reports of occupational injuries submitted by employers to the Croatian Institute for Health Insurance (HZZO). Croatian Institute for Occupational Health and Safety (HZZZSR) based on data collected by the Central Bureau of Statistics (DZS) [6] on the number of employees by counties and data on the number of sick days and the number of injuries reported at work HZZO [4], analyzes data on occupational injuries in accordance with the methodology of the European Statistics on Occupational Injuries (ESAW methodology) and publishes each year a comprehensive report *Analysis of occupational injuries* for the previous year [3]. The report is made public on the website HZZZSR www.hzzzsr.hr.

In this paper, based on published data in the period from 2010 to 2020, the conducted correlation analysis is described, which determined the correlations between the number of of sick days and the number of injuries at work in the Republic of Croatia and in the City of Zagreb in the observed period of 11 year.

2. INPUT DATA FOR ANALYSIS

According to DZS statistics, the number of employed persons in the Republic of Croatia in the period from 2010 to 2020, at the annual level until 2014 recorded a declining trend, and from 2015 we notice an increase in the number of employed persons until 2019. In 2020, there was a slight decline in the number of employed persons in the Republic of Croatia compared to the previous 2019. The number of active insured persons, both in the Republic of Croatia and in the City of Zagreb, also decreased until 2015, when this number began to grow until 2020, when it decreased slightly [9, 10]. According to the HZZO, the number of used sick days at the level of the Republic of Croatia and at the level of the City of Zagreb has similar behavior: when the number of sick days increases / decreases at the state level, the same happens at the level of the City of Zagreb. Sick days and the total number of injuries at work usually have the same trend, be it rising or falling. All these data support the total number of recorded injuries at work, both globally in the Republic of Croatia and locally in the City of Zagreb (columns 5 and 8 of Table 1).

Table 1: Data on the number of employees, the number of active insured persons, the number of sick days and the total number of recorded injuries at work

Year	Number of employees in Republic of Croatia	Number of active insured persons in Republic of Croatia	Sick days in Republic of Croatia	Total injuries at work in RH	Number of active insured persons in the City of Zagreb	Sick days in the City of Zagreb	Total injuries at work in the City of Zagreb
2010	1.432.000	1.493.148	14.765.230	13.588	441.866	4.742.332	1.756
2011	1.411.000	1.485.324	15.001.353	13.817	437.032	4.840.485	2.221
2012	1.395.000	1.471.662	14.315.198	14.076	434.514	4.627.757	2.584
2013	1.364.000	1.455.152	12.997.567	13.796	430.269	4.252.216	3.123
2014	1.342.000	1.448.737	12.518.637	13.929	430.467	4.181.640	3.469
2015	1.357.000	1.466.654	13.893.980	16.013	433.633	4.680.349	4.212
2016	1.390.000	1.497.178	14.391.304	16.235	441.890	4.882.916	4.183
2017	1.407.000	1.522.335	15.599.777	17.768	448.575	5.242.565	4.329
2018	1.427.000	1.564.677	16.942.139	18.724	459.081	5.685.998	4.611

2019	1.555.000	1.599.311	17.566.616	18.138	469.133	5.810.766	4.386
2020	1.544.000	1.575.192	17.812.140	14.424	468.038	5.810.706	3.337

Source: DZS, www.dzs.hr (2. column), HZZO, www.hzzo.hr (3., 4., 6. i 7. column), HZZZSR, www.hzzzsr.hr (5. i 8. column)

Table 2 provides data on the total number of injuries at work reported by HZZO employers in the period from 2010 to 2020. HZZZSR processed the obtained data and extracted data related to the place of occurrence of the injury at work (at the place of work or on the way from / to the place of work). The published data show that the majority of injuries at work occur at the place of work, which is to be expected.

Table 2: Data on recorded injuries at work from 2010 to 2020

Year	Republic of Croatia			City of Zagreb		
	Total injuries at work	Workplace injury	Injury while traveling	Total injuries at work	Workplace injury	Injury while traveling
2010	13.588	10.540	3.048	1.756	1.111	645
2011	13.817	10.654	3.163	2.221	1.444	777
2012	14.076	10.657	3.419	2.584	1.641	943
2013	13.796	11.252	2.544	3.123	2.296	827
2014	13.929	11.444	2.485	3.469	2.566	903
2015	16.013	13.161	2.852	4.212	3.108	1.104
2016	16.235	13.281	2.954	4.183	3.027	1.156
2017	17.768	14.431	3.337	4.329	3.090	1.239
2018	18.724	15.609	3.115	4.611	3.306	1.305
2019	18.138	15.079	3.059	4.386	3.104	1.282
2020	14.424	12.404	2.020	3.337	2.468	869

Source of data: HZZZSR, Occupational injury analysis (2010.-2020.), www.hzzzsr.hr

3. THEORETICAL POSTULATES OF CORRELATION ANALYSIS

Correlation analysis using specific statistical methods and techniques examines the degree of correlation between two or more phenomena or variables. The relationship between the phenomena can be [8, 11]:

1. functional (deterministic) - each value of one phenomenon corresponds to a specific value of another phenomenon,
2. statistical (stochastic, random) - on the basis of one phenomenon it is not possible to determine with certainty the value of another phenomenon.

Since the stochastic relationship is not complete, the degree of correlation (strength and direction) between the observed phenomena and variables is determined by correlation analysis [1].

Correlation analysis includes [7]:

1. construction of an appropriate graphical representation of the relationship between variables (scatter plot),
2. determination of numerical indicator of strength and direction of connection between variables (correlation coefficient),
3. determination of numerical indicator of statistical significance of correlation coefficient (p-value).

The scatter diagram is a graphical representation of the points $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ in a rectangular coordinate system where they are $x_1, x_2, \ldots, x_n$ values of the independent variable x, and $y_1, y_2, \ldots, y_n$ values of the dependent variable y. It is easy to see from the scattering diagram [5]:

- the form of the relationship between the selected variables,
- direction of connection,
- strength of connection.

Numerical indicators of the degree of statistical correlation are correlation coefficients. If the relationship between two variables is investigated and if this relationship is linear, the degree of correlation is expressed by the *Pearson correlation coefficient* or the *linear correlation coefficient*. If the existence of a linear relationship of one variable depending on two or more other variables is investigated, the degree of correlation is expressed by the *coefficient of multiple linear correlation* [2].

There are several formulas by which the linear correlation coefficient r is calculated, for example when covariance values are known $\operatorname{cov}(x, y)$, variables x i y and standard deviations σ_x (variables x) i σ_y (variables y):

$$r = \frac{\operatorname{cov}(x, y)}{\sigma_x \cdot \sigma_y} \tag{1}$$

gdje su:

$$\operatorname{cov}(x, y) = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{n} = \frac{\sum_{i=1}^{n} x_i y_i}{n} - \bar{x} \cdot \bar{y}$$

$$\operatorname{cov}(x,y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n} = \frac{\sum_{i=1}^{n} x_i y_i}{n} - \bar{x} \cdot \bar{y}\,, \quad (2)$$

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} = \sqrt{\frac{\sum_{i=1}^{n} x_i^{\,2}}{n} - \bar{x}^2}\,, \quad (3)$$

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n}} = \sqrt{\frac{\sum_{i=1}^{n} y_i^{\,2}}{n} - \bar{y}^2}\,. \quad (4)$$

The linear correlation coefficient assumes values between –1 i 1 $(-1 \le r \le 1)$, where the value of the coefficient indicates the strength of the connection, and the sign of the direction. A positive coefficient of linear correlation indicates the administrative proportionality of variables x i y (the growth of one variable causes the growth of another, and vice versa), while negative r indicates the inverse proportionality of the variables the growth of one variable causes the fall of another, and vice versa). The degree of correlation strength is defined as shown in Table 3 [12].

Table 3: Determination of the degree of correlation strength

$\lvert r \rvert$	Correlation strength
0	no correlation
0 - 0,5	weak correlation
0,5 - 0,8	moderately strong correlation
0,8 - 1	strong correlation
1	complete correlation

Notice: if the coefficient of linear correlation is equal to +1 or -1, there is a complete linear correlation between the variables, and if it is equal to 0 there is no linear correlation. If the value of the coefficient is closer to +1 or -1, the degree of linear correlation is higher.

In order for the correlation analysis to be complete, a *test of the significance* of the calculated linear correlation coefficient should be performed, i.e. it should be determined whether the change in the value of the dependent variable is really caused by the influence, or by the change in the value of the independent variable

(there is a correlation between the variables x and y) or the change in the value of the dependent variable occurred by chance due to the combination of other circumstances (there is no correlation between the variables x and y) [1, 2].

The hypotheses of the significance test of the calculated coefficient of linear correlation between the variables x and y are [7, 8]:

$$H_0 \dots \rho = 0$$

$$H_1 \dots \rho \neq 0$$

where is ρ coefficient of linear correlation of the basic set (population). The null hypothesis (H_0) contains the claim that the correlation between the variables x and y is not present, while an alternative hypothesis (H_1) contains the opposite claim that a correlation is present. The test size is defined by the following expression:

$$t = r \cdot \sqrt{\frac{n-2}{1-r^2}} \,. \quad (5)$$

The decision is made by comparing the calculated value of the test quantity with the theoretical value of the Student's t-distribution with a given level of significance α and a given number of degrees of freedom (n-2). The decision rule is [5, 8]:

discard H_0 if it is $r \cdot \sqrt{\frac{n-2}{1-r^2}} < -t_{n-2,\alpha/2}$ or $r \cdot \sqrt{\frac{n-2}{1-r^2}} > t_{n-2,\alpha/2}$.

4. RESULTS OF STATISTICAL ANALYSIS

Based on the input data, correlation analyzes were performed to determine the connection between the two phenomena. The analyzes are differentiated according to the approved dependent variable:

- Analysis 1- Analysis 4, the dependent variable is the number of sick days used,
- Analysis 5 - Analysis 8, the dependent variable is the total number of injuries at work.

The analyzes were conducted globally for the Republic of Croatia and locally for the City of Zagreb.

Table 4: Correlation analyzes depending on the *number of sick days* used

Analysis 1	Analysis 2	Analysis 3	Analysis 4

Number of active insured persons in the Republic of Croatia	Sick days in the Republic of Croatia	Total injuries at work in the Republic of Croatia	Sick days in the Republic of Croatia	Number of active insured persons in the City of Zagreb	Sick days in the City of Zagreb	Total injuries at work in the City of Zagreb	Sick days in the City of Zagreb

Table 5: Correlation analyzes depending on the variable the *total number of injuries at work*

Analysis 5		**Analysis 6**		**Analysis 7**		**Analysis 8**	
Injury at the place of work in the Republic of Croatia	Total injuries at work in the Republic of Croatia	Injury while travelling-Republic of Croatia	Total injuries at work in the Republic of Croatia	Injury at the place of work in the City of Zagreb	Total injuries at work in the City of Zagreb	Injury while travelling-City of Zagreb	Total injuries at work in the City of Zagreb

The significance test of the linear correlation coefficient with a significance level of 5% comes down to hypothesis testing:

$H_0 \ldots \ \rho = 0$ (there is no correlation)

contrary to the hypothesis:

$H_1 \ldots \ \rho \neq 0$ (there is a correlation).

Theoretical value for $\alpha / 2 = 0{,}05 / 2 = 0{,}025$ and (n-2)=11-2=9 degrees of freedom is:

$t_{9;0{,}025} = 2{,}262157$. The results of the performed analyzes are given in Table 6.

Table 6: Results of performed correlation analyzes

Analysis	Pearson's coefficient	Correlation strength	*t*- value	Accepted hypothesis
Analysis 1	0,969868847	strong correlation	11,942843	H_1
Analysis 2	0,554811327	moderately strong correlation	2,000579	H_0
Analysis 3	0,970191227	strong correlation	12,0102585	H_1
Analysis 4	0,448869574	weak correlation	1,506952567	H_0
Analysis 5	0,978095049	strong correlation	14,09637989	H_1
Analysis 6	0,354100384	weak correlation	1,135898979	H_0
Analysis 7	0,994296945	strong correlation	27,96975532	H_1
Analysis 8	0,93136256	strong correlation	7,674102377	H_1

Source: author's processing

5. CONCLUSION

Correlation analysis conducted on the basis of data on the number of registered active insured persons, the number of used sick days and the number of reported injuries at work in the period from 2010 to 2020, found that in the observed period there is:

- strong correlation between:
  - the number of active insured persons in the Republic of Croatia and the number of used sick days in the Republic of Croatia,
  - the number of active insured persons in the City of Zagreb and the number of used sick days in the City of Zagreb,
  - the number of injuries at the place of work in the Republic of Croatia and the total number of injuries at work in the Republic of Croatia,
  - the number of injuries at the place of work of the City of Zagreb and the total number of injuries at work in the City of Zagreb,
  - the number of injuries on the way to / from the place of work in the City of Zagreb and the total number of injuries at work in the City of Zagreb,
- moderately strong correlation between:
  - the total number of injuries at work in the Republic of Croatia and the number of used sick days in the Republic of Croatia,
- weak correlation between:
  - the total number of injuries at work in the City of Zagreb and the number of used sick days in the City of Zagreb,
  - the number of injuries on the way to / from the place of work in the Republic of Croatia and the total number of injuries at work in the Republic of Croatia.

All the obtained results of the analyzes are expected and indicate the need for more responsible planning, implementation, control and improvement of safety at work both in the Republic of Croatia and in the City of Zagreb.

LITERATURE

[1] Biljan-August, M.; Pivac, S.; Štambuk, A.: Uporaba statistike u ekonomiji, Ekonomski fakultet Sveučilišta u Rijeci, Rijeka, (2009.)
[2] Dumančić, K.; Bahovec, V.; Čižmešija, M.; Kurtonoga-Živadinović, N.: *Poslovna statistika,* Element, Zagreb, (2011.)
[3] Hrvatski zavod za zaštitu zdravlja i sigurnosti na radu (HZZZSR): *Analiza ozljeda na radu*, objavljeno na www.hzzzsr.hr, HZZZSR, Zagreb, (2010.–2020.)
[4] Hrvatski zavod za zdrastveno osiguranje: *Izvješće o poslovanju Hrvatskog zavoda za zdrastveno osiguranje*, *www.hzzo.hr* , HZZO, Zagreb, (2010.-2020.)

[5] Newbold, P.; Carlson, W.L.; Thorne, B.: *Statistika za poslovanje i ekonomiju,* MATE d.o.o., Zagreb, (2010.)
[6] Državni zavod za statistiku: *Statistički ljetopisi Republike Hrvatske,* objavljeno na www.dzs.hr, DZS, Zagreb, (2010.-2020.)
[7] Šošić, I.: *Primjenjena statistika*, Školska knjiga, Zagreb, (2006.)
[8] Štambuk, Lj.; Devčić, K.: *Statistika*, Veleučilište Nikola Tesla u Gospiću, Gospić, (2010.)
[9] Tevčić, M.; Kirin, S.: *Trend ozljeda na radu u Karlovačkoj županiji od 2010. do 2017. godine*, Sigurnost: časopis za sigurnost u radnoj i životnoj okolini, Vol. 61 No. 3, Zagreb, (2019.)
[10] Tevčić, M.; Pavlović, B.: *Trend ozljeda na radu u Republici Hrvatskoj od 2010. do 2015. godine*, Book of Proceedings - 6th International Professional and Scientific Conference "OCCUPATIONAL SAFETY AND HEALTH", Veleučilište u Karlovcu, Karlovac, (2016.)
[11] Tevčić, M.; Lorković, N.; Kirin, S.: *Korelacijska analiza primijenjena na ozljede na radu i dane bolovanja;* Sigurnost: časopis za sigurnost u radnoj i životnoj okolini, Vol. 63 No. 3, Zagreb, (2021.)
[12] Vukičević, M.; Papić, M.: *Matematičko-statistički priručnik za poduzetnike,* Golden marketing-Tehnička knjiga, Zagreb, (2003.)
[13] Zakon o zaštiti na radu (NN 71/14, 118/14, 94/18, 96/18)

CONTACT DERMATITIS IN HEALTHCARE PROFESSIONALS

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Abstract: *Contact dermatitis is an inflammatory skin disease caused by direct contact with environmental substances. Depending on the mechanism of the inflammatory process, a distinction is made between allergic and irritative contact dermatitis. If the contact is a result of factors present in the workplace, it is called occupational contact dermatitis and as such accounts for approximately 30% of all occupational diseases. Due to the peculiarities of their work, healthcare professionals are at risk of developing this disease. They must have clean hands during contact with patients which is achieved by proper and frequent hand washing and wearing protecting gloves, but can also lead to contact dermatitis. Giving the significance of the role healthcare professionals have in our society, it is extremely important to place emphasis on preventative measures.*

Keywords: *healthcare professionals, occupational contact dermatitis, allergens, irritants, preventative measures*

1. INTRODUCTION

Occupational diseases are caused by the direct and immediate influence of processes and working conditions over a long period of time, and are characterized by a specific connection with the action of harmful factors present in the working environment. The intensity of harm and the duration of exposure should be at a level known to cause health damage.[1,2] The most common occupational skin disease is contact dermatitis, which is defined as an inflammatory skin disease that occurs during direct contact with environmental substances. Contact dermatitis is a very common disease in the general population, while occupational contact dermatitis accounts for approximately 30% of all occupational diseases. According to official data from the register of occupational diseases in the Republic of Croatia, the frequency of occupational skin diseases is higher among healthcare workers than among the rest of the working population and it accounts for approximately one

third of all occupational skin diseases. Due to the specific nature of the work, given the working conditions and the daily use of protective equipment, healthcare workers belong to the risk group for developing skin damage and diseases.[3,4] In addition, exposure to skin irritants and allergens in the workplace of healthcare professionals is the most significant independent risk factor for the development of occupational dermatitis.[1] In more detail, depending on the mechanism of the inflammatory process, a distinction is made between allergic contact dermatitis caused by an allergic reaction, i.e. mediated by allergens, and non-allergic or irritant contact dermatitis, which is caused by the irritating effect of an irritant.[5] Contact dermatitis cannot be transmitted to other people, nor can it be caused by an infection. Skin changes caused by professional exposure, as a rule, worsen on a daily basis in the working environment while they disappear very quickly after the exposure stops.[6]

2. ALLERGIC CONTACT DERMATITIS

Allergic contact dermatitis accounts for between 5 and 15% of all skin diseases that have an inflammatory etiology, and is caused by direct contact with allergens which means that it is mediated by substances from the environment that provoke the initiation of an immune reaction in the human body. This phenomenon is called a type IV cellular hypersensitivity reaction, which is also called delayed cell-mediated hypersensitivity, and takes place in two phases. The first phase, i.e. the antigen sensitization phase, represents the process of detecting, locating and binding the allergen by the dendritic cells of the epidermis, called Langerhans cells. These cells migrate to the regional lymph nodes where the antigen is processed by them and is then presented to the before mentioned T cells. Sensitized T cells go to the epidermis and upon re-exposure to the allergen, their activation occurs. During this process, pro-inflammatory cytokines are released and attract other inflammatory cells, resulting in characteristic symptoms that are interpreted as allergic contact dermatitis. Depending on the duration of the sensitization phase, the duration of which can vary from a few days to several years, some people may be exposed to the allergen for years and only later on develop symptoms.[7]

Therefore, allergic contact dermatitis is an inflammatory dermatosis that occurs as a result of a late hypersensitivity reaction type IV according to Coombs and Gell to a contact allergen in a previously sensitized person on the part of the skin that was in direct contact with the causative agent.[2]

Examples of substances from everyday life, respectively allergens, that most often cause allergic contact dermatitis are nickel, rubber, perfumes and preservatives used in creams and cosmetic products. The most common are contact allergic reactions to metals (chromate, cobalt), mercury, plastic ingredients, epoxy resins, fragrances, charcoal tars, etc. Also, contact with protective gloves made of latex can lead to the development of allergic contact dermatitis. Ointments, creams and lotions used in treatment of contact dermatitis can cause such a reaction as well.[5]

Professional allergens most often present at the workplace of healthcare professionals are shown in the table below.[2]

TABLE 1: The most common professional allergens among healthcare professionals[2]

ANTISEPTICS	formaldehyde, glutaraldehyde, glyoxal, quaternary ammonium compounds, isothiazolinones, hypochlorites with dichromate
TOOLS	nickel
AUXILIARY MEANS	lanolin, propylene glycol
PRESERVATIVES	parabens
ANTIOXIDANTS	
PERFUMES	
ANESTHETICS	propanidid
LOCAL ANESTHETICS	procaine
COMPOUNDS OF MERCURY	amalgam and disinfectants
ANTI-INFLAMMATORY AGENTS	piperazine
ANTIBIOTICS	sulfonamides
BENZODIAZEPINES	
PHENOTHIAZINES	
CYTOSTATICS	antimitotics
DYE	Sudan III and IV
FIXATIVES	chromium, gluteraldehyde
EPIXID RESINS	
RADIOLOGICAL CHEMICALS	hydroquinone, pyrocatechol
ISOTHIAZOLINONES (KATHON CG)	
RUBBER GLOVES	thiurams, carbamates, MBT, IPPD
LATEX WITH POWDERED VEGETABLE PROTEINS	
WASH BALM	
PLANT EXTRACTS	

3. IRRITATIVE CONTACT DERMATITIS

Irritative or non-allergic contact dermatitis is a non-specific inflammatory reaction caused by contact with substances that are characterized by irritating properties and called irritants and it accounts for approximately 80% of the incidence of contact dermatitis. When this type of dermatitis occurs, the immune system is not activated. Irritants are substances such as detergents and solutions that strip the skin of its natural oils and thus promote development of dermatitis upon contact. The most important factor that determines the occurrence of irritant dermatitis is the amount of irritant with which the skin comes into contact. The likelihood of the development of irritant contact dermatitis depends on the characteristics of the irritant, specifically the extreme pH and its solubility in the lipid layer on the surface of the skin, an environment where low humidity, high temperatures and friction are present, and the characteristics of the organism itself that is exposed to irritants.[6,7]

Many occupations pose a risk for the development of skin damage and diseases. Irritant contact dermatitis is particularly common among people who work a lot in water, because skin damage is most often caused by soaps, detergents and work in or with water which is so-called wet work. A non-specific local inflammatory reaction occurs after only one or repeated contact with a risk factor on the part of the skin that was in direct contact. The mechanism of formation includes local drying and irritation of the skin. Symptoms appear during exposure or within 48 hours at the latest.[2] Strong irritants, such as acids and alkalis, and some organic solvents, which are all often present at the workplace of healthcare professionals, can cause changes on the skin after just a few minutes of first contact.[5]

Due to the specificity of the job description and the characteristics of the workplace, healthcare workers must have clean hands when working with patients. Therefore, proper and frequent hand washing and regular disinfection are very important. When washing your hands, the protective layer of the skin is removed, and as a result free passage of irritants into the deeper layers of the skin is possible, which leads to the appearance of irritant contact dermatitis. In addition, the most common irritants regularly used by healthcare professionals are disinfectants and detergents.[3]

4. SYMPTOMS

Dermatitis causes changes and damage to the skin in the form of eczema. Inflammation of the upper layers of the skin occurs, which causes the formation of vesicles on the skin, local redness and swelling, draining of fluid, formation of scabs, and consequently peeling and itching.[8] Often, the resulting rash contains small vesicles characterized by itching which later on become scabs. Furthermore, the most common symptom, which usually appears the earliest, is itching of the skin and it can be extremely intense.[5] The changes on the skin that occur can occur in the

form of mild and short-term redness at the beginning, i.e. erythema, and lead to the formation of significant swelling, blisters and ulceration. When the dermatitis becomes less active, the skin takes on the appearance of a thick and dry crust, and extremely painful small cracks appear on the joints.[6] In the case of irritant contact dermatitis, burning and peeling of the skin is usually present, and appears on the back of the hands.[2]

The area affected by dermatitis can be very small, while on the other hand, it can also cover the whole body, depending on the surface that was in contact with the provoking substance. The rash is limited to a specific area and has clear borders. Although it is initially limited only to the place of contact, it can later spread. Changes most often occur on the hands, since they are the most exposed part of the body to external factors in daily functioning. Besides the hands, contact dermatitis can also occur on the forearms, face, neck, legs, and other uncovered parts of the body.[2,8]

5. DIAGNOSIS

Considering first the wide spectrum of substances that can cause changes on the skin as part of contact dermatitis, but also that most people are not at all aware of which substances they come into contact daily, it can sometimes be very difficult to identify the real cause of contact dermatitis. Often, a very important link in determining the origin of contact dermatitis is the location of the initial rash, as it indicates the location of contact with the provoking substance.[5]

The diagnosis of contact dermatitis is made based on data of exposure to the provoking substance in the patient history, a clinical examination that confirms the typical clinical picture, and sometimes usage of diagnostic methods, the most important one being epicutaneous testing or patch testing.[7] Other tests that are used during the diagnostic procedure od contact dermatitis include prick test to detect an early allergic reaction, some physical tests to reveal dermographism and hypersensitivity of the skin to heat, cold or pressure, and in vitro tests that determine levels of total and specific immunoglobulin E.[2]

Irritant contact dermatitis is confirmed by simply identifying the substances to which the skin was exposed and to what extent it was exposed. Allergic contact dermatitis is diagnosed by a procedure carried out in specialist dermatology departments, called an epicutaneous test.[6] Epicutaneous testing or patch testing is a diagnostic procedure used for proving cellular allergic hypersensitivity and it presents the basis of the diagnosis of professional contact dermatitis. Allergens that are most often present in everyday life and at the workplace are being tested according to the recommendation of the International Contact Dermatitis Research Group (ICDRG). This group of provoking factors, respectively standardized European series of contact allergens includes compounds of chromium, nickel, cobalt, mercury, ammonia, aniline, formalin, turpentine oil, petroleum, charcoal tars, etc. In addition, there are also various professional series of commercial allergen preparations specific for individual professions named "targeted allergens" and also

sometimes applied. Testing with substances brought from the workplace is not a standard procedure, but this type of testing has to be used in cases when commercial preparations of potential contact allergens are not available. The epicutaneous test is performed on the clean skin of the back where allergen samples are applied. The reactions are read after 48 and 72 hours and they can be negative or positive. In the case of a positive reaction, redness, swelling and itching appear at the site of occlusion of the corresponding allergen. This reaction can be graded in three degrees depending on the severity of skin changes. A positive epicutaneous test confirms the diagnosis of allergic contact dermatitis, and a negative epicutaneous test directs the diagnostic procedure towards the diagnosis of irritant contact dermatitis.[8]

When proving the occupational etiology of a disease, a test of exposure and cessation of exposure at the workplace plays a significant role. The mentioned test determines the direct connection between the clinical picture of the skin disease and the harmful substance present in the workplace. In support of the occupational etiology of the disease is the presence of disease remission during absence from the workplace, for example during sick leave or vacation, and progression of the disease when returning to the same workplace.[2]

6. TERAPHY AND PREVENTATIVE MEASURES

The proper way to treat contact dermatitis is to determine its cause, that is, to identify the irritant or allergen and then remove it or reduce contact. Locally applied corticosteroid creams or ointments, and cold compresses alleviate the symptoms of mild to moderate contact dermatitis. Oral corticosteroids are used for severe blistering rashes or extensive disease, while systemic antihistamines relieve itching. Removing the provoking substance may be easy for some types of contact dermatitis, however, complete avoidance is impossible for people whose contact dermatitis is caused by prolonged contact with soap and water, as is often the case with healthcare workers. In such cases, protective measures can help.[5,6] By preventing occupational skin diseases in risky occupations, long-term sick leave and high treatment costs are avoided. If the patient's health condition is serious, and there is no possibility of eliminating the provoking substance in the workplace, change of workplace is sometimes necessary. Given the specificity of the jobs of healthcare professionals and the frequent hand washing that the workplace requires, as well as exposure to various irritants and allergens, it is necessary to know the preventative measures very well.[3] Preventative measures serve to protect the skin, which is firstly regular wearing of protective gloves and the use of emollient creams several times a day to maintain the skin soft. Thick emollients are the most useful for hands and it is advised to find the right one. The most important guidelines for dealing with contact dermatitis are avoidance of provoking substances, care and protection of the skin, and, if necessary, the use of recommended therapy.[6]

7. CONCLUSION

In conclusion, professional contact dermatitis is most often localized on the hands and forearms, and therefore has a significant impact on the quality of life and work ability of the affected person. This occupational disease often leads to permanently altered or reduced work ability and consequently to the need for adaptation or change of workplace, or retirement. It is important to be aware of the high frequency of occupational contact dermatitis among healthcare professionals. In order to protect their patients' health, healthcare professionals must have clean hands during work, which they achieve by frequent hand washing and disinfection that can lead to skin irritation, or by wearing protective gloves that can cause an allergic reaction. Considering that during work they are also in contact with many different substances (acids, alkalis, organic solvents, medications, etc.), some of which are irritants or allergens, healthcare workers are exposed to a high risk of developing allergic contact dermatitis and irritant contact dermatitis as well. Giving the significance of the role healthcare professionals have in our society, it is extremely important to place emphasis on primary and secondary prevention. The best way to protect the health of healthcare professionals is to identify and then avoid or at least reduce contact with allergens and irritants. Proper care and protection of the skin is achieved by wearing appropriate protective gloves and applying emollient creams several times a day. In the case where therapy is recommended, it is important to apply it regularly. Overall, protecting health of healthcare professionals means better health care for the entire population.

8. REFERENCES

[1] http://www.hzzzsr.hr/index.php/porefesionalne-bolesti-i-ozljede-na-radu/profesionalne-bolesti/

[2] Bogadi Šare, A.; Bubaš, M.; Kerner, I.; Macan, J.; Pejnović, N.; Skroza, D.; Tursk, R.: *Pristup profesionalnim bolestima kože u medicine rada*, Tiskara Dutković, 978-953-7959-25-8, Zagreb, studeni 2014.

[3] Birkić Belanović, I.; *Profesionalne bolesti kože u medicinskih sestara*, Zagreb, medicinski fakultet Sveučilišta u Zagrebu, 2015.

[4] Pezo, J.; Bakija-Konsuno A.; Zoranić, S.; Betica-Radić, Lj.: *Povezanost pranja ruku i kontakntog dermatitisa kod zdravstvenog osoblja u Općoj bolnici Dubrovnik*, Med Jad 2,19; 49(2): 121-127

[5] http://www.msd-prirucnici.placebo.hr/msd-za-pacijente/kozne-bolesti/dermatitis/kontaktni-dermatitis

[6] https://kbc-rijeka.hr/wp-content/uploads/2020/09/Kontaktni-dermatitis.pdf

[7] http://www.msd-prirucnici.placebo.hr/msd-prirucnik/dermatologija/dermatitis/kontaktni-dermatitis

[8] https://www.poliklinikaabr.hr/objasnjenje-pojmova/202-kontaktni-alergijski-dermatitis

4

TECHNICAL-TECHNOLOGICAL PROTECTION FACTORS

THE INFLUENCE OF THE COATING CHARACTERISTIC IN THE WELDING FUME PRODUCTION

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Abstract: *The aspiration of every electrode manufacturer is to determine the optimal composition of the electrode, which, in addition to satisfactory production of welding smoke, will also have good welding characteristics in every respect. The chemical composition of the basic material and coated electrode to be welded, the shielding gases in some welding processes, ambient gases, and welding parameters determine the production and chemical composition of the welding fumes.The electrode coating in the MMAW welding process, participates in the generation of welding fume with (80÷90)%. A prerequisite for performing the experiments, which include the collection of welding fume, was to design a welding chamber according to the standard EN ISO 15011-1. The welding chamber is located at the Faculty of Mechanical Engineering in Mostar. Experimental studies to determine the production of welding fume were performed with MMAW welding process coated with rutile electrode E 35 2 R 12 and coated with basic electrode E 42 4 B 32 H5, for the base material of low carbon structural steel S235JRG2. For the experimental analysis, we have worked with 5 different electrode diameters (Ø2.0; Ø2.5; Ø3.25; Ø4.0; Ø5.0) mm, both types, and 5 different currents (55, 70, 110, 160, and 200) A. The results of this experimental analysis are used to research the influence of the coating characteristics in welding fume production. Based on the results of the experimental analysis, the main experiment is designed. In the main experiment, for extensive testing is used experimental coated electrodes made according to our own recipe in the factory for the production of additional material "ELEKTRODA ZAGREB".*

Keywords*: welding chamber, welding fume, production, MMAW, character of the coating*

1. INTRODUCTION

Oscar Kjellberg's first patents on the development of coated electrodes were approved in 1904 and 1905 and applied in 1907. These patents represent the fundamental basis for a completely new era of electric arc welding [1]. The global trend in the welding consumables market predicts that the market value will reach 19.2 billion US dollars by 2024, with an annual growth rate of 6%, in the period from (2019 to 2024). In 2018, the consumption of additional welding materials amounted to 13.9 billion US dollars [2]. It is estimated that 0.5% of the total mass of additional material is converted into harmful welding fume [3]. Increased consumption of additional welding material indicates an increase in the number of harmful welding fume. During the welding process and related processes, a complex mixture of organic gases and particles is created that can be harmful to human health and the environment. The emission level depends on the welding process and procedure, welding parameters, basic material, coated electrodes, and materials that can be coated

on the metal surface. Knowledge of welding fume and gas emission levels and the amount, composition, and particle size of welding fume is necessary if it is desired to provide a favorable air atmosphere in the working environment and atmosphere so that the necessary measures can be taken to reduce them if they exceed the allowable values.The concept of the empirical basicity index, on the basis of which, in exchange for a precise analytical approach, the type of lining can be determined, is given using form 1 [4]:

$$BI = CaO + CaF_2 + MgO + K_2O + Na_2O + LiO + \frac{1}{2}\frac{(MnO + FeO)}{SiO_2} + \frac{1}{2}(Al_2O_3 + TiO_2 + ZrO_2) \quad (1)$$

The types of coating based on the BI basicity index are:

- BI <1,0 the coating is considered acidic,
- BI =1,0÷1,2 the coating is neutral,
- BI >1,2 the coating is basic.

It was found that the higher the BI, the higher the purity of the welds concerning the oxygen content from the correlation of high toughness with low oxygen content, the importance of the basicity index of BI is clear. For low BI, for acid coating the weld quality is better, the crystal grains are smaller, the deposition rate is higher and the quality and shape of the slag is better and it is easily separated. BI cannot link the hardness and toughness of welds when the coating contains high concentrations of amphoteric oxides (acid and base coating) [4].

During the welding process and related processes, a complex mixture of organic gases and particles is created that can be harmful to human health and the environment. The emission level depends on the welding process and welding parameters. Knowledge of welding fume and gas emission levels and the amount, composition, and particle size of welding fume is necessary if a favorable air atmosphere in the working environment is to be provided so that the necessary measures can be taken to reduce them if they exceed the permitted values. Evaporation emission levels, without chemical analysis, cannot be used directly to assess welder exposure levels, but processes, consumers, and low emission welding parameters are expected to result in lower welder exposure than high-emission processes under the same operating conditions [4,5,6].

2. EQUIPMENT AND PROCEDURE FOR CONDUCTING TESTS FOR THE COLLECTION OF WELDING FUME PARTICLES

Standard EN ISO 15011-1 defines the method for taking evaporation samples and describes the laboratory procedure for determining the emission levels of corrections arising during arc welding and suggests possible analytical techniques or chemical analysis determine the chemical composition of consumer-generated evaporation. during welding [7].

The emission level and evaporation composition depend on the welding process, welding parameters, coating, work surface size, etc. Test equipment (evaporation chamber, filters, and pump, measuring equipment, basic material, and other welding consumables depending on the welding process) is completed and tested before the start of the test experiments. Standard glass fiber filters are used to collect welding fume particles. The filters must be able to withstand the air pressure of the pump and allow the collection of vapors of 0.4÷1.2 mg/cm2. The minimum filter efficiency must be 99.5%. The diameter of the filter is 250 mm. When determining emission levels, the stability of the filter weight depending on humidity is essential, and therefore quartz and glass fiber filters, which are not sensitive to moisture, are recommended. The filter holder allows easy installation and removal of the filter and there must be no leakage of evaporation between the filter holder and the welding chamber. The filters are kept on a steel wire mesh, and the recommended dimension for the openings on the mesh is 0.5÷2.0 mm. In the tests used to collect welding fume particles to determine hexavalent chromium, all solid welding fume particles were removed from the filter.The pump must not interfere with welding and is cleaning the chamber after welding. The pump at the beginning of the test has an air flow level of 25÷30 l/s at a pressure of 0.1 bar at the beginning of the test, which is consistent with the resistance of the filter to 0 mg of evaporation, while at the end of the test the air flow level is at least 5 l/s at a pressure of 0.16÷0.2 bar.During welding, the required welding current is set and the arc duration is measured [7].

To estimate the production of welding fume particles, it is necessary to perform three tests and calculate the mean value. If the individual results differ by more than ± 10% from the mean, two more tests must be performed and the mean of the five test results calculated. Welding fume production or emission, P mg / s is calculated according to the form 2 [7]:

$$P = \frac{M_2 - M_1}{t} \quad \frac{mg}{s} \qquad (2)$$

where: M_1 – mass of filter before welding (mg)
M_2 – mass of filter after welding (mg)
t – duration of the arc (s)

The collection chamber model, conical in shape, intended for MMAW and MIG/MAG welding, has a base diameter of 600 mm, a height of 600 mm, and an upper part for a filter with a diameter of 300 mm.The chamber is equipped with two openings lined with rubber for the operation of the welder from the outside.A large window with a protective light filter allows visibility during the welding process.The base of the chamber rests on three supports and is raised 15 mm from the work table, which gives space through which air enters.The top of the section can be a pipe connected to the filter space and the suction system [7].

3. PERFORMING THE EXPERIMENTAL ANALYSIS

There are several aspects of measuring harmful welding products and their impact on health. Measurement of emissions and sampling of welding fume can be performed in the breathing zone of the welder, the working environment as well as at the outlet of the ventilation systems into the atmosphere. In this paper, welding is performed by MMAW welding process with a coated electrode in a welding chamber that is made for these purposes according to the standard EN ISO 15011-1.

The Figure 1.a) shows the welding chamber and the position of the welder during the experiment, and Figure 1.b) shows the welding chamber and the welding machine.

a) b)

Figure 1. a) The welding chamber and the position of the welder during the experiment, b) The welding chamber and the welding machine

The mechanism at the outlet of the chamber enables hermetic closing of the chamber so that there are no losses of welding fume particles and the entry of ambient air. Standard glass fiber filters "Sartorius-Membranfilter GmbH-PF 142.D-3400" Göttingen, 260 mm in diameter, were used in the experimental work to collect welding fume particles. A positive report for glass fiber filters has been given in the literature [7,8]. The welding chamber is used to perform two basic experiments:

1. measuring the production of welding fume particles and
2. collection of solid particles of welding fume for chemical analysis.

Preliminary experimental analysis was performed in two phases:In the first phase, an experiment was performed with two commercial electrodes for welding carbon steels, with different coating characters, rutile and basic, in order to investigate the influence of the coating character on welding fume production. At the same time, the influence of different electrode diameters and welding currents on production (results are presented in this paper) and chemical composition of weldin fume particles, as well

as the influence of electrode manufacturer's recipe on production and chemical composition of welding fume particles (results are not presented in this paper). In the second phase of the experimental work, the research of welding fumes in the welding of high - alloy steels with two CrNi purpose-made rutile electrodes on the production and chemical composition of welding fume particles was performed (the results are not presented in this paper) [3].

4. THE RESULTS OF THE EXPERIMENTAL ANALYSIS

Within the first phase of the preliminary experiment, research of the influence of the character of the coating on the production of welding fume, the production of welding fume particles was measured, for rutile and basic electrode, with changing electrode diameter and current change. The basic materials that are welded with the electrode E 35 2 R 12 is structural steel, pipe steel, steel for pressure equipment, shipbuilding steel, and steel thin sheets. The basic materials that are welded with the electrode E 42 4 B 32 H5 is structural steel, pipe steel, steel for pressure equipment, shipbuilding steel, and steel castings.

Tests for rutile electrode were performed for 5 different diameters of the electrode core, as follows: Ø2.0; Ø2.5; Ø3.25; Ø4.0 and Ø5.0 mm. The welding current also changed with the change of electrode diameter and was: 55, 70, 110, 160, and 200 A, Table 1. Tests for the basic electrode were performed with 5 different diameters of the electrode core, as follows: Ø2.5; Ø3.25; Ø4; Ø5.0, and Ø6.0 mm. The welding current also changed with the change of the electrode diameter and was: 80, 110, 160, 200, and 300 A, Table 1. The experiment to measure the welding fume production was done in the welding chamber. Welding is performed for each test with one electrode on the base material of low carbon steel S235JRG2, where the duration of the arc is measured. The weight of the filter is measured before and after welding.

The difference between the weights of the full and empty filters per unit time represents the production of welding fume particles. The results of welding fume particle production for the rutile and basic electrode are given in Table 1[3]:

Table 1: Technical report on welding fume production

Welding fume production values										
Label electrodes	E 35 2 R 12					E 42 4 B 32 H5				
Ø electrodes (mm)	2,0	2,5	3,25	4,0	5,0	2,5	3,25	4,0	5,0	6,0
Production P (mg/s)	1,4	1,4	1,4	2,8	2,8	4,2	5,6	8,3	8,3	11,1
Current strength (A)	55	70	110	160	200	80	110	160	200	300
Polarity electricity	= (-)					= (+)				

Graphic representation of welding fume production depending on the electrode diameter and welding current, according to the data from Table 1, are given in Figure 2.

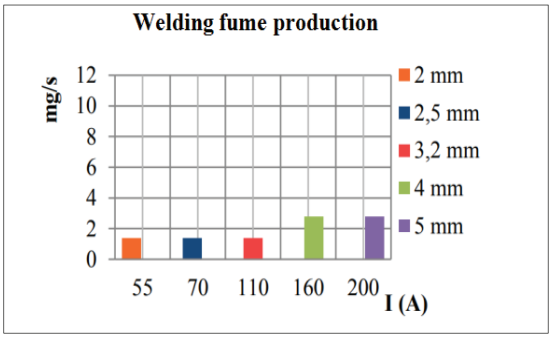

Figure 2: Welding fume production for the rutile electrode

Graphic representation of the results depending on the electrode diameter and welding current, according to the data from Table 1, are given in Figure 3.

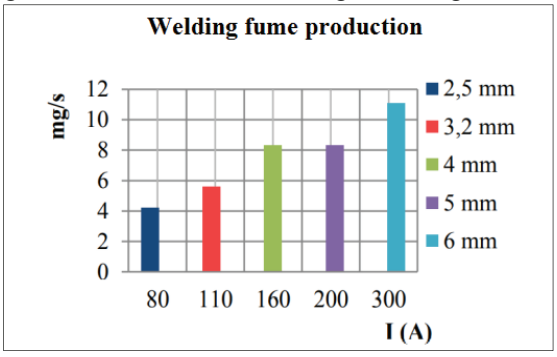

Figure 3: Welding fume production for the basic electrode

The trend of change in welding fume particle production is increasing with increasing electrode diameter and current increase for both electrodes, with welding fume production being significantly higher for the basic electrode for all welding current values compared to the rutile electrode. The production of welding fume particles in the rutile electrode ranges from 1.4 ÷ 2.8 mg / s, and in the basic electrode in the range of 4.2 ÷ 11.1 mg / s [3].

5. CONCLUSION

Examination the production of welding fume particles, depending on the character of the coating for the base and rutile electrode, showed that the higher production of welding fume particles in the base electrodes for all tested electrode diameters. The

production of welding fume particles increases with increasing welding current. For this reason, in order to decrease the production of welding fume, lower welding currents are used, if there is a possibility of such a choice.The production of welding fume particles for welding increases with increasing electrode diameter at the same current strengths, i. the coated electrode generates a smaller amount of welding fume particles if its total coating mass is smaller. The real danger is the inadmissible amount of harmful ingredients in weldingfume particles, which can be determined by chemical analysis.

REFERENCES

[1] The ESAB WELDING AND CUTTING JOURNAL vol.59 No.1.2004 ESAB 1904-2004 SVETSAREN.
[2] https://www.imarcgroup.com, 2021.
[3] Begić R., Doctoral thesis, Investigation of the optimal technological composition of the electrode coating from the aspect of minimizing welding fume, 2011, Technical Faculty, Bihać B&H.
[4] Robert W. Messler, Jr; Principles of welding; NY, 2004.
[5] Pašić O., Welding, 1998, Sarajevo B&H.
[6] Klaus-Jürgen; Erhard Richter, Schweißtechnik. Leipzig, Germany, 2008.
[7] EN ISO 15011-1, Health and safety in welding and allied processes-Laboratory method for sampling fume and gases generated by arc welding-Part 1: april 2002.
[8] Hazardous substances in welding fume and allied processes, 1996.

USE OF EDIBLE FILMS FOR CHEESE PRESERVATION

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Abstract: *Due to dynamic biochemical and microbiological changes, which undergo in cheese from its production to storage, packaging plays an important role in cheese industry. In recent years, much attention has been made to extending the shelf life of cheese products but at the same time overcoming a wide range of environmental and health issues regarding packaging materials. Selection of the appropriate biodegradable materials for edible film development represents a huge challenge because of complex cheese composition and specific environment preservation conditions. This paper gives an overview on the use different biodegradable materials as a choice for developing edible cheese films in relation to cheese quality and safety.*

Keywords: *edible films, cheese*

1. INTRODUCTION

Food packaging materials are primarily used to store food, protect it from environmental influences and maintain good quality during its shelf life. However, over the last decade, food packaging was also associated with two types of issues; high levels of waste production and migration problems from applied synthetic material that is in direct contact with food. One of the strategies to counteract both problems is the development of new materials obtained from renewable natural resources. Natural polymers offer the greatest opportunities in this field, since their environmental compatibility is ensured and their specific properties can be obtained using different processes and technologies. Generally, proteins, polysaccharides and lipids derived from animals, plants and marine life are used for the production of new biodegradable materials in the form of edible films or coatings, or composites. According to the latest scientific discoveries in this field, edible packaging materials are successfully used for commercial packaging of different kinds of vegetables, fruits and meat products. Different types of edible materials can respond to the product differently, therefore the selection of appropriate materials for the production of edible films depends not only on the type of food products that will be packed but also on the storage conditions: applied relative humidity and temperature level [1]. Special emphasis is put on the application of edible films for cheese

preservation due to specific biochemical and microbiological changes that occur, not only during cheese manufacture, but also during the ripening process. Added value of this type of packing lies in their ability to carry and release antioxidants, antimicrobials and flavoring agents.

2. EDIBLE FILMS AND/OR COATINGS

2.1. Characteristics of edible films/coatings

Edible films or coatings are defined as a thin layer of material (thickness of less than 0.3 mm) that provides barrier and protection for food products, but can also be consumed simultaneously with food [2]. The unique advantage of edible packaging is that it is an integral part of the product, so it does not produce waste. Although some authors do not distinguish between the terms edible film/coating; others distinguish them due to the manufacturing techniques and its integration into the food products [3]. Edible film differs from edible coating in the way it is applied to the surface of the product. Edible film is prepared previously and then applied to the product as a wrapping material, whereas edible coating is usually in the form of an emulsion or a suspension, which is formed directly on the food surface. Nevertheless, in both cases, rigid matrices are formed with similar characteristics.

The most important characteristics that edible film/coatings for cheese preservation must have are mechanical, chemical and microbiological barrier. Control of mass transfer involves regulating microenvironments of gases around food products as well as controlling migration of additives in food systems [4]. But in addition to all of the above, they must also be sensorially acceptable. Edible films/coatings display similar mass transfer phenomena, and are usually evaluated according to their mechanical properties; rigidity and elasticity. However, both mechanical properties and mass transfer phenomena are influenced by the type of biopolymeric matrices applied and the methodology of production. To create a distinct properties and functionalities of a film/coating, the properties of selected biomolecule can be manipulated by adding plasticizers and additives into the biopolymer matrix [5]. In general, hydrophobic molecules are strong moisture barriers, but also exhibit good gas barrier properties (O_2 and CO_2). On the other hand, hydrophilic molecules demonstrate efficient mechanical properties. Therefore, the combination of these two types of molecules with different characteristics yields films with added or up-to-date advantages.

Table 1: Applied edible films/coating material and its functionality

Materials	Properties	Function	Examples
Polysaccharides	Thickeners Stabilizers Gellants Emulsifiers	• Solid base structure	Chitosan Pectin Starch Cellulose

			Agar Alginate
Proteins	Gellants Thickeners Stabilizers Foaming	• Transport of antimicrobials and antioxidants • Gas transport control (O2)	Whey protein Casein Gelatin
Lipids	Protectors Coatings	• Dehydration or drying avid • Providing flexibility	Glycerides Waxes Paraffin
Additives			
Plasticizers	Viscosity Resistance Flexibility	• Decrease melting • Modify viscosity and rheological properties	Glycerol, Sorbitol Polyoxyethylene glycol Propylene glycol Aloe Resins
Chaotropic agents	Destructuring agent Antioxidants Stabilizers	• Increase water solubility	Urea
Others	Fungicides Herbicides Fertilizers	• Stabilizers • Protection of the products	Polyphenols

2.1.1. Protein based films

Due to complicated spherical structures of protein, which is associated to specific amino acid sequences placement along the protein polymer, the chain is held together by hydrogen, ionic, hydrophobic and covalent (disulfide) bonds. Therefore, the protein must be denatured before approaching to film making process by changing the pH, heat and/or solvent. Once the structure of protein is extended, the chain-to-chain interaction produces cohesive films. The stronger the interactions, the stronger the films, but also less flexible and less permeable they became to gases, vapors and liquids. Polymers containing functional groups connected by hydrogen or ionic bonds, in form of edible films, demonstrate excellent oxygen barrier properties, but are susceptible to moisture [2]. So, edible films/coatings consisting only of proteins can result in barriers with good mechanical stability, but with the disadvantage of low susceptibility for gas barrier and moisture.

2.1.2. Polysaccharide based films

Polysaccharides are the most common group of biopolymers for the production of edible films and coatings. They are very abundant in nature and can be obtained from different source material such as plants, microorganisms and crustaceans. Polysaccharides are generally very hydrophilic molecules. Edible films made only from polysaccharides results in films with poor water vapor and gas barrier properties, but with very good structural stability [2,3]. These coatings can act as sacrificing agents retarding moisture loss from food products.

2.1.3. Lipid based films

Lipid compounds are the oldest compounds utilized as a protective coating for cheese preservation. Due to their relatively low polarity, lipids have an excellent moisture block transport and a low gas transfer property. Generally, water vapor permeability decreases when the concentration of hydrophobicity phase increases. The hydrophobic characteristic of lipids forms brittle and thick films. For this reason, they are often combined with other polymer structures, usually polysaccharides or proteins, to obtain good mechanical strength [2,6]. Most common lipid used are paraffin wax, beeswax and fatty acids.

2.2. Edible films and coatings for cheese preservation

Cheese is a generic name for a large number of fermented milk-based products of diversified aroma, texture, size and origin. It can be prepared from different types of milk. More than 1000 cheese varieties are produced worldwide [6]. Several methods have been used to classify cheese varieties, but the most acceptable classification from the packaging point of view is: hard, semi-hard, soft and fresh cheese. Cheese has a complex composition due to dynamic biochemical reactions that occur not only during production but also during the storage process. Moreover, cheese will continue to undergo ripening changes even after the packaging process is finished. This greatly influences its physical, microbiological, chemical and sensory characteristics resulting in changes such as color, flavor and texture [7]. Moreover, significant reduction in cheese quality can occur as a result of extensive growth of microorganisms on the cheese surface due to the external environmental conditions. Selection of the appropriate packaging material represents a difficult task as it should not interfere with normal biochemical and microbiological changes occurring during cheese ripening but should offer good protection and ultimately extend the cheese shelf life. Optimal cheese packaging must provide a moisture barrier in a manner that controls the rate of cheese water loss with the moisture permeating out of the package; impermeability to gases, especially oxygen, which minimizes UV penetration as well as the activity of microorganisms, but simultaneously leads to good textural and sensory properties of cheese [8]. As previously mentioned, there are various types of cheese with different moisture content and composition, and,

consequently, different shelf lives. The cheese surface is susceptible to contamination by bacteria and fungi due to acidity conditions and high water activity. Therefore, edible films should not be chosen just based on the type of cheese (fresh or matured) but also according to the storage conditions (temperature, relative humidity, etc.).

Table 2. Various types of cheese and their properties [9]

Type of cheese	**Rheological properties**			**Maturity** (Ripening period)	**Shelf life (fridge)**	**Packaging Requirements**
	Moisture content (%)	**Viscosity Factor**	**Elasticity factor**			
Hard	<25	>9	>6.3	6–24 months	4-6 m	- Packaging with very low permeability to oxygen and UV radiation and moisture. - Gradual rate of ripening. - Ripen for a very long time in an anaerobic environment.
Semihard	25–36	8–9	5.8–6.3	~3 months > 2 years	2-4 m	
Semisoft	36 - 40	7,5 -8	<5,8	~2–6 months	1–2 m	- Medium barrier packages. - Control relative humidity and microbial growth. - The moisture barrier should allow a balance between the external RH and the RH surrounding the cheese. - To preserve fresh cheeses from moisture loss (easily dehydrate). - Permeability to oxygen and UV radiation.
Soft	>40	<7,5	<5,8	-	2-3 w	

3. CONCLUSION

Edible coatings and/or films represent very promising investment as a sustainable alternative to conventional packing material.

Their use for cheese preservation has been increasingly exploited in recent years and has resulted in the commercialization of edible coatings and films by some companies.

The current state-of-the-art lies in the formulation of composite edible films and coatings from such biomolecules.

4. REFERENCES

[1] Jeevahan, J.; Chandrasekaran, M.; Venkatesan, S. P.; Sriram, V.; Britto, J.; Mageshwaran G.; Durairaj R.B.: Scaling up difficulties and commercial aspects of edible films for food packaging: A review, Trends in Food Science & Technology, **100** 2020, 210-222, https://doi.org/10.1016/j.tifs.2020.04.014.
[2] Bourtoom, T.: Review Article Edible films and coatings: characteristics and properties, International Food Research Journal 15(3): 2008, 237-248
[3] Díaz-Montes, E.; Castro-Muñoz, R.: Edible Films and Coatings as Food-Quality Preservers: An Overview, Foods 2021, 10, 249, https://dx.doi.org/10.3390/foods10020249
[4] Kamal I.: Edible Films and Coatings: Classification, Preparation, Functionality and Applications- A Review, Arc Org Inorg Chem Sci 4(2) 2019.
[5] Jung H: Edible Films and Coatings: A Review, Pepsico Inc., Plano, Texas, USA, 2013.
[6] Ahmed M. Y.; Assem F. M.; El-Sayed S. M.; Salama H.; Abd El-Salam M. H.: Utilization of Edible Films and Coatings as Packaging Materials for Preservation of Cheeses, *J Package Technol Res*, https://doi.10.1007/s41783-017-0012-3
[7] Costa M.J.; Maciel L.C.; Teixeira J.A; Vicente A.A.; Cerqueira M. A.: Use of edible films and coatings in cheese preservation Opportunities and challenges, Frin, 2017. https://doi.org/10.1016/j.foodres.2018.02.013
[8] Pantaleão, I.; Pintado, M.; Pocas, F.: Evaluation of two packaging systems for regional cheese. Food Chemistry. 102. 2007, 481-487 http://doi:10.1016/j.foodchem.2006.05.058
[9] Jafarzadeh S,; Salehabadi A.;Nafchi A. M. ; Oladzadabbasabadi N.; Jafari S.M.: Cheese packaging by edible coatings and biodegradable nanocomposites; improvement in shelf life, physicochemical and sensory properties, Trends in Food Science & Technology 116, 202, 218–231

BATTERY SYSTEM 600 [Wh] WITH SOLAR CHARGE OPTION

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Abstract: *The need for electricity has never been higher, which requires new technologies for electricity storage systems that would enable uninterruptible power supply in combination with renewable energy sources, all with the aim of sustainable development and zero carbon dioxide emission. With the goal of uninterruptible power supply, without connection to the power system, the idea of making a battery system with photovoltaic panels for smaller consumers, such as laptops, television, radio, small refrigerator, mobile phones, was developed. The battery system is made of Lithium-ion modules with a capacity of 600 Wh, with the possibility of increasing the capacity itself. The paper will describe the technology of designing and manufacturing electricity storage systems with the possibility of charging the system via photovoltaic panels.*

Key words*: electrical storage system, sustainable development, zero emission of carbon dioxide, renewable energy sources*

1. INTRODUCTION

Nowadays, the need for electricity is greater than ever and the negative effects of fossil fuels are more obvious than ever. There is a specific need for us to use an alternative energy source to generate electricity, and using solar energy can go way beyond reducing carbon emissions. The cleanest energy that we can harness is solar energy, and its adoption will reduce the impact that we have made towards driving climate change. The greenhouse effect and global warming are two of the biggest environmental concerns that our children and we will face. The question is how to supply this energy of "life" of modern man to conditions where infrastructure is not available, such as camping, traveling or socializing in nature. Aware of the negative effects of fossil fuels this type of portable battery is an alternative to some smaller versions of petrol or diesel aggregates. In particular, the possibility of "collecting"

solar energy and storing it for later helps to pay off the CO_2 "debt" created by the materials used for this system in production. The possibility of upgrading such system is provided by the initial modular configuration of the battery modules that has been used. Unlike commercial solutions, this performance is infinitely expandable. Capacity of battery system can be increased by using 24 [V] Li-ion modules that we stack in parallel.

2. PARTS OF SOLAR SYSTEM

The whole system can be divided into 6 segments. The first segment is the heart of the system, it is of course a battery pack of six 25.2 [V] Li-ion modules with a capacity of 100-110 [Wh] connected in parallel. The second segment is a pure sine wave inverter manufactured by Reliable Electric, with a power of 800 [W] continuous load, but it can withstand a load of 1600 [W] power for a short time with inductive resistance consumers. The third segment are "Quick Charge 3.0" modules that offer 4 USB A format outputs for connecting all types of handheld electrical consumers, primarily smartphones, the theoretical maximum output power of a single USB slot for phones with "QC3.0" standard is 24 [W], in practice this depends on the charging standard for particular smartphone manufacturer connected to the “QC module”. The fourth addition to the whole system is the necessary "MPPT Solar Charge Controller" which, due to its "boost" DC characteristics, will use as a regulator of charging from the network. His primary role is charging the battery from the solar panel. The fifth part includes DC-DC converters for car socket 12 [V] and laptop output 19.5 [V]. Also, there is a special output for laptops for efficiency reasons, since using a standard laptop AC-DC converter makes sense while using a home network, it is certainly not justified in this mobile battery version where we already have DC battery voltage. The solar panel is the sixth segment of this system. It is used to charge the battery capacity via the MPPT controller. Since the controller is essentially a DC "boost" voltage converter, it doesn't matter whether the input is a solar panel or an ordinary DC source such as a laptop charger. All components, except the solar panel are housed in a box dimension 35x25x10 [cm], the weight of the whole system is 4.8 [kg] (Figure 1.) [1]

Figure 1: Battery system

2.1. Inverter efficiency measurement

Although the manufacturer's specifications state an efficiency of over 90% in practice, this depends a lot of load connected to the inverter output. With the help of a power meter for a single-phase socket that displays the current power being extracted from the socket, current clamps and a voltmeter built into the inverter, we can calculate the inverter efficiency accurately enough depending of the load. Pure ohm loads were used for this measurement, as in this way we have a constant resistance that does not fluctuate. The inverter efficiency measurement is shown in Figure 2. Table 1 shows the results of inverter efficiency measurements for seven different loads.

Figure 2: Inverter efficiency measurement, 100 [W] loads

Table 1: Measured inverter efficiency

Output power [W] displayed on the meter connected to the inverter output	Inverter input voltage [V]	Source current [A]	Efficiency η
54	28.3	2.389	0.798
99.7	27.9	4.62	0.773
155	27.8	5.575	0.813
213	27.6	9.19	0.844
381	27.3	15.989	0.872
482	27.1	19.98	0.894
614	26.9	25.05	0.913

2.2. Measuring the power output of a solar panel

Solar panels are classified according to their rated power output in Watts. This rating is the amount of power that solar panel should produce in 1 peak sun hour. Solar panels can be wired in series or in parallel to increase voltage or current respectively. The rated terminal voltage of a 12 Volt solar panel is usually around 17.0 Volts, but through the use of a regulator, this voltage is reduced to around 13 to 15 Volts as required for 12 [V] battery charging.

In our case, the maximum output voltage from solar panel is 19.4 [V], and with MPPT and its DC-DC boost converter we boost up this voltage to usable voltage for charging out 24 [V] battery system (output voltage from DC-DC boost converter for charging our battery system must be between 19 [V] and 29.4 [V]).

The solar panel is located vertical to the direction of the sun's rays (Figure 3.), and the charging power did not exceed 29 [W]. Which turns out to be 72% of the declared value. After we have set all the parameters on the solar panel controller and stored in memory, the charging test has begun. After 60 minutes of charging, 27.34 [Wh] entered the battery, and the voltage of solar panel was 18.22 [V] (Figure 4.). Guided by this knowledge, we conclude that in 5 hours of charging the batteries can receive more than 120 [Wh] of energy, which would in any case be more than enough to power small consumers.

Figure 3: The position of the entire solar system

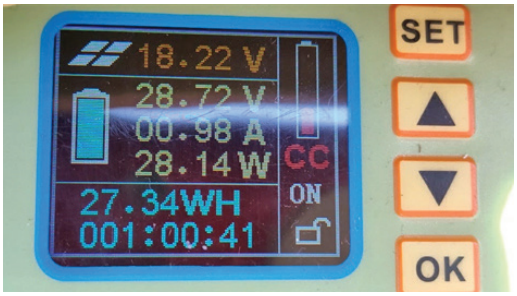

Figure 4: Solar charge values on the controller LCD

2.3. Battery system capacity measurement

Since we measured the efficiency of the inverter for various consumers, it was decided to use the pure sine inverter as an intermediary in measuring the capacity of the entire system. It is connected to a power meter from a single-phase socket that neatly records the amount of extracted [kWh] and displays them on its LCD screen. An 82 [cm] plasma TV was selected for the consumer, which required 138-162 [W] of power. The demand for power depended on the scene being shown on the television program. The battery is charged to 29.3 [V] with AC-DC converter from the power network. After approx. 3.5 [h] that TV has been connected, the inverter beeped and turned off. This indicated that the total system voltage dropped below the 19.5 [V] limit after which the inverter shuts down. The efficiency of the inverter at a load of about 150 [W] was 0.813. Approximation capacity of the battery system is obtained by dividing the recorded energy consumption by the efficiency factor, 489[Wh] / 0.813 = 601.47 [Wh]. [1]

3. IMPLEMENTATION FOR A BIGGER SOLAR SYSTEM

a) Photovoltaic (PV) Direct – A simple system, no energy storage

The simplest system consists of a load, such as a ventilation fan or an electrical pump to move water, and a PV source as a single solar PV module.

b) Battery-Based System – storing power for times when there is no sunlight

When energy is needed to power loads at times of the day when the sun is not shining, a system needs to have access to a source of constant, non-interrupted power like a utility, or a generator. An alternative is to use a stored energy source such as a battery. A battery-based, stand-alone system (also called "off-grid" system) is more complicated than a PV-direct system.

c) Off-Grid System – living in a residence not connected to a utility

One limitation to living in a remote area is the cost to bring in utility-supplied electricity. A homeowner would need to rely on a fossil-fueled generator, propane gas, or a combination of both. Today, a battery-based solar PV system can be designed to power home or cabin not connected to a local utility. This is an off-grid system.

d) Grid-Connect System - connecting to local electric utility and sending power to the grid

One of the fastest growing type of PV systems is the grid-connect system. Residential and commercial grid-connect systems are popular for reducing the amount of energy supplied by the local utility. The grid-connect system is made up of a solar array (PV modules wired together), and an inverter to change DC electricity into AC electricity.

e) Hybrid System – adding wind or hydro energy

A hybrid system includes more than one energy-producing source. [2]

4. CONCLUSION

A battery system made of lithium-ion batteries has proven to be very practical for camping and powering smaller consumers in areas where electricity is not available. This system can be example how larger solar systems can reduce dependence of electricity that has been produced from fossil fuels, by reducing greenhouse gas emissions and contributing to sustainable development.

REFERENCES

[1] Crnogorac A., Baterijski sustav 600 [Wh] s opcijom solarnog punjenja, *Available from* https://urn.nsk.hr/urn:nbn:hr:128:842386 *Accessed:* 2022-06-01

[2] Franklin E., Types of Solar Photovoltaic Systems, *Available from* *https://repository.arizona.edu/bitstream/handle/10150/625568/az1745-2017.pdf?sequence=1&isAllowed=y* *Accessed:* 2022-07-07

STORAGE OF ALCOHOL-BASED HAND SANITISERS

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Abstract
During the last 2 years, the use of biocidal agents, more precisely hand sanitizers increased dramatically. Many companies, enterprises, institutions etc. store larger than usual quantities of those biocidal agents. In general, there are two main types of sanitizers: alcohol based and non-alcohol based. Alcohol based hand sanitizer contains ethanol or isopropanol, both with optimal concentration for antimicrobial activity in range 60–80%. Although the general use of small quantities of alcohol-based hand sanitizer poses a low risk from a fire hazard point of view, the risk increases significantly when large quantities are stored in an improper way. In this paper, we discuss the safe storage of alcohol-based hand sanitizer in companies to mitigate the fire risk to property and life.

***Key words**: hand sanitizers, alcohol-based, storage, fire hazard*

Introduction:

In the last two years, many companies have been storing, for the first time, large quantities of alcohol-based sanitizers without carrying out Risk Assessments associated with handling and storage of sanitizers. As a result, the risk of fire due to improper storage has increased. Key recommendations are set out in this paper to assist smaller companies who are unfamiliar with the procedures related to safe storage.

The main alcohols used, as disinfectants for a broad spectrum of bacteria, viruses and fungi are ethanol and isopropanol. The optimal concentration for antimicrobial activity is in the range minimum 60 % for ethanol-based sanitizer and minimum 70% for isopropyl alcohol-based sanitizer. Ethanol is preferable against hydrophilic viruses (e.g. rotavirus) while isopropanol is better choice against lipophilic viruses

(e.g. hepatitis A virus).[1, 2] According to Flammable Liquids and Gases Act (Official Gazette 108/95, 56/10) safety measures whilst storing flammable liquid depends on the quantity: up to 2000 litres and more than 2000 litres.[3]

The storage of flammable liquids and gases in buildings, parts of buildings or spaces within buildings that are not intended for the storage of flammable liquids are prohibited according to the Flammable Liquids and Gases Act.[3]

This paper will discuss the storage of small quantities of alcohol-based sanitizers, which are most often used in companies.

Propositions for storage of alcohol-based sanitizers

The alcohol-based sanitizer can be stored in indoor storage cabinets or outdoor bulk storage lockers. Indoors storage safety cabinets provide heat resistance to protect contents from fires and they are available in a wide range of sizes and styles. Outdoor storage lockers are designed for safe storage of bulk quantities of flammable liquids outside the buildings and without the necessity of constructing a storage room .[4].

As alcohol-based sanitizers are highly flammable liquids, adequate storage within buildings should be regulated. Flash points of 60% ethanol and 70% isopropanol are 22°C and 18°C, respectively. Low flash point means that it is not necessary to have an external heat source for fire to occur because vapours from this substance in high concentrations are dangerous in itself. This is the reason why alcohol-based sanitizers should be treated as highly flammable liquids. [1, 7]

Users who store flammable liquids in containers must follow manufacturer's instructions for manipulation. In addition, it is important to mention that containers must closed after use.

According to Flammable Liquids Regulation (Official Gazette 54/99) hermetically sealed containers (volume up to 20 litres must be stored in specially built metal cabinets and total amount of flammable liquids must not exceed 200 litres) are used for storage of alcohol-based sanitizers.[6]

Metal cabinets must have tight joints and doorsills should be raised at least 10 centimetres above the bottom of the cabinet. Cabinets should have lockers and ventilation with access to open space. Metal cabinets must be at least 5 meters away from open flames and at least 2 meters away from combustible parts within the structure of buildings and other flammable substances.[4, 8]

Alcohol based sanitizer should be keep in a well-ventilated place and storage areas must be marked in accordance with the Chemicals Act (Official Gazette 18/13, 115/18, 37/20), always away from food and drink.[9]

Considerable care should be taken when handling all packages and containers to minimise spills. After handling alcohol-based sanitizers, one must wash their hand thoroughly.

Storage of alcohol-based sanitizers at workplaces should be away from electrical panels or power strips, ignition sources, heating devices, computers, electronics, electrical outlets and switches, but also kept away from direct sunlight, oxidants, reducing agents, strong acids and bleach.[10] All containers for alcohol-based sanitizers should be marked with a GHS02 pictogram for flammability, a GHS07 pictogram due to hazardous substance and a no smoking sign according to Safety signs ordinance (Official Gazette 91/15).[11] Ethanol-based sanitizers are marked with the hazard statement H225, which means highly flammable liquid and vapour.[12, 13, 14, 15]

Containers with alcohol-based sanitizer must be closed when not in use and in its original form.

The risks of storing flammable substances indoors should be controlled by reducing the quantities of such substances at the workplace. It has been recognized that if flammable liquids are use at the workplace, there is likely a need for a limit on the number of sanitizers stored at the workspace.[16] It is important to emphasize the responsibility of the employer who should evaluate the risk when storing any specified amount of flammable liquid in the work area. However, the guiding principle is that only the minimum amount required for frequently occurring activities or one shift should be present in the workspace. Moreover, the actual quantities will depend on the work activity and the organizational arrangements for fire risk control.

Aliquots of bulk volume of alcohol-based sanitizers should be transferred to dispensers. Those dispensers should not be placed above or close to potential sources of ignition (e.g. light switches, electrical outlets, etc.) due to the increased risk of vapours igniting. [17, 18, 19] Consideration should be given to the risks associated with spillage onto floor coverings due to the risk of pedestrian slips. Workers should be warned about excessive amounts of alcohol-based sanitizers and not to smoke immediately after use.

In the case spoilage or fire

If a spillage occurs, it should be absorbed by an inert material (e.g. dry sand) and then disposed of in a chemical waste container. A well-ventilated room is critical for keeping vapours dispersed.

In the case of fire, suitable extinguishing media are carbon dioxide, alcohol-resistant foam or dry powder.[12, 13, 14, 15] Although water can initially dilute alcohol and

eventually reduce its concentration, it is better to use a fire extinguisher as mentioned above.

Conclusion:

In order to keep employees and facilities safe it is necessary to store alcohol-based sanitizers in an appropriate way to minimise the dangers associated with fire to property and life. It is also important to keep in mind that it is the employer's responsibility to keep staff safe by making sure safety protocols are adhered to.

References

[1] Chojnacki, M.; Dobrotka, C.; Osborn, R.; Johnson, W.; Young, M.; Meyer, B.; Laskey, E.; Wozniak, R.; Dewhurst, S.,; Dunman, P.:. Evaluating the Antimicrobial Properties of Commercial Hand Sanitizers, *mSphere*, **Vol. 6** (2021) No.2, 00062-21, ISSN 2379-5042.

[2] Gold, N.A.; Mirza, T.M.; Avva, U.: Alcohol Sanitizer. *Available from* https://www.ncbi.nlm.nih.gov/books/NBK513254/ *Accessed:* 2022-06-01.

[3] Flammable Liquids and Gases Act (Official Gazette 108/95, 56/10)

[4] Flammable Safety Cabinets vs. Outdoor Chemical Storage Lockers – What is the Difference? *Accessed:* 2022-06-01.

[5] What you need to know about fire safety and alcohol-based hand sanitizer, *Available from* https://resources.impactfireservices.com/what-you-need-to-know-about-fire-safety-and-alcohol-based-hand-sanitizer *Accessed:* 2022-06-01.

[6] Flammable Liquids Ordinance (Official Gazette 54/99)

[7] Proper Use and Storage of Alcohol-based Hand Sanitisers, *Available from* https://www.hsa.gov.sg/consumer-safety/articles/alcohol-based-hand-sanitisers *Accessed:* 2022-06-02

[8] Joka, G.: Dezinfekcijska sredstva za ruke*, Kemija u industriji*,Vol 69 (2020) No.7-8, pp 455-456, ISSN 1334-9090 *Accessed:* 2022-06-02

[9] Chemicals Act (Official Gazette 18/13, 115/18, 37/20).

[10] Alcohol-based hand sanitiser – Work Health and Safety responsibilities *Available from* https://www.safework.nsw.gov.au/resource-library/hazardous-chemicals/manufacturing-hand-sanitisers/alcohol-based-hand-sanitiser-work-health-and-safety-responsibilities *Accessed:* 2022-06-02

[11] Safety Signs Ordinance (Official Gazette 91/15)

[12] Sigurnosno tehnički list, *Available from:* https://kemoplastika.hr/wp-content/uploads/2020/04/Dermo-DeziKem-STL.pdf *Accessed:* 2022-05-29

[13] Sigurnosno tehnički list, *Available from:* https://www.saponia.hr/media/85503/stl-bis-handysept.pdf *Accessed:* 2022-05-29

[14] Sigurnosno tehnički list, *Available from:* http://www.antiseptica.hr/STL2015/Big%20Spray%20New.pdf *Accessed:* 2022-06-04
[15] Sigurnosno tehnički list, *Available from:* https://www.makromikrogrupa.hr/Documents/product_document/180707335_180707333_180707330_180707145_aresept-1.pdf *Accessed:* 2022-06-04
[16] O'Leary, F.; Price, G.: Alcohol hand gel - A potential fire hazard. *Journal of plastic, reconstructive & aesthetic surgery*, **Vol. 64** (2011) No.1, pp. 131-132, ISSN: 1748-6815.
[17] Fire Safety and Alcohol-Based Hand Sanitizer (ABHS), *Available from* https://www.cdc.gov/handhygiene/firesafety/index.html *Accessed:* 2022-06-03
[18] Alcohol-Based Hand Sanitizers and Fire Safety, *Available from* https://fireprevention.utexas.edu/alcohol-based-hand-sanitizers-and-fire-safety *Accessed:* 2022-06-03
[19] Hand sanitizer fire safety: safe handling, dispensing and storing, *Available from* https://www.ehs.washington.edu/system/files/resources/hand-sanitizer-fire-safety.pdf

PRELIMINARY DESIGN OF A RADIAL INFLOW TURBINE FOR A GEOTHERMAL POWER PLANT

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Abstract: *Organic Rankine Cycle (ORC) is an efficient technology for generating power from low-to-medium temperature renewable energy sources such as geothermal sources. Radial inflow turbine is a suitable expander for an ORC geothermal power plant. In this paper a model for preliminary design of a radial inflow turbine with an organic working fluid is presented. The model determines turbine geometry, and predicts losses and efficiency based on a set of input parameters. All the calculations for the model were made in Engineering Equation Solver software. The model was compared to the models available in literature. The results obtained with this model show good match with data from the literature.*

Keywords: *Radial inflow turbine, Preliminary design, Organic Rankine Cycle*

1. INTRODUCTION

Organic Rankine cycle (ORC) is a thermodynamic cycle analogous to steam Rankine cycle. It contains the same four main components: evaporator, expander (turbine), condenser and a pump. The difference is that the ORC uses an organic fluid instead of steam as a working fluid. Organic fluids used in the ORC are compounds with large molecular mass and low evaporation temperature and pressure. These properties of organic fluids make the ORC a suitable technology for power generation from low–to–medium temperature energy sources. These sources include geothermal heat, solar heat, industrial waste heat, and heat generated by burning biomass.

The expander is a component that has a high impact on power output and efficiency of the cycle. The most common expander in power generation is a turbine. Turbines are classified as axial flow and radial inflow turbines (RIT). Axial flow turbines suitable and efficient for large – scale power generation with large mass flow rates and low expansion ratios (gas and steam turbines). RITs are used with high pressure ratios and low mass flow rates which makes them suitable for use in the ORC.

2. RADIAL INFLOW TURBINE ARCHITECTURE

Radial inflow turbine consists of three main components, as presented in Figure 1: the volute, the stator (nozzle), and the rotor. If the flow exits the rotor at high velocity (high kinetic energy), a diffuser can be used to recover some of that kinetic energy which is otherwise wasted.

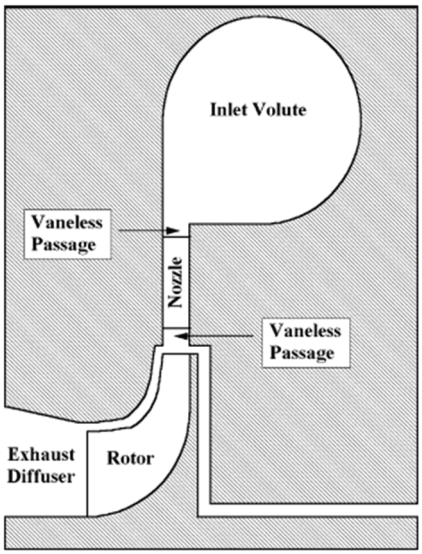

Figure 1: RIT meridional view [1]

The fluid enters the volute first. The purpose of the volute is to distribute the flow uniformly around the periphery of the nozzle inlet. Then the fluid enters the nozzle blades where it is accelerated and directed to the rotor blades. Lastly, the fluid enters the rotor where it expands, converting the kinetic energy to work. If it is necessary, a diffuser is placed after the rotor to convert some of the exit energy of the fluid into static pressure. A vanless passage (interspace) is set up between the nozzle and the rotor so the nozzle wakes can mix out before entering the rotor.

3. PRELIMINARY DESIGN MODEL

Preliminary design model is given in [2]. It defines the geometric parameters and velocity triangles at inlet and outlet stations of each component of the turbine. It also predicts the efficiency of the turbine. To carry out all the calculations an algorithm was written in Engineering Equation Solver software. A simple flowchart of the algorithm is presented in Figure 2.

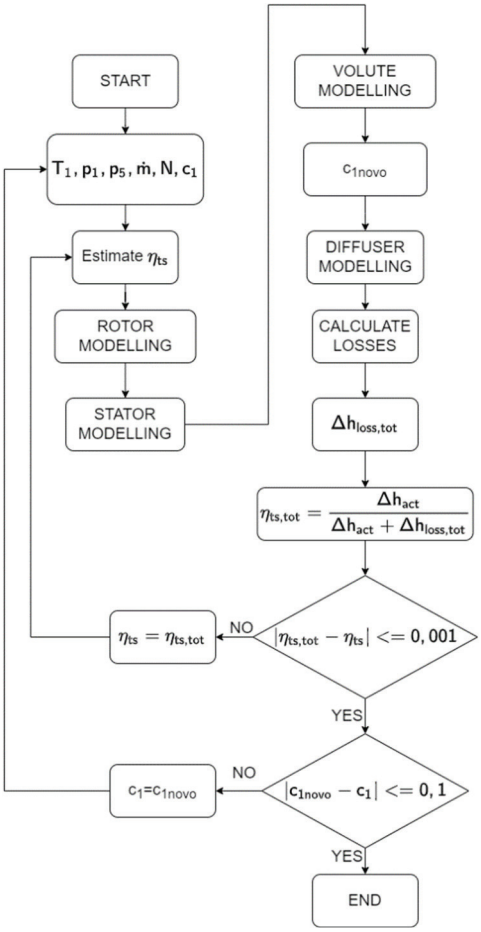

Figure 2: Preliminary design flowchart [2]

All the equations used and a detailed description of modelling for each component is available in [2]. The nomenclature of the parameters used in equations is the same as presented in [2]. The input parameters for the model are static temperature T_1 and static pressure p_1 at the turbine inlet, static pressure at rotor outlet p_5, rotational speed N, and guess value of absolute flow velocity at turbine inlet. Velocity c_1 is needed to calculate stagnation thermodynamic parameters. With the input parameters it is possible to completely define the thermodynamic state of the fluid at the turbine inlet. To initiate further calculations an estimation of total–to–static efficiency η_{ts} is needed. Estimated value of η_{ts} is given by equation (1) presented in [1].

$$\eta_{ts} = 0,87 - 1,07(N_s - 0,55)^2 - 0,5(N_s - 0,55)^3 \quad \textbf{(1)}$$

N_s is a dimensionless parameter called specific speed. It is defined by equation (2) given in [3].

$$N_s = \omega \cdot \frac{\left(\frac{\dot{m}}{\rho_{05}}\right)^{0,5}}{(\Delta h_{id})^{0,75}}$$

(2) Using the estimated value of η_{ts} the calculations that define the turbine geometry are initiated. After the geometric parameters are defined the program calculates the losses. The losses considered in this model are:

1) Rotor incidence loss [4]

$$\Delta h_i = 0,5 \cdot w_4^2 \cdot sin^n(\beta_4 - \beta_{4,opt})$$

(3)

2) Rotor passage loss [5]

$$\Delta h_p = m_f \cdot 0,11 \cdot \left[\frac{L_h}{D_h} + 0,68\left(1 - \left[\frac{r_t}{r_4}\right]^2\right)\frac{cos(\beta_t)}{\frac{b_t}{C}}\right] \cdot \frac{w_4^2 + w_t^2}{2}$$

(4)

3) Rotor tip clearance loss [6]

$$\Delta h_c = u_4^3 \cdot \frac{Z_r}{8\pi} \cdot [0,4\varepsilon_a C_a + 0,75\varepsilon_r C_r - (\varepsilon_a \varepsilon_r C_a C_r)^{0,5}]$$

(5)

4) Rotor windage (disc friction) loss [7]

$$\Delta h_w = k_f \frac{\bar{\rho} u_4^3 r_4^2}{2\dot{m}}$$

(6)

5) Rotor trailing edge loss [8]

$$\Delta h_{te} = \frac{\Delta p_{0,rel}}{\rho_5}$$

(7)

6) Exit energy loss

$$\Delta h_e = \frac{c_5^2}{2}$$

(8)

7) Volute loss [9]

$$\Delta h_{vol} = 0,1 \cdot \frac{c_2^2}{2}$$

(9)

8) Stator (nozzle) loss [10]

$$\Delta h_{st} = \frac{0,05}{\overline{Re}_{stat}^{0,2}}\left[3\frac{tan(\alpha_3)}{\frac{s_{n3}}{c_{n3}}} + s_{n3}\frac{cos(\alpha_3)}{b_3}\right] \cdot \frac{c_3^2}{2} \quad \textbf{(10)}$$

With the losses calculated, a new more accurate value of η_{ts} is defined. With this new value the next iteration of the model is initiated and the process is repeated until convergence.

4. RESULTS AND COMPARISON WITH LITERATURE

The model presented in this paper (VUKA model [2]) was compared to the model in literature [11]. The model was modified to include specific speed N_s and velocity ratio v_s as input parameters instead of calculating them. The results of comparison are given in Table 1. The nomenclature is as presented in [2]. The differences in values are shown as percentages in the brackets. The compared models show good match in values of majority of geometric parameters. The large difference in the predicted efficiency is due to different loss models used in the calculations.

***Table 1**: Model comparison*

Input	Da Lio [11]	VUKA model
Working fluid	R245fa	
$\dot{m}$ [kg/s]	20	
T_{01} [°C]	65	
p_{01} [bar]	4,63	
p_5 [bar]	1,976	
N_s	0,45	0,45
v_s	0,65	0,65
Output		
r_4[m]	0,246 (-0,08%)	0,2462
Z_r [-]	23 (0%)	23
β_{4blade}[°]	0 (0%)	0
k_{B4} [-]	0,85 (-0,42%)	0,8536
b_4[m]	0,032 (-2,32%)	0,03276
r_{s5}[m]	0,170 (-1,33%)	0,1723
r_{h5}[m]	0,068 (-0,07%)	0,06805
b_5[m]	0,102 (-2,2%)	0,1043
β_{5blade}[°]	58,5 (+0,29%)	58,33
Z [m]	0,153 (-2,17%)	0,1564
b_3[m]	0,032 (-2,32%)	0,03276
b_2[m]	0,032 (-2,32%)	0,03276
r_3[m]	0,260 (-0,65%)	0,2617
o_{n3}[m]	0,0122 (+3,21%)	0,01182
c_{n3}[m]	0,0752 (+3,01%)	0,07308

γ_3[°]	9,0 (-1,11%)	9,101
r_2[m]	0,28 (+0,94%)	0,2774
γ_2[°]	24,3 (+13,76%)	21,36
β_2 [°]	24,3 (+13,76%)	21,36
Z_s	29 (-3,33%)	30
r_1[m]	0,377 (+4,6%)	0,3604
A_1[m^2]	0,030 (+27.49%)	0,02353
SP[m]	0,12 (-1,72%)	0,1221
VR	2,3 (+1,45%)	2,267
η_{ts}[%]	88,9 (+12,55%)	78,99

5. CONCLUSION

A preliminary design model for a radial inflow turbine using an organic working fluid was presented in this paper. For a set of input parameters, the model defines geometric parameters of the turbine and thermodynamic parameters of the working fluid at inlet and outlet stations of each component. The model analyses losses and predicts total-to-static efficiency of the turbine. The model shows good match with the model available in the literature. The large difference in the value of turbine efficiency is due to the different loss models the authors used to predict the losses. Geometric parameters obtained using preliminary design model are a good starting point for further analysis and optimization using CFD (Computational Fluid Dynamics).

REFERENCES

[1] Aungier, R. H.: *Turbine aerodynamics: Axial-flow and radial-inflow turbine design and analysis, 1st ed.*, ASME Press, ISBN: 9780791802410, New York, 2006.

[2] Đuretković, M.: *Konstrukcija turbine s radijalnim ulazom radnog fluida za potrebe geotermalne elektrane*, Završni rad, Karlovac: Veleučilište u Karlovcu, 2021.

[3] Balje, O. E.: *Turbomachines: A Guide to Design, Selection and Theory,* John Wiley and Sons, ISBN: 0471060364, New York, 1981.

[4] Wasserbauer, C.A., Galssman, A.J.: Fortran program for predicting off-design performance of radial-inflow turbines, *Available from:* https: //ntrs.nasa.gov /citations /19750024045 , *Accessed*: 2021-06-10.

[5] Moustapha, H., Zelesky, M. F., Baines, N. C., Japikse, D.: *Axial and Radial Turbines,* Concepts NREC, ISBN: 0933283121, White River Junction, VT, USA, 2003.

[6] Dambach, R., Hodson, H.P., Huntsman, I.: An experimental study of tip clearance flow in a radial inflow turbine, *Available from* https: //asmedigitalcollection.asme.org /GT /proceedings/GT1998/78620/V001T01A110/248667 , *Accessed*: 2021-06-20

[7] Vilim, R.B.: Development and Validation of a Radial Inflow Turbine Model for Simulation of the SNL S-CO 2 Split-Flow Loop*, Available from* https: //publications.anl.gov /anlpubs /2012 /07 /70861.pdf , *Accessed*: 2021-06-20.

[8] Qi, J., Reddell, T., Qin, K., Hooman, K., Jahn, I. H. J.: Supercritical CO_2 Radial Turbine Design Performance as a Function of Turbine Size Parameters, *ASME. J. Turbomach*., **139** (2017), No. 8: 081008. ISSN: 0889-504X

[9] Suhrmann, J. F., Peitsch, D., Gugau, M., Heuer, T., Tomm, U.: Validation and Development of Loss Models for Small Size Radial Turbines, *Proceedings of ASME Turbo Expo: Power for Land, Sea and Air*, pp. 1937–1949, ISBN: 978-0-7918-4402-1, Glasgow, UK, June 2010, ASME, New York, 2010.

[10] Deng, Q., Shao, S., Fu, L., Luan, H., Feng, Z.: An Integrated Design and Optimization Approach for Radial Inflow Turbines-Part I: Automated Preliminary Design, *Appl. Sci.,* **8** (2018)*,* No. 11: 2038. ISSN: 2076-3417

[11] Da Lio, L., Manente, G., Lazzaretto, A.: A mean-line model to predict the design efficiency of radial inflow turbines in organic Rankine cycle (ORC) systems, *Applied Energy* **205** (2017) pp. 287 – 209, ISSN: 0306-2619

GEOTHERMAL POWER PLANT OPTIMIZATION WITH TURBINE PRELIMINARY DIMENSIONS ESTIMATION

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Abstract: *Organic Rankine Cycle (ORC) with a radial inflow turbine (RIT) as the expander is a suitable technology for power generation from geothermal sources. In this paper geothermal power plant based on simple ORC configuration is optimized based on first and second law of thermodynamics. A model that estimates geometry and efficiency of RIT is integrated in the model of the ORC. The optimization was performed on an example of the geothermal field Rečica near Karlovac. Optimization is conducted for 6 organic working fluids and different combinations of values of input parameters. Objective functions of optimization are exergetic efficiency and net generated power of the power plant. Dimensions of the RIT determined during optimization for each combination are analyzed and compared.*

Keywords: *Radial inflow turbine, Preliminary design, Organic Rankine Cycle, Geothermal power plant, Optimization*

1. INTRODUCTION

Organic Rankine Cycle (ORC) is a Rankine cycle using an organic fluid instead of steam as a working fluid. Organic working fluids are characterized by low temperature and pressure of evaporation, and large molecular mass. Due to the properties of the organic fluids the ORC is a viable technology for power generation from low and medium temperature renewable energy sources such as solar and geothermal. It is also suitable for power plants that use biomass fuel and for waste heat recovery. Basic ORCs can be divided into those working with subcritical pressures and those working with supercritical pressures (up to 80 bar). A schematic of a simple subcritical ORC geothermal power plant is presented in Figure 1. The pump pressurizes the working fluid (red line) which is then preheated, evaporated, and superheated using the heat from geothermal fluid (green line). The heat exchange between the geothermal and working fluid occurs in 3 heat exchangers.

The preheater (PRG), the evaporator (ISP) and the superheater (PR). After that, the organic fluid vapour expands in the turbine, and lastly, it is condensed in the air cooled condenser. The supercritical configuration is the same except the heat exchange between the geothermal and working fluids is performed in one high-pressure heat exchanger (Figure 2).

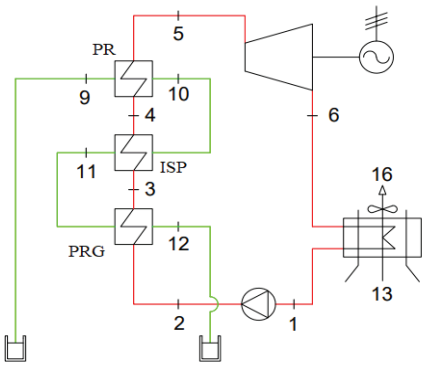

Figure 1: subcritical simple ORC [1]

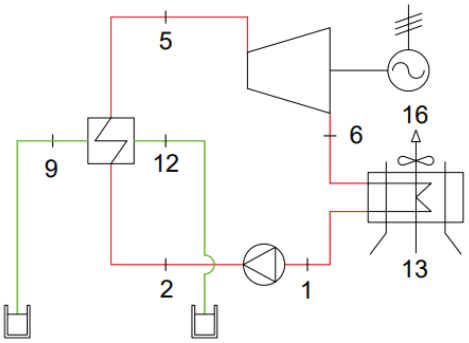

Figure 2: supercritical simple ORC [1]

2. OPTIMIZATION

A mathematical model of a simple ORC geothermal power plant was defined in the Engineering Equation Solver software. Mathematical model of a radial inflow

turbine (RIT) was integrated with the ORC model. It is common to set a fixed value of turbine efficiency when analyzing ORCs, but with simultaneous modelling of parameters of the ORC and the RIT, more realistic results are obtained. The details of the model are available in [1].

The optimization was performed using the genetic algorithm method in the Engineering Equation Solver software. The optimization was performed on an example of the geothermal field Rečica near Karlovac. The parameters of the geothermal fluid of the field Rečica used in the model are: temperature $T_{geo,in}$=120°C, pressure p_{geo}=20 bar and mass flow rate of the fluid $\dot{m}_{geo}$=94,38 kg/s. The optimization of the following ORC configurations is presented:

1) Simple ORC with subcritical pressure, ΔT_{pp} =5°C, N=3000 rpm
2) Simple ORC with subcritical pressure, ΔT_{pp} =10°C, N=3000 rpm
3) Simple ORC with subcritical pressure, ΔT_{pp} =5°C, $N\neq$3000 rpm
4) Simple ORC with subcritical pressure, ΔT_{pp} =10°C, $N\neq$3000 rpm

ΔT_{pp} is the pinch point temperature and it is alternated between the values of 10°C and 5°C. N is the rotational speed of the turbine and it is set as 3000 rpm or it is set as an independent variable of optimization. The value of N=3000 rpm was chosen because it is a common speed of rotation of a generator designed for a 50 Hz electrical grid. In that case there would be no need for a reduction gearbox. The 4 configurations were combined with 6 different working fluids: R32, R134a, R143a, R290, R1234yf and propylene.

The objective functions to be maximized are exergetic efficiency of the plant $\eta_{plant,ex}$, and net generated power W_{net}. The independent variables are maximum pressure in the cycle p_5 (turbine inlet pressure, state 5 in Figure 1 and 2), degree of superheating ΔT_{SH}, and rotational speed N in the case it is not fixed.

3. RESULTS

The results are presented in Figure 3 and Figure 4. The figures contain the maximized values of $\eta_{plant,ex}$, and W_{net}. The size of the turbine can be estimated and compared by the values of axial length Z of the rotor and the diameter d_4 of the rotor inlet. The sketches of the rotor contour are provided for comparison.

The results obtained in [1] show that the two objective functions have the maximal value for the same values of independent parameters, so in this paper only the result of maximization of $\eta_{plant,ex}$ are presented.

The results show that the configurations with ΔT_{pp} =5°C have higher efficiency and net power, and slightly larger dimensions of the rotor compared to the configurations with ΔT_{pp} =10°C.

The configurations with $N\neq$3000 rpm have higher efficiency and net power, and smaller dimensions of the rotor compared to the configurations with N=3000 rpm. The optimal value of N for all fluids is higher than 3000 rpm.

From the obtained results it can be concluded that the optimal configuration for the geothermal power plant considered in this paper would be the configuration with the working fluid R1234yf, ΔT_{pp} =5°C, and N = 5689 rpm

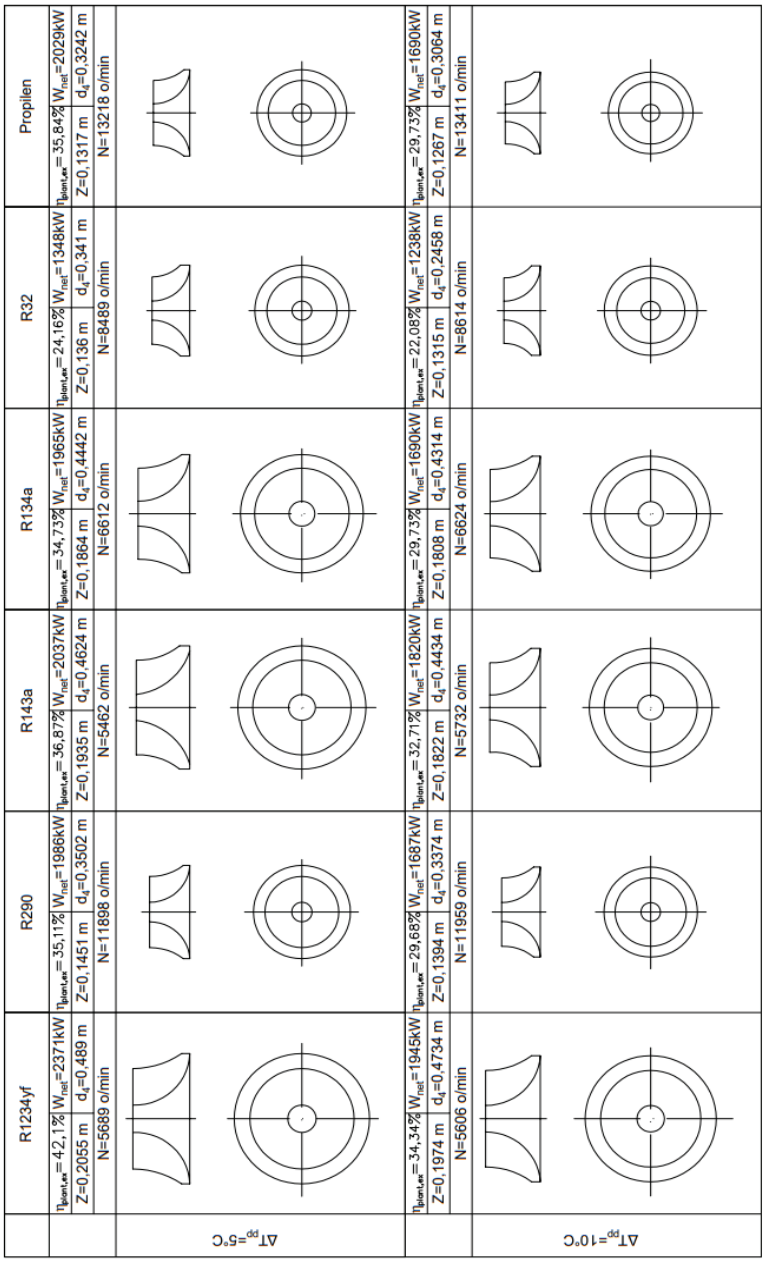

***Figure 3**: Results - Objective function $\eta_{plant,ex}$, N≠3000*

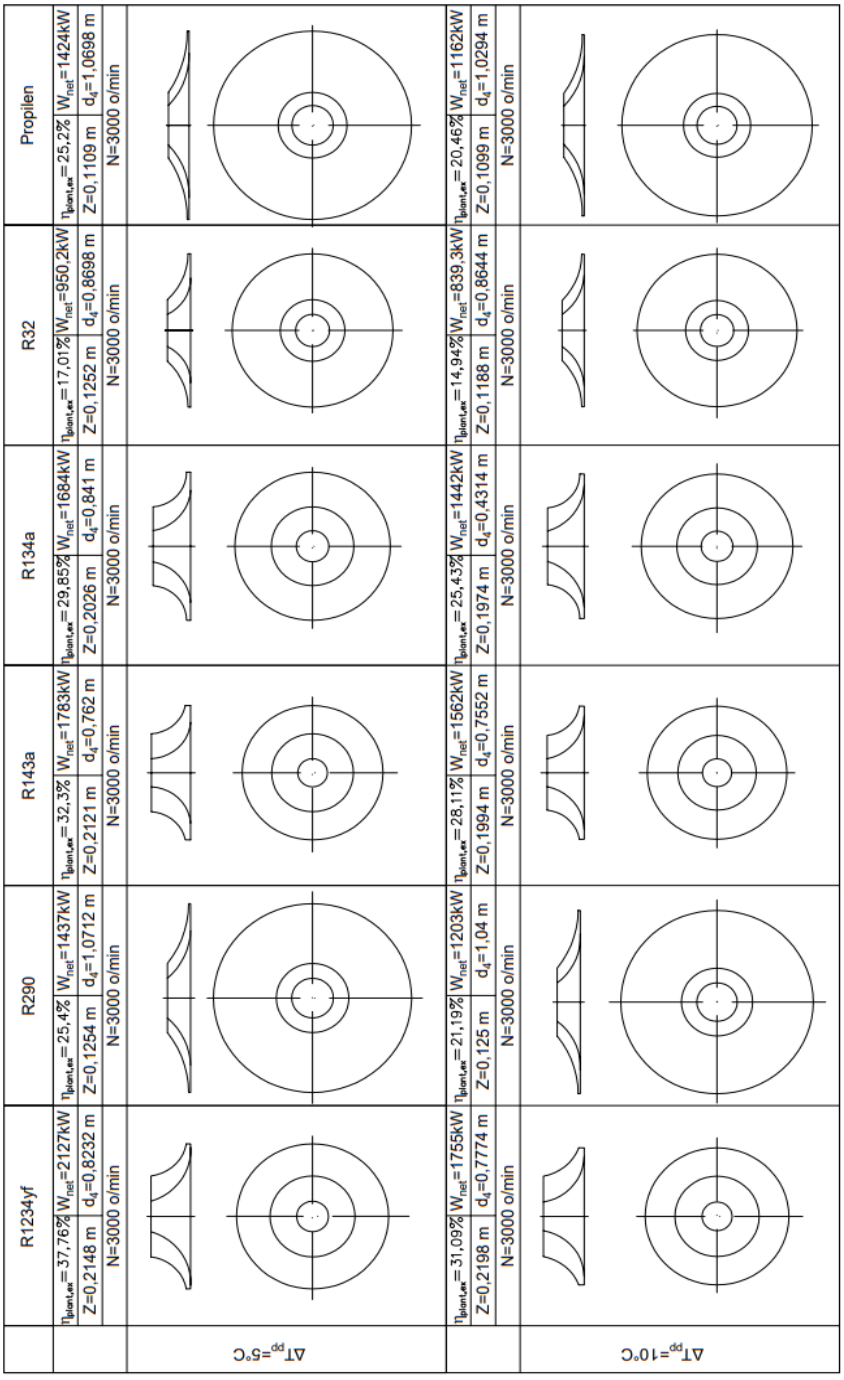

Figure 4: Results - Objective function ηplant,ex, N=3000

4. CONCLUSION

In this paper optimization of an ORC geothermal power plant is presented. The independent variables to be optimized are maximum pressure in the cycle p_5 (turbine inlet pressure, state 5 in Figure 1 and 2), degree of superheating ΔT_{SH}, and rotational speed N in the case it is not fixed at 3000 rpm.

The optimal configuration that yields the maximum exergetic efficiency ($\eta_{plant,ex}$=42,1%) and net generated power (W_{net}=2371 kW) for the geothermal power plant considered in this paper would be the configuration with the working fluid R1234yf, ΔT_{pp}=5°C, and N = 5689 rpm. The rotational speed of the turbine in this configuration is not a standard rotational speed for a 50 Hz generator, so a reduction drive has to be used.

If the use of a reduction drive is not acceptable, the optimal configuration is the configuration with working fluid R1234yf, ΔT_{pp}=5°C, and N=3000 rpm. This configuration has lower efficiency ($\eta_{plant,ex}$=37,76%) and net power (W_{net}=2127 kW), a larger turbine, but there is no reduction drive.

Economic analysis should be performed to determine if the increase in exergetic efficiency and net generated power is worth the increase in cost due to the need for a reduction drive.

REFERENCES

[1] M. Đuretković, "KONSTRUKCIJA TURBINE S RADIJALNIM ULAZOM RADNOG FLUIDA ZA POTREBE GEOTERMALNE ELEKTRANE", Završni rad, Veleučilište u Karlovcu, Karlovac, 2021. Dostupno na: https://urn.nsk.hr/urn:nbn:hr:128:732786

INFULENCE OF STEERING ON SAFETY OF TRAILERS WITH TWO AXLES IN CURVED TRAJECOTRY

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Abstract: *The aim of this paper is to show an assessment process of two axle trailers steering mechanism's influence on safety in curved trajectories. Safety is in first order considered through the envelope of trailers sides in curved trajectory and its tires path, in relation to the road's edge. The assessment is based on numerical solution for trailer position w.r.t. time. The geometrical equations have been developed and solved in discretized time steps.*

A trailer with two axles with rigid front axle pivoting around a midrange axis and an Ackermann's principle all-wheels steering trailer have been considered for a case study. Kinematics of the trailer's path have been described by equations which are then discretized in time. The trailer's cargo part's envelope is one of the safety factors considered, while the second one is the tires path envelope w.r.t. the road edge.

The results show that the all wheels steering offers more safety by the two considered criteria than the rigid front axle pivoting steering principle.

Keywords: *trailer, steering, curved trajectory, safety, envelope.*

1. INTRODUCTION

The trailers considered in this paper are usually used in road traffic as additional load carrying vehicles towed by a truck [1, 3, 7, 9]. The distinction between a trailer and a semi-trailer is in the center of gravity of trailer in relation to its wheels, i.e. a trailer is self-carrying vehicle, having its weight supported by the tires. Trailers have at least 2 axles, which is for the simplicity taken as a case study example. Usually, the front axle is rigid and pivots around the mid-width axis. The towing arm can swivel around a horizontal axis to compensate in vertically curved trajectories. The rare cases [9] are used in road traffic, while [4, 5] most using all wheel steering, in form of rigid axles or individually turning wheels, are in agricultural and sport applications. This type of steering offers advantages in sense of the rear axle(s) does not follow a wide

track relative to the front tires. Additionally, the steering mechanism lever ratio is a free parameter which affects the tilt angle of towing arm to the radius of curvature for the trailer's center of gravity. It also affects the trailer's dynamic [9].

2. VEHICLE KINEMATICS

The vehicles considered are a truck with two axles, and the connecting trailer. The truck chosen for the case study is shown in figure 1 a). The names of either vehicles manufacturers is ommited here. It is a two axle medium carrying capacity truck. The trailer chosen for the case study is of the simmilar overall length, with two axles. The first trailer steering type is shown in figure 1 b). It has a rigid front axle, with a pivoting joint in the middle of axle's width. The second type, intended to show possibilities of improvement of safety in driving through the curved parts of road [6, 8] is steerable trailer, with the same overall length, same wheelbase, and same wheels. The steering mechanism is based on the Ackermann principle [1, 9], with mid-length line as the intended "fixed" line for the kinematics pole, shown in figure 1 c).

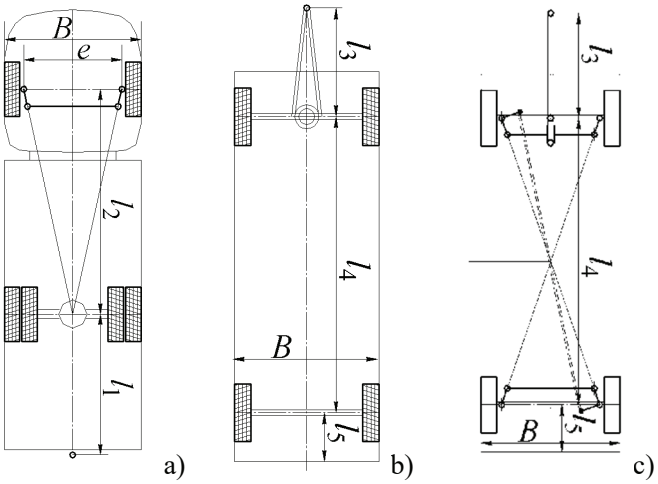
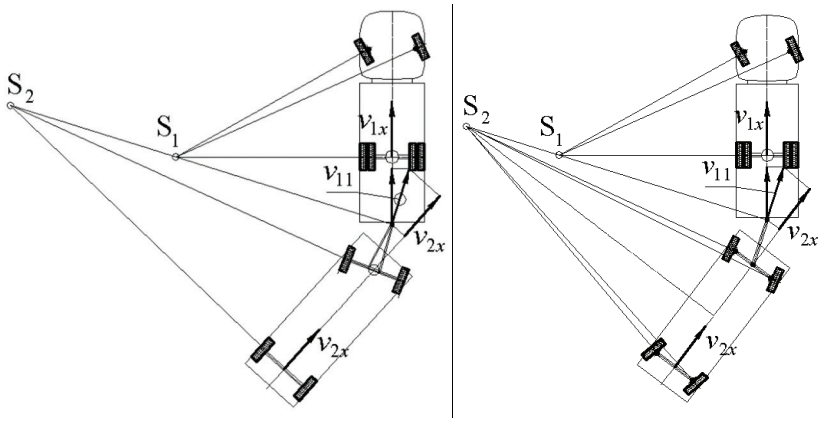


Figure 1: Vehicles basic geometric parameters: a) truck, b) trailer with a rigid front axle, c) trailer with steerable wheels

A truck with a trailer in a curved road is shown in figure 2. Trailer with a rigid front axle is shown in figure 2 a), while a trailer with all wheel steer is shown in figure 2 b). The truck has a kinematic pole marked "S_1" and the velocities are determined from the rotation around that kinematic pole in horizontal plane. In the figure 2 v_{11} denotes velocity of the trailer' hitch point, v_{1x} is the longitudinal component of velocity for the truck, φ_{11} is the angle defined by the pole S_1, r_{Tl} is the path curvature radius of the trailer' front left wheel, Δ is the distance from S_1 to S_2, ω_2 is current

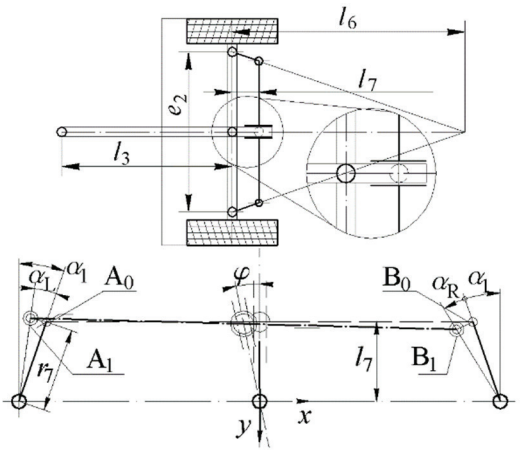
angular velocity for trailer. The connecting point between the truck and trailer is the hitch, with velocity v_{11}, determined by the truck's kinematics. Hence, the same line perpendicular to the v_{11}, is the line connecting the kinematic pole for the trailer, marked "S_2". The trailer could at any given point (time) have different rotational velocity from the truck's. By the line of least resistance principle, the front axle adjusts its position to aline the axis with the line passing through S_2. Further, the rear axle alines its axis to pass through S_2. Following the geometry relations in figures 1 and 2 a), the trialer kinematics is described by

$$v_{11} = \frac{v_{1x}}{\cos(\varphi_{11})}\ ;\ \varphi_{11} = \operatorname{atan}\left(\frac{l_1}{r_{TI}}\right)\ ;\ r_{TI} = \frac{e}{2} + \frac{l_2}{\tan(\alpha_L)}\ ,$$
$$(r_{11} + \Delta)\sin(\varphi_{21}) = l_3\ ;\ r_{21} = \frac{l_3}{\tan(\varphi_{21})}, \cos(\varphi_{22}) = \frac{r_{22}}{r_{21}}$$
$$v_{11}\cos(\varphi_{21})\cos(\varphi_{22}) = r_{22}\omega_2 = v_{2x}\ ;\ v_{\perp} = v_{11}\sin(\varphi_{21}) \qquad (1)$$



a) b)

Figure 2: Vehicle's kinematics in a curved trajecotry:
a) trailer with a rigid front axle, b) all wheel steering



a) b)

Figure 3: Trailer all wheel steering mechanism:
a) top view, b) geometry in steering

For the all wheel steering trailer, according to geometric parameters shown in figure 3 a), with l_6 = 0,5 l_4, the relationship between the connecting rod l_5 rotation angle and the wheels rotation angle can be derived based on the kinematics analysis in figure 3 b). Connecting towing rod pivots around an axis placed on midrange of the front axle, and slides within a tilting slider detailed in a bigger circle on figure 3 a). The connecting rods in trapeze mechanism have length r_7 which is calculated from the parameter l_7 by $r_7 = l_7/\cos(\alpha_1)$, with $\tan(\alpha_1) = e_2/l_4$. The joint stubs denoted A and B in figure 3 b) move as the towing rod tilts in cornering, and their position as a function of the difference in angle for each wheel (sideways, left and right) in vector form is

$$x_{A_1} = \{-0{,}5e_2 + r_7\, sin(\alpha_1 - \alpha_L)\,, -r_7\, cos(\alpha_1 - \alpha_L)\}$$

$$x_{B_1} = \{0{,}5e_2 - r_7\, sin(\alpha_1 + \alpha_R)\,, -r_7\, cos(\alpha_1 + \alpha_R)\} \qquad (2)$$

The length of rack is considered constant, and relates to the steering angles in (2) by

$$l_{rack} = const. = e_2 - 2l_7 \tan(\alpha_1) = \sqrt{(x_{A_1} - x_{B_1})^2 + (y_{A_1} - y_{B_1})^2} \qquad (3)$$

Another kinematic relation in the steering mechanism is the motion of the towing rod, in relation to motion of the rack. Relation of the tilting angle of rod to motion of the midpoint of the rack is given by

$$\frac{x_{A_1}+x_{B_1}}{2} = -l_8 \sin(\varphi)\,, \frac{y_{A_1}+y_{B_1}}{2} = -l_8 \cos(\varphi) \Rightarrow \frac{x_{A_1}+x_{B_1}}{2\sin(\varphi)} = \frac{y_{A_1}+y_{B_1}}{2\cos(\varphi)} \qquad (4)$$

At any given point of time in motion through the curved trajectory the truck has an angular velocity ω_1 determined by its translational velocity and the road curvature radius. With the geometry relations described, the next step is the calculation of the envelope of trailer's body and tires track in a curved trajectory. This will be calculated by the finite difference method [10], discretizing the velocity equation by the forward difference scheme. This means the path for a chosen period of time Δt for vehicles is calculated from the velocity equation.

3. FINITE DIFFERENCE METHOD

The kinematics equations describing trailer's motion (1) – (4) are solved in an incremental manner, utilizing the finite difference method [2, 10]. For the sake of brevity, many details are ommited here, including figures depicting solution steps. All the solutions are based on the simplest finite difference scheme, explicit Euler method using forward difference [10]. Since the vehicles rotate in horizontal plane, the difference in angle with respect to the coordinate system at the beginning of the curved trajectory, the difference in position after a chosen time step is averaged. First, the truck's position for each time instance is calculated, using equations (1), then by the equations (2) – (4) for the trailer. This means the new position is calculated as

$$\omega_i = \frac{v_{1x}}{r_i} \; ; \; \omega_{i+1} = \frac{v_{1x}}{r_{i+1}} \Rightarrow \varphi_{i+1} = \varphi_i + 0{,}5(\omega_{i+1} + \omega_i)\Delta t.$$

$$x_{i+1} = x_i + v_{1x}\Delta t cos[0{,}5(\varphi_{i+1} + \varphi_i)]; \Rightarrow y_{i+1} = y_i + v_{1x}\Delta t sin[0{,}5(\varphi_{i+1} + \varphi_i)] \quad (5)$$

In the equation (5) φ_i is the angle of the rear axle' axis w.r.t. the y axis in figure 2 a) at the time instance t_i , At the next position after Δt that angle is changed to φ_{i+1}.

4. RESULTS AND COMPARISSON

After solving above equations using a constant time step, the envelope of body and tires can be drawn. The truck's envelope is shown in figure 4 throughout the curved trajectory. The trailer' envelope is shown in figure 5.

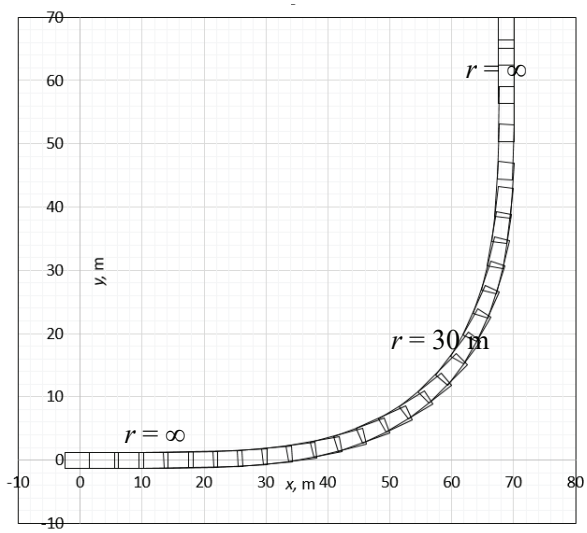


Figure 4: Truck's kinematics (envelope) in a curved trajectory

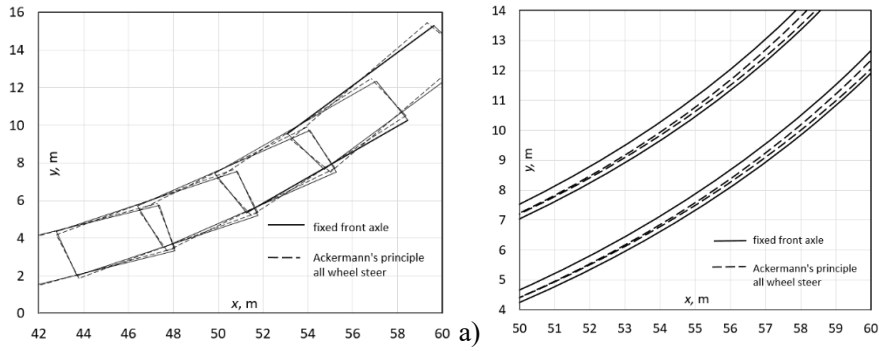


Figure 5: Comparison of the trailer' trajectory envelope: a) body, b) tires

As it can be seen from figure 4, the widest envelope of truck is in the parts of trajectory with highest rate of change of the curvature radius, around the minimum radius, mid way through the curve. From the diagrams showing envelopes of trailer's body and tire tracks, in figure 5, it is noticable the all wheel steering trailer has a narrower body envelope and tire tracks. This is more pronouneced in parts of the trajectory where more rapid change of radius occurs, leading to the bigger and rapidlly changing difference in angle of truck to the towing arm. In these conditions the all wheel steering trailer has more pronouneced advantage over rigid front axle.

5. CONCLUSION

This paper shows comparison of trailer kinematics between trailer with a rigid front axle and a trailer with al wheel steer. The comparison shows improved envelope of trailer's body in curved trajectory, and the tire track in relation to the tarmac edge.

The trailer with a fixed front axle exhibits a wider trajectory envelope that the one with Ackermann's principle all wheel steering, having the same geometry. The improvement for the all-wheel steering trailer has proven to be around 0,13 m in envelope width in the narrowest part of trajectory, with the middle road radius of 30 m. The trailer tires track is also affected by the steering mechanism; the all-wheel steering shows narrower tire track than the rigid front axle by 0,15 m with the middle road radius of 30 m. The road variable radius also affects the trailer behavior and difference in envelope and tire track. In the parts of road with larger gradient of radius along the trajectory, the difference is slightly bigger.

The analysis shown above, hence the results, do not include trailer dynamics. Therefore, the different steering mechanisms do show improvement of all wheel steering over the rigid pivoting front axle.

REFERENCES

[1] Gillespie, T.D. *Fundamentals of Vehicle Dynamics*; ISBN 978-1-4686-0176-3, SAE International: Warrendale, PA, USA, 2021.
[2] Group of authors: *Inženjerski priručnik IP1* (in Croatian), Školska knjiga, ISBN 953-0-31662-3, Zagreb, 1996.
[3] Heisler, H. *Advanced Vehicle Technology*, 2nd edition; ISBN: 9780080493442, Elsevier: Amsterdam, The Netherlands, 2002.
[4] https://www.demco-products.com/agriculture/harvest-equipment/head-transports/all-wheel-steer-head-transports. Accessed: 11.04.2022.
[5] https://www.mafi.de/en/products/trailers/anwendung-instrieanhaenger/. Accessed: 11.04.2022.
[6] Lamm, R.; Psarianos, B.; Mailaender, T.; Choueiri, E.M.; Heger, R.; Steyer, R. : *Highway Design and Traffic Safety Engineering Handbook*, 1st edition; McGraw-Hill: ISBN 0070382956, New York, NY, USA, 1999.
[7] Mikulić, D.: *Motorna vozila. Teorija kretanja i konstrukcija, III izdanje* (in Croatian). Veleučilište Velika Gorica, ISBN 978-953-7716-89-9, Velika Gorica, 2020.
[8] *Pravilnik o osnovnim uvjetima kojima javne ceste izvan naselja i njihovi elementi moraju udovoljavati sa stajališta sigurnosti prometa*, (In Croatian), available online : https://narodne-novine.nn.hr/clanci/sluzbeni/2001_12_110_1829.html. Accessed: 15.04.2022.
[9] Preda, I., Covaciu, D.: *About the Steering Kinematics of the Road Trains*. 11th International Congress of Automotive and Transport Engineering. DOI: 10.1007/978-3-319-45447-4_7. University of Pitesti, Romania, November 2017.

[10]Sorić, J.: *Uvod u Numeričke Metode u Strojarstvu* (in Croatian); Golden Marketing: Zagreb, Croatia, 2008.

IMPROVEMENT OF SAFTEY OF COLUMNS WITH GEOMETRICAL IMPERFECTIONS IN FRAME STRUCTURES

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Abstract: *In this paper derivation of differential equation describing buckling of a column with initial geometrical imperfections and variable cross – section is presented. The column geometry (the cross section) is changeable (variable), for the purpose of achieving higher load carrying capacity at given load set with optimizing the material quantity. A solution of the differential equation has been obtained by the collocation method.*

The assessment of safety (carrying capacity) of such a loaded column is carried out comparing the extreme stress in the deformed column with the material limit stress value with a dictated safety factor. Side loads, such as the wind pressure, is condensed into a side force at the column tip. The vertical loads act twofold on the columns; directly compressional and indirectly flexural through the horizontal beam and column joint due to flexing of horizontal beam.

The results show improvement in safety by adding simple widening of hot rolled standard HE profiles by inserting distance plates and welding.

Keywords: *safety, column, frame structure, buckling, geometrical imperfection*.

1. INTRODUCTION

The frame structures are an essential part of various metallic structures, such as warehouses, farm facilities, and so on. The frame structure consists of columns, the vertical (mostly) elements, and a beam, bridging the columns. Often the beam is designed as a truss carrier. Loads in frame structures are always their own weight, sometimes a “usefull” load from weight of an object being lifted, i.e suspended from the beam, and sometimes sideways load from the wind. All the vertical loads act on bending the beam, causing the end parts of it to rotate. Those ends are rigidly joined (connected) to the columns tips, and so acting on the columns by the bending moment. The columns react and oppose those rotations in some extent, acting as resistance to the beams rotation. The columns are supposed as geometrically imperfect, i.e., not straight, rather in all the points between the ends have some deflection. This initial deflection is presumed as a shifted cosine. All the vertical load acts on columns in sense of pressing them. The wind sideways load acts on bending the columns. Any rotation of columns at their tips acts on the beam by a bending moment. Overall, the initial

geometrical imperfection and all the loads cause the column's tips to deflect from the initial vertical position above the base foundation position of the column's cross – section center of gravity, hence giving the vertical pressing load a distance at any cross – section along it. This is the root cause of column's nonlinear behavior.

For the frame structures in a case of combined loads described in Technical roolbook ("Tehnički pravilnik o čeličnim konstrukcijama" in Croatian) for steel constructions [5] and in EUROCODE [3] roolbook offers solutions for critical load for various constraint cases. which are the basic carrying elements of the mentioned buildings, the safety calculation (the carrying capacity) Calculation proceedure in those roolbooks cover wide range of load and support combinations. However, they do not offer details in introducing stiffeners or reinforcements. A user cannot view in detail how the bending moment hence the stress is distributed. So, tha aim of this approach is to offer a numerical solution procedure to have an insight into details of deformation and load of columns.

2. PROBLEM FORMULATION

Following the detailed derivation of the differential equation for the initially imperfect (non strainght) column, shown in [6], a frame structure, figure 1 a), shows problem statement. A column with loads and constraint is shown in figure 1 b). A free body diagram of a part of a column in equelibrium state is shown in figure 1 c). The initial geometrical imperfection shown in figure 1 b) by w_0 shall be simplified as a shifted cosine rather than real measurement and approximation of the measured data by polynomial or some other function. The shifted cosine has the form $w_0\,(x) = 0{,}5e(1 - \cos\left[\frac{2\pi x}{L}\right])$.

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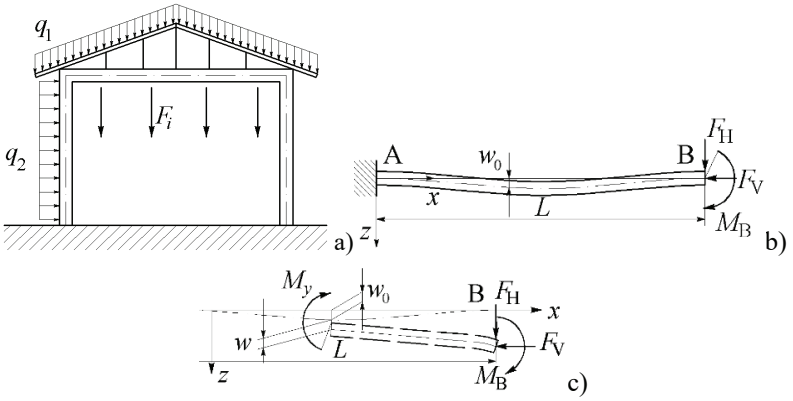

Figure 1: Column in a frame structure: a) A frame structure, b) Physical model of a column, c) A free body diagram

2.1. Differential equation for column deformation description

Using the equlibrium equation of moments around the *y* axis in figure 1 c) gives the differential equation for deformation state of a column. The underlying theory is Euler – Bernoulli thin beam bending theory [1, 2, 4]. Equilibrium equation is in form

$$M_y = -F_V\left(w_B - w\,(x) - w_0(x)\right) - F_H(L-x) - M_B = -\frac{d^2w}{dx^2}EI_y(x) \tag{1}$$

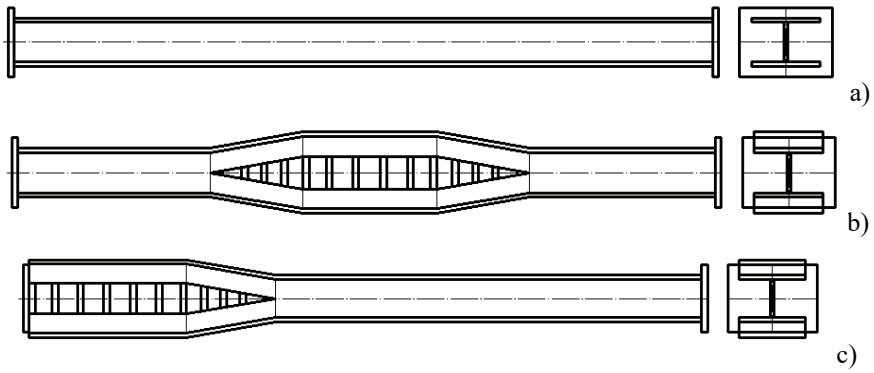

Figure 2: Columns from the standard hot rolled HE profile: a) A constant cross section, b) Simmetrically reinforced, c) unsimmetrically reinforced

The solution of the structure's deformed state (i.e, the columns) has been obtained by adopting numerical procedure based on a presumed solution and imposing a condition of exact satisfying the differential equation (1) at chosen set of points, described in detail in [2, 4, 7]. The solution is in polynomial form, without detailing for the sake of brevity, depicted by

$$w(x) = C_0 + C_1x + C_2x^2 + C_3x^3 + C_4x^4 + C_5\left(1 - cos\left[\frac{2\pi x}{L}\right]\right). \tag{2}$$

On the solution (2) firstly the constraint conditions for the fixed lower end, $w(0) = 0$, $dw/dx(0) = 0$ have been imposed. Further on, the remaining 4 unknown parameters will be calculated from the system of equations by setting the exact equilibrium at points $x_i = \{L/4, L/2, 3L/4, L\}$.

Reinforcements for a hot rolled HE profile [3, 5] have been introduced into calculation in two forms, shown in figure 2. The symmetrical one, shown in figure 2 b) has been presumed to consists of cutting the profile at the mid-height for the selected length, widening it for desired height, inserting small distance plates, and welding it together. The unsymmetrical reinforcement is shown in figure 2 c). It is an attempt to give more rigidity to a seemingly critical part of column, next to the joint with the truss beam.

3. ANALYSIS RESULTS

Following the creation of system equations matrix based on input parameters, including material properties, geometry of frame structure parts, load details, the equilibrium state, in detail forces and moments at the joints, are being calculated by means of iterative predictor – corrector method. Equilibrium state is expressed through equal rotation angles at joints and equal column's tip displacement. In the diagrams in figures 3, 4 and 5 various frame structure configurations in deformed, equilibrium state, have been shown.

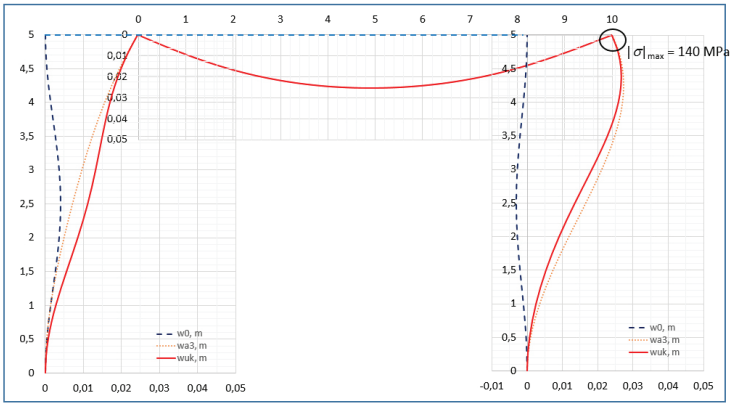

Figure 3: Deformed shape for simmetrically reinforced columns

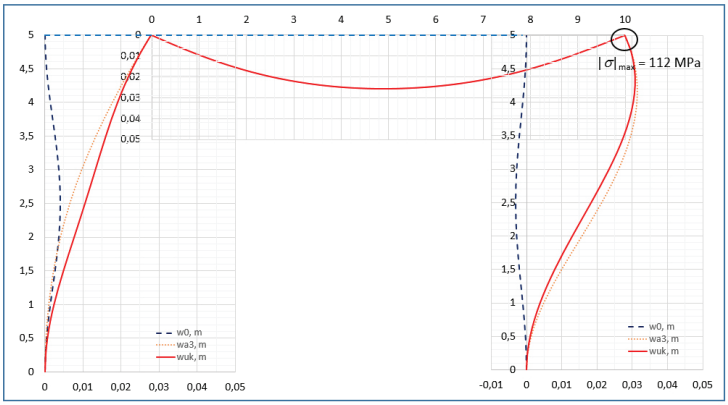

Figure 4: Deformed shape for unsimmetrically reinforced columns

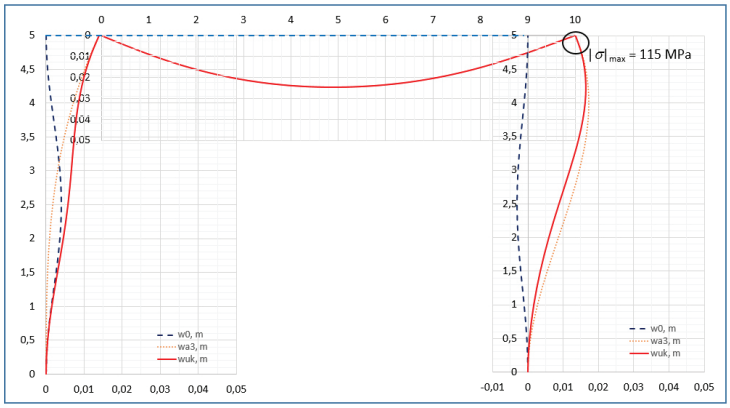

Figure 5: Deformed shape for constant cross section columns

In structure configurations taken for the case study, standard hot rolled profiles have been taken for coulumn solutions, and square tubes for the truss beam solution. The solutions in figures 3, 4 and 5 are based on optimum material use, achieving stresses closest to allowable value as possible. The results shown in figure 5 gives columns with HE120AA , with cross section area 1750 mm^2, while the columns for which the results are shown in figure 3 and 4 have profile HE80AA, with cross section area 1440 mm^2. The unsimmetrical reinforcement of column gives for same increase in profile height more rigidity, and less stress, around 114 MPa, compaerable to the constant cross section with 115 MPa. This leads to approximatley 17% less material w.r.t. the HE120AA profile, with some additional work invested in giving the column localy different geometry.

3. CONCLUSION

This paper presents in brief the differential equation for columns with initial geometrical imperfection loaded with combined three loads, such that it describes behavior of frame structures. The differential equation has been solved numerically by the presumed solution method. The columns were varied in their cross section to investigate how a simple widening of standard hot rolled HE profile can contribute to improvement of safety (load carrying capacity) with total lower material consumed. The widening has been designed as cut in mid width (the flange part of profile) insertion of intermitted plates to maintain increase in the bending height and additionally reinforced by cutting at the mid-height, expanding and inserting small plates and welding it together.

Loads on the columns are vertical force, horizontal force and a bending moment, all acting in the frame structure plane. The load case studied consists of vertical loads caused by the snow covering the roof, beam's own weight, useful cargo weight, and horizontal load from the wind. The initial geometrical imperfection has been modeled as a shifted cosine.

This approach gives detailed analysis of the frame structures, with exception of the truss beam which has been modeled as a continuous beam with analogue cross section moment of

inertia to take into consideration the change of the chord profiles geometry (position). It has been calculated by the analogue beam method. The results for unsymmetrically reinforced columns can lead to 17% less material with same maximum stress in columns.

REFERENCES

[1] Alfirević, I.: *Nauka o čvrstoći I*, Tehnička knjiga d.d., ISBN 953-172-010-X, Zagreb, (1995)
[2] Assakkaf, Ibrahim A.: Advanced Topics in Mechanics-I, *Available from* http://www.assakkaf.com/courses/enes220/lectures/lecture28.pdf *Accessed:* 2016-02-13.
[3] Group of authors: *EUROCODE 3: Design of Steel Structures*, *Available from*, https://law.resource.org/pub/eu/eurocode/en.1993.1.1.2005.pdf, *Accessed:* 2016-02-15.
[4] Group of authors: *Inženjerski priručnik IP1*, Školska knjiga, ISBN 953-0-31662-3, Zagreb, (1996)
[5] Group of authors: *Tehnički propis za čelične konstrukcije*, *Available from*, http://narodne-novine.nn.hr/clanci/sluzbeni/2008_10_112_3269.html, *Accessed:* 2016-02-14.
[6] Hoster, J., Vreš, M.: Saftey of columns with geometrical imperfections in frame structures, *Proceedings of 8th International Professional and Scientific Conference Occupational Safety and Health*, Kirin, S. (Ed.), pp. 306-312, ISSN 2623-6435, Zadar, September 2018., Karlovac University of Applied Sciences, Karlovac, (2018.)
[7] Liu, G. R.: *Mesh Free Methods; Moving beyond the Finite Element Method*, CRC Press, ISBN 0-8493-1238-8, Boca Raton, 2003.

ASSESSMENT OF DANGERS, DAMAGE AND EFFORT TO WHICH THE WORKER IS EXPOSED IN THE TECHNOLOGICAL PROCESS OF ASSEMBLY AND MAINTENANCE OF ANTENNA PLANTS AND DEVICES

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***Abstract**: The paper provides an overview, analysis and assessment of dangers, harms and efforts at the workplaces of assembly and maintenance of antenna plants and devices.*

The paper is formulated in several parts. In the introductory part, the technological process of assembly and maintenance of antenna plants and devices is briefly described. After that, dangers, harms and efforts are processed in more detail through the appropriate form at the workplace "worker on installation and maintenance of antenna plants and devices" and the calculation of the workload of workers during manual load transfer is presented.

In the final part, the application of basic and special occupational safety rules in the work process of assembly and maintenance of antenna plants and devices is presented, and a plan of measures to reduce the level of danger is given.

***Key words**: safety at work, antenna plants, installations, preventive measures*

INTRODUCTION

Safety at work is a set of measures that are implemented to protect the health of workers and persons at work, prevent injuries at work, occupational diseases and work-related diseases. Safety at work is an integral part of every organization and as such is very important to ensure a healthy workplace.
Contributing to worker safety at the workplace is an extremely important task. Risk assessment is a procedure that the employer must do for each workplace. Risk assessment at workplaces can determine specific risk phenomena that appear and to which the worker is exposed (dangers, harms and efforts). The results we obtain

enable the application of certain methods in order to reduce the risk to an acceptable level or eliminate it completely. A well-made risk assessment provides quality knowledge about the requirements of the workplace and the requirements that the worker must meet at such a workplace. For the purpose of creating the final paper, valid laws, rules and regulations in the field of occupational safety were applied. Legal regulations regulate the rights and obligations of employers and workers for the purpose of removing or reducing danger, harm and effort.

The subject area of the final thesis is the review, analysis and assessment of dangers, harms and efforts in the technological process of assembly and maintenance of antenna plants and devices. The paper will present the technological process of assembly and maintenance of antenna plants and devices, analysis and assessment of risks, and measures to eliminate or reduce identified risks will be presented. Assembly work and maintenance of antenna plants and devices are mainly performed on inaccessible terrains, which are difficult to access. Works must be carried out during all periods of the year, during emergency interventions and in unfavorable weather conditions.

Installation works include installation of antennas and devices on antenna structures, installation of waveguides and coaxial cables, as well as installation work on radio relay stations and plants.

Maintenance of antenna poles and devices includes disassembly and assembly of worn out devices and spare parts, removal of rust and worn out parts of the poles, welding and painting of the poles, as well as control of the operation of the device with measuring instruments and a series of accompanying works. There are about 1,000 antenna systems in the Republic of Croatia [1].

RISK EVALUATION

The installation and maintenance of antenna plants and devices is quite a complex process, and due to improper organization of work, faulty work equipment, savings, improvisation, non-compliance with rules, lack of communication and other factors, accidents at work occur, which can result in injury. The work tasks of assembly and maintenance of antenna plants and devices take place mainly at heights and in difficult-to-access terrains at all times of the year, and at these workplaces there are various dangers, hazards and efforts that can cause work injuries, work-related illnesses and professional diseases. The height of antenna systems can exceed 60 meters.

This paper will determine the risks to which workers are exposed during the installation and maintenance of antenna plants and devices, such as the risk of falling from a height of more than 3 meters, working outdoors, exposure to non-ionizing radiation, statodynamic efforts, dangers of electric shock.

Workers in the production process are exposed to an increased risk of falling from a height of more than 3 meters, which can lead to serious injuries and fatal consequences.

Since the risk to the safety and health of workers on antenna poles could not be removed by organizational and basic rules of occupational safety, the employer is obliged to provide workers with personal protective equipment. Therefore, work on antenna poles is unthinkable without personal protective equipment for falling from a height. Personal protective equipment must be safe, maintained, adapted to work and in good condition. Before each start of work, the worker must check all protective equipment and check whether it is in proper condition, and if the equipment has defects or is defective, he must report it to the employer.
The employer must always strive to eliminate or reduce dangers, harms and efforts at the workplace through organizational or basic rules of occupational safety.
On the basis of the created Assessment, rules are applied that eliminate or reduce to the smallest possible extent dangers, harms and efforts, and for this purpose, the necessary material resources are provided.
The risk assessment is carried out in accordance with the Risk Assessment Matrix [3] in accordance with the provisions of Article 7 of the Ordinance on Risk Assessment (Official Gazette No. 112/14), adapted to enable the identification and assessment of deficiencies and risks that may lead to injuries at work or occupational diseases. In cooperation with the experts of the employer and executive workers, the current situation was recorded, the types and extent of hazards related to each workplace were determined.
The analysis of compliance with the requirements on the means of work is the basic preliminary work for the assessment of the remaining risk. In fact, the application of all basic rules of occupational safety (prescribed and recognized) is analyzed.
In doing so, deficiencies in the application of these rules are identified on all machines and devices for work, working and auxiliary rooms, installations and plants.
All deficiencies are documented in the appropriate minutes on the existing condition, so their credibility and the method of elimination, i.e. the application of protective measures, are determined.
As the implementation of the measures must be carried out in an organized manner, the person responsible for their implementation is appointed, as well as the deadline for the elimination of deficiencies, i.e. the application of the protection measure.
In addition to these measures, it is necessary to consider the need to apply appropriate protection measures to the means of work by analyzing all fatal, collective and serious injuries at work, as well as occupational diseases, that is, all dangerous disorders in the work process.
When all the possibilities of applying basic occupational safety rules have been exhausted, the application of special occupational safety rules should be considered.

Special rules analyze the skills of workers for organizing and managing, that is, for working in a safe manner in their jobs and tasks. In doing so, one should primarily take into account the correctness of working procedures.
In addition to the above, care is taken to apply special working conditions, personal protective equipment, safety signs, instructions for working in a safe manner, provision of beverages, first aid and evacuation of persons from closed spaces.

DATA ON HEALTH HAZARDS

The Law on Occupational Safety prescribes the recording of every accident and injury at work, as well as occupational diseases and disruptions in the technological process that could result in injury to workers .Data on injuries at work were taken from documentation on injuries at work, such as reports on injuries at work (OR form) and annual reports on injuries at work. Recorded injuries, occupational diseases and disorders in the work process are shown in Table 1 by year.

Table 1. Presentation injuries , professional diseases and disturbances in the process of work by years

RB	TYPE OF DATA	PERIOD				
		in 2017	2018	in 2019	in 2020	in 2021
1.	Total number of employees			60	59	62
2.	Total number of injured employees			0	0	0
3.	Total number of men injured			0	0	0
5.	Number of minor injuries			0	0	0
6.	Number of serious injuries			0	0	0
7.	Number of fatal injuries			0	0	0
8.	Number of collective injuries			0	0	0
9.	Number of injuries per 1000 employees			0	0	0

10.	Number of injuries per 1,000 employees in the branch of activity	6.44	7.68	7.24	-	-

RISK ASSESSMENT DURING MANUAL CARGO TRANSFER

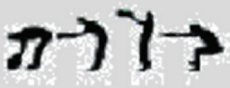
Manual handling of loads means any physical work that involves lifting, carrying, lowering, pushing, pulling or carrying loads by human power and other similar actions (e.g. supporting, holding). More than a third of injuries are caused when handling materials - lifting and carrying loads with the strength of the hands or body. When carrying loads by hand, the vital organs of the human body are strained, such as the heart, back and muscles of the arms and legs. The amount of effort during manual transport of loads, lifting, carrying and lowering, depends not only on the weight of the object itself, but also on its shape, volume and suitability. for transport, as well as the length of the required transport. The danger of manual cargo transport increases with worker fatigue, overestimation of one's own capabilities and unsafe handling of the cargo. As a result of fatigue, reflexes become dull, movements become slower, and gait more uncertain, so the load is lifted improperly and gripped insecurely, which makes the transport itself difficult.[4,5

CALCULATION OF THE DEGREE OF WORKER LOAD DURING MANUAL TRANSFER OF LOADS

Periodic repetitive motion with short-term load transfer › number of tasks during the working day	Long-term transmission › the sum of the time of human power when carrying loads in a working day	Value in points **T (1)**
less than 10 times	less than 30 minutes	1
10 – up to 40 times	from 31 minutes to 60 minutes	2
41 – up to 200 times	from 61 minutes to 180 minutes	4
200 to 500 times	from 181 minutes to 300 minutes	6
more than 500 times	more than 300 minutes	8

Cargo weight (kg)		Value in points **T(2)**
For men	For women	

up to 10 kg	up to 5 kg	1
10 to 20 kg	5 to 10 kg	2
20 to 30 kg	10 to 15 kg	4
30 to 40 kg	–	7
more than 40 kg	–	10

Body position	Description of the position when transferring the load	Value in points **T(3)**
	– upper body upright without turning, – load next to the body (leaning on the body), – short transmission path	1
	body in treasure bow down or is the upper one part bodies leisurely rotated burden with body , sitting position or shorter transfer path (up to 5 steps)	2
	body in the deep bow down or very tilted according to forward . a slight forward bend, at the same time the upper part of the body is slightly turned, the load is far from the body or at shoulder height, sitting or standing position	4
	the body in a deep forward bend while the upper part of the body is turned at the same time, the load is far from the body, inappropriate stability of the body posture in a standing, squatting or kneeling position	8

Condition at the workplace	**Value in points T(4)**
Good, ergonomically appropriate conditions at the workplace (enough space, flat and solid floor, which is not slippery, satisfactory lighting, adequate load handling)	0
Non-ergonomic conditions at the workplace, Cramped work space (surface for the worker is less than 1.5m ^{2} , the safety of the position is limited (uneven, inclined, soft or slippery, stairs)	1
Space limited due to height < 2 m	2

Work experience in the jobs he performs	**Value in points T(5)**

0 – 12 months	1
12 months and more	0

T emperature (°C)	**Value in points T(6)**	**Temperature (°C)**	**Value in points T(6)**
below -20	10	-4	0.4
- 18	8.1	-2	0.1
- 16	6.4	from -1 to +21	0
-14	4.9	22	0.7
- 12	3,6	24	1.74
-10	2.5	26	3.74
-8	1.6	28	6.02
-6	0.9	above 30	10

Evaluating the total workload of workers

The total load is an indicator of the worker's load with all the mentioned parameters of work and environment. The evaluation of the total load is calculated according to the equation:

UO= (T2+T3+T4+T5+T6) x T1

For lifting and carrying loads:

T1 – 1 **T2** – 2 **T3** – 4 **T4** – 0 **T5** – 0 **T6** – 0

UO= **(T2+T3+T4+T5+T6) x T1**

UO= (2+4+0+0+0) x 1

IN ABOUT	Explanation of the determined values
until 10	Low load – there is no health risk due to manual load handling.
10 to 25	Increased workload – the possibility of excessive workload for workers with reduced working capacity.
26 to 50	High workload – the possibility of excessive workload in healthy workers. Possibilities to reduce the load due to manual load handling should be explored.
above 50	Very high load – high possibility of health damage due to manual load transfer. It is necessary to use appropriate equipment or other work methods to reduce body load.

PLAN TO REDUCE THE LEVEL OF DANGER

The plan of measures to reduce the level of danger contains the application of basic and special rules of safety at work, as well as other measures that must be applied or taken with the aim of eliminating or reducing the dangers to the minimum possible extent.

The following measures have been determined that must be taken in order to reduce the level of danger at work˘[7-10]

Table 2. Plan to reduce the level of danger

The subject of planning	Deadline for realization	Person responsible for enforcement	Mode of control
Train new workers to work in a safe manner according to Article 27 of the Occupational Safety and Health Act (Official Gazette No. 71/14, 118/14, 94/18 and 96/18)	continuously	Work protection specialist	By reviewing the beliefs
Periodically renew the knowledge of workers for working at height	permanently	Work protection specialist	By reviewing the beliefs
Health examinations of workers	After the deadline	Work protection specialist	By reviewing the beliefs

CONCLUSIONS

By visiting some of the spaces and rooms where the work takes place, reviewing the existing documentation, and analyzing the risks at the workplaces of workers in the technological process of assembly and maintenance of antenna plants and devices , it was established that workers are exposed to medium and high risk when performing tasks and tasks .
As the work takes place mostly at heights of more than three meters, the biggest danger is falling from a height if the employees do not follow all the established and special safety rules at work.
The analysis of all safety rules at work concluded that all conditions for safe work are ensured at an acceptable level of risk, but it can also be concluded that all recorded risks at workplaces can be a potential source of danger for the health and safety of workers.
A plan of measures to reduce the level of danger has been developed, the activities that should be carried out in order to reduce the risk to the minimum possible extent have been defined.

LITERATURE

[1] Risk assessment of the telecommunications company from March 2020.

[2] Rulebook on jobs with special working conditions (Official Gazette 5/84)

[3] Ordinance on creating a risk assessment NN no. 112/14

[4] Ordinance on occupational health and safety training and professional examination (Official Gazette No. 142/2021)

[5] Law on occupational safety NN no. 71/14, 118/14, 94/18 and 96/18
[6] Rulebook on occupational safety in telecommunications companies from 2010.
[7] Directive on temporary work at height (2001/45/EC)
[8] Article: "Rules of safety at work",
https://hr.wikipedia.org/wiki/Pravila_za%C5%A1tite_na_radu

[9] Article: "Injuries at work in the Republic of Croatia",
http://www.hzzzsr.hr/index.php/porefesionalne-bolesti-i-ozljede-na-radu/ozljede-na-radu/ozljede-na-radu-u-hrvatskoj/

[10] Rulebook on the use of personal protective equipment (Official Gazette No. 5/2021)

DRAINBACK SYSTEMS FOR WATER HEATING

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Abstract: *EU strategic policy towards renewable energy consumption brought about incentives and even obligatory usage of solar collectors for water heating in new buildings. Drainback solar systems are becoming increasingly popular for water heating. The operation principle of drainback systems is explained here, along with classification of existing variants of drainback systems and their description. The components used in drainback systems are described and their required characteristics presented. Finally, the advantages of drainback systems over common pressurized antifreeze solar systems are stated.*

Keywords: *solar systems, drainback system, water heating*

1. INTRODUCTION

Fossil fuel resources depletion, population growth, and global warming have strongly promoted the exploitation of renewable energy sources as well as the efficient energy usage. In addition to the absence of energy costs, the utilization of free solar energy has ecological benefits: there is no pollution and greenhouse gas emission.

Residential and service buildings account for approximately 40% of global energy consumption [1]. In Europe, about 15% of household energy is used for water heating [2]. Solar water heating (SWH) presents the most frequent usage of solar energy [3]. The investment in SWH will pay off in 6-15 years, while the system is expected to last for about 40 years [4]. SWH can provide 50-60% energy for domestic water heating [5].

In solar drainback systems (DSs), solar collectors always remain empty of solar fluid in periods of pump inactivity. Due to this main characteristic, there is no risk of freezing in DSs. Also, the excessive fluid temperatures and pressures are prevented.

2. OPERATION PRINCIPLE

A DS can be used in residential and industrial buildings for water heating and space heating as an alternative to the predominant pressurized antifreeze system. Usually, one of these two systems is used in climates with freezing conditions. Most DSs have a separate drainback tank (DT) installed into the supply line, and a heat exchanger (HE) in the collector loop (Fig. 1). The collector loop includes collectors, a DT, a HE, and a pump.

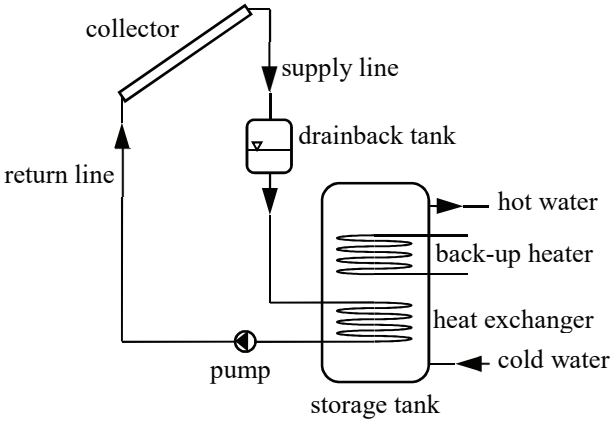

Figure 1: DS with drainback tank and collector-loop heat exchanger

The required amount of air must always be present in the collector loop. While the circulation pump is inactive, this air fills out the collector and all connection tubes situated above the DT. When the collector reaches sufficiently high temperature, the regulator turns the pump on. The pump fills the collector and connection tubes using the fluid stored in the DT. Simultaneously, the air from the collector is pushed into the DT. The normal circulation is thus established – solar fluid drops freely into the DT through the full supply line. The created siphon effect reduces the necessary pump head. The pump is turned off when the sufficiently high water temperature is reached in the storage tank, or when the temperature of the collector is too low. The solar fluid is then drained from the collector, through the return line, the pump, and the HE back to the DT. The air from the DT is simultaneously sucked into the collector and the upper pipeline sections. This way the exposed installation parts are empty whenever freezing or excessively high solar fluid temperatures could occur. Water without glycol is therefore usually used as solar fluid in DSs.

3. DRAINBACK SYSTEM CONFIGURATIONS

The usual DSs are indirect (closed-loop) active systems; direct DSs are rarely used. DSs are usually designed as open (vented to the atmosphere), but almost all system types can be implemented also in pressurized version [6].

Besides the most popular DS type shown in Fig. 1, other system configurations depicted in Fig. 2 are sometimes applied. In DSs with load-side HE, the air volume can be placed either in the DT (Fig. 1) or in an oversized HE (Fig. 2a). In DSs with a separate HE (Fig. 2b), an additional pump is necessary (two-pumped system) for hot water recirculation. Recirculation speed must be low, in order not to disturb the stratification in the storage tank. This DS is particularly suitable if the storage tank must be situated above the collector. Instead of the separate HE, a serpentine HE is sometimes integrated in the lower part of the DT. The application of a load-side HE (Fig. 2c) requires large HEs. The DT is not necessary, as the storage tank can act as DT. DSs without a DT require larger pump heads at startup.

Table 1: Classifications of drainback systems

According to the location of air volume	According to the position of HE
In drainback tank (Figs. 1, 2b)	HE in the collector loop (Figs. 1, 2a)
In oversized HE (Fig 2a)	Separate HE (Fig 2b)
In storage tank (Fig 2c)	HE in the hot water loop (Fig 2c)

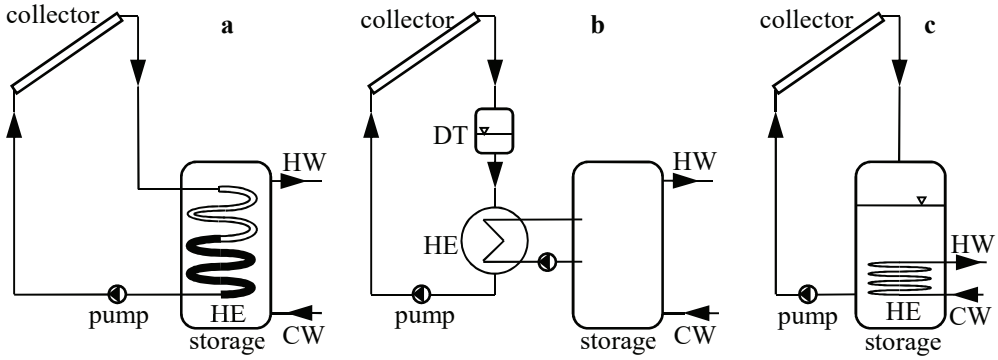

Figure 2: Other DS configurations (CW-cold water; HW-hot water): a) with oversized collector-side HE b) with separate HE c) with load-side HE

4. SYSTEM AND COMPONENT CONSIDERATIONS

Due to the permanent input of fresh air, metal parts of **open systems** should be corrosion protected, while the growth of algae sometimes causes clogs. The pressure in the collector loop is roughly in accordance with the fluid column measured from the surface of the fluid in the DT. Such low pressures permit the use of cheap plastic components. On the other hand, collectors are subjected to underpressure, which can cause the impermissible evaporation. Therefore the underpressure has to be eliminated. The permissible slight underpressure or slight overpressure in collectors can be achieved by installing a vacuum breaker in the supply line below the collectors (shorter siphon as side-effect) or by installing a pressure sustaining valve at the end of supply line (both methods increase the required pump head for circulation). It is also possible to put the DT under a slight overpressure (closed system).

Closed systems are designed for pressures up to 3 bar, while the obligatory safety valve is usually set to 6 bar [7]. System components are made from metal and the problems with corrosion and algae are considerably reduced.

In order to ensure the total **drainage** of solar fluid from the collector, the hydraulic project and installation must be carefully performed for all DSs. Collectors and pipes must be installed at a minimum 2% slope for drainage [4]. Especially in large DSs, a solenoid venting valve may be installed at the highest pipeline point to break the siphon effect for quicker draining – it opens when the pump turns off.

Flat plate or evacuated tube **collectors** are used in DSs. Harp type absorber tubes must not be horizontal. Serpentine (meander-flow) absorbers and roll-bond absorbers [6] can also be used. It is possible to use EPDM rubber collectors in open DSs. Collector arrays must be connected in parallel to enable drainage.

Drainback tanks are made of stainless steel or plastic (open systems). They ought to be insulated and located in conditioned space. They should be positioned at the highest possible place to diminish both the necessary pump head at startup and the unwanted underpressure in collectors. The DT is sometimes integrated in the storage tank or in (under) the collector.

The DT must be large enough to receive all solar fluid from collectors and pipes above it. In addition it must be overdimensioned (1/8 ÷ 1/2 full in operation [6]) to prevent the splashing originated air bubbles from entering the pump.

In order to prevent splashing and the resulting noise, the inlet pipe end can be submerged under the fluid surface in the DT. In that case, air must be brought into the supply pipe from outside to enable the draining process. The simplest way is to drill some holes in the pipe that passes through the air-filled part of the DT. The air-filled part of the DT can also be connected to the supply pipe outside the DT by means of an additional parallel pipe branch (bleeder). Finally, a solenoid venting valve may be installed at the highest pipeline point for drainage.

DT always has a level sensor (e.g. sight glass) that must be regularly monitored. In closed systems, DT takes the role of expansion vessel and always has a pressure relief valve.

Storage tanks are made of stainless steel or coated plain carbon steel. Those storage tanks that contain solar fluid (Fig. 2c) can in open DSs be made of plastic materials.

At startup, the **pump** head must overcome the pressure losses together with the height from the DT fluid level to the installation top. In DSs without a DT, a greater height must be overcome. The pump head necessary for normal operation is smaller due to the siphon effect. It includes pressure losses and only the height of the air volume.

A single centrifugal pump is sometimes used in DSs. During normal operation, the lower pump head leads to a greater flow rate and greater power consumption. It would even be favorable to prevent siphon formation and maintain the greater required head. This problem is often solved by adjusting the available pump head by means of changing the pump speed. Another method requires installing an additional booster pump in series with the circulation pump. The booster pump works only during startup. It is bypassed during normal operation. It is also possible to use a positive displacement pump that has approximately the same flow rate regardless of the head. In that case a bypass with a check valve is necessary to enable back-flow during the draining procedure.

Collector loop **pipes** are usually made of copper, although stainless steel or cheap plastic pipes may also be used. But the transition pipes connected to the collector must be made of metal (recommended minimum 0.9 m long copper pipe sections [6]) to withstand high temperatures. Furthermore, plastic tubes are prone to sagging, which may impede the total draining. Therefore, it is necessary to decrease the distance between plastic pipe supports. The minimum 14 mm pipe diameter ensures that the supply pipe will empty in drainage process [6]. The minimum 0.3÷0.4 m/s velocity in the supply pipe is necessary to remove air and establish the siphon effect [6].

5. ADVANTAGES AND LIMITATIONS OF DRAINBACK SYSTEMS

Pressurized antifreeze systems are the predominant solar systems for SWH. DSs can usually be applied instead. The advantages and drawbacks of DSs in comparison with pressurized antifreeze systems are listed in Table 2.

Table 2: Comparison with antifreeze pressurized systems

Advantages	Drawbacks
• Glycol addition is unnecessary • Evaporation due to high temperatures is prevented • High glycol temperatures are prevented • Fewer components (expansion vessel, safety valve, check valve)	• Careful installation and pump selection necessary for complete drainage • Increased pump head at startup complicates the pump selection • increased corrosion • increased organic matter formation

• Plastic materials compatible • Less maintenance	• increased noise level

6. CONCLUSION

The basic DS operation principle is explained using the example of the most frequent type of DS that has a separate DT and a HE in the collector loop. Variations in existing DSs are listed and the system and component characteristics described.

Finally, the following advantages of DSs are specified. The application of glycol is unnecessary – water is usually used as solar fluid. Excessive temperatures and pressures in collectors are prevented, and the possible evaporation of solar fluid avoided. If glycol is used, its degradation is prevented through the absence of excessive temperatures.

REFERENCES

[1] Nejat, P. et al.: A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries), *Renewable and Sustainable Energy Reviews*, **Vol.** 43 (2015), pp. 843-862, ISSN 1364-0321

[2] Energy consumption in households, Eurostat – Statistics explained, *Available from* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households *Accessed:* 2022-04-16

[3] Mbakwe, S.: Design and application of a photovoltaic powered domestic solar water heating system in Regina, SK., Canada, *Proceedings of 2016 IEEE Electrical Power and Energy Conference (EPEC)*, pp. 1-8, ISBN: 9781509019205, Ottawa, October 2016, IEEE, Piscataway NJ (2016)

[4] Ramlow, B.; Nusz, B: *Solar Water Heating*, New Society Publishers, ISBN: 978-0-86571-668-1, Gabriola Island, Canada (2010)

[5] *Priprema PTV solarnim kolektorima – Poticanje energetske efikasnosti u Hrvatskoj*, http://www.enu.fzoeu.hr/ee-savjeti/priprema-potrosne-tople-vode/priprema-ptv-solarnim-kolektorima, *Accessed:* 2020-10-02

[6] Botpaev, R. et al.: Drainback solar thermal systems: A review, *Sol. Energy*, pp. 41-60, **Vol.** 128 (2016), ISSN 0038-092X

[7] Fink, C. et al.: Projekttitel: Selbstentleerende Kollektorsysteme zur Vermeidung von Stagnationsproblemen in großen solarthermischen Anlagen – SolarDrain, *Available from* https://energieforschung.at/wp-content/uploads/sites/11/2020/12/SolarDrain-publizierbarer-Endbericht.pdf, *Accessed:* 2022-04-29

APPLICATION OF PHOTOVOLTAIC POWERED PUMP IN A DRAINBACK DOMESTIC WATER HEATING SYSTEM

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Abstract: *A drainback water heating system for a typical four-member residential house in Zagreb area is considered. The solar collector, drainback tank, solar storage tank, heat exchanger, and pipes are selected in accordance with preliminary calculations. The necessary head and capacity of the circulation pump are then computed, and a suitable solar powered DC pump selected, along with the photovoltaic panel necessary for the pump power supply. The energy which a common AC circulation pump (supplied from electrical grid) would spend for the same task is estimated. In addition to its cost, this energy would at least be partially nonrenewable.*

Keywords: *solar systems, drainback system, water heating, PV pump*

1. INTRODUCTION

On account of the free and renewable sun energy, a solar heating system can provide 50-60% of energy needed for domestic water heating in residential and industrial buildings [1]. In climates with freezing conditions either pressurized antifreeze systems or drainback systems (DSs) are usually used for water heating and space heating. Because the DS solar collectors are empty in cold and hot circumstances, water in collectors cannot freeze or evaporate. During the DS startup procedure, the pump head increases. That condition complicates the pump selection and operation.

This paper considers a domestic water heating DS in a typical family house in Zagreb region. The assessment is made of the circulation pump operation parameters and power consumption. To this end, an approximate DS design procedure is carried out and the basic elements selected. The pump operation with and without the siphon effect is analyzed. The siphon unexpectedly manifests unfavorable influence.

The proposed photovoltaic (PV) driven pump saves all power costs and operates entirely environmentally friendly. On top of this, its action is excellently adapted to the system needs.

2. SYSTEM DESCRIPTION

In this analysis, the most popular indirect non-pressurized DS (Fig. 1) is adopted for domestic water heating support. It includes collectors, a separate drainback tank (DT), a heat exchanger in the collector loop, a heat storage tank, and a circulation pump.

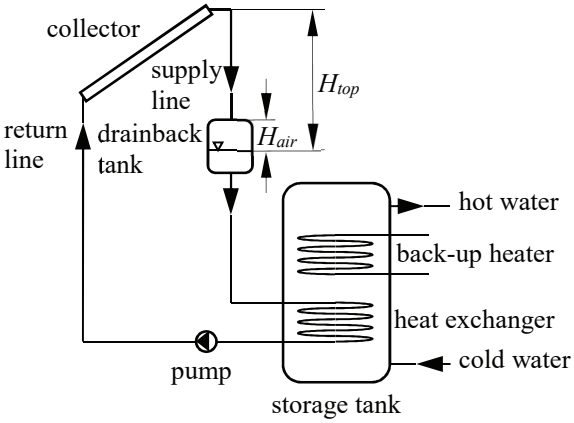

Figure 1: Drainback system with drainback tank and collector-loop heat exchanger

The controller switches the circulation pump off if the collector temperature is too low, or the storage temperature is sufficiently high. Then the collectors and upper pipeline sections fill up with air, while the solar fluid drains backwards through the pump into the DT. When the pump starts, it fills up the collectors, while the air returns to the DT, and the circulation begins. The filled up downcomer (supply pipe) reduces the necessary pump head due to the siphon effect. DTs are normally situated in conditioned space. This way the exposed installation parts are always empty when freezing conditions or extremely high solar fluid temperatures could occur. This allows the common praxis, which is adopted here also, of using plane water as solar fluid.

The pump startup process is depicted in the head-flow rate (*H-Q*) diagram (Fig. 2). The pump starts at the point 1, whereupon the necessary head increases as the return pipe and the collectors fill with water. The maximum required head (point 2) is reached when water reaches the highest installation point. After that, the supply pipe

starts to fill, thus forming the siphon that reduces the necessary head. The normal circulation point 3 is reached when the supply pipe fills up completely.

3. CIRCULATION PUMP OPERATION PARAMETERS

The calculation of pump power consumption for the circulation through the solar collector loop is carried out for a typical four-member two-storey family house in Zagreb region, located at latitude 45.8^0 N and longitude 16° E, at 160 m elevation above sea level. The roof is oriented towards South. The assumed water consumption is 60 l/day per person. The average daily **hot water energy load** Q_l amounts to

$$Q_l = \rho C_P \dot{V}(t_H - t_C) = 13.44 \ \frac{\text{kWh}}{\text{day}}, \tag{1}$$

where water density ρ = 1000 kg/m^3, water specific heat C_P = 4200 J/kg/K, daily hot water demand $\dot{V}$ = 0.24 m^3/day, hot water temperature t_H = 60^{0}C, and cold water temperature t_C = 12^{0}C.

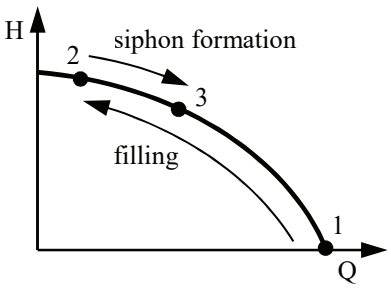

Figure 2: Centrifugal pump operation point during the filling process: 1-start, 2-highpoint reached, 3-normal operation

The **solar collector** tilt angle equal to the latitude of 45° is chosen, which is suitable for collector usage throughout the year [2]. The annual average solar irradiation on a surface tilted at 45° in Zagreb is G_T = 3.44 kWh/m^2/day [2]. Two collectors Vaillant auroTHERM VFK 135/2 VD are chosen; the absorber area is A_C = 2×2.33 m^2, and the collector inner volume is V_C = 2×1.46 l [3]. The approximate collector useful heat gain Q_u can be estimated from [4]

$$Q_u = \eta_C A_C G_T = 8.02 \ \frac{\text{kWh}}{\text{day}}, \tag{2}$$

where the assumed collector efficiency is $\eta_C = 0.5$. This yields the favorable value of solar fraction $f = 60\%$.

The minimum water velocity $v_P = 0.4$ m/s is necessary to remove the air bubbles from supply pipe at startup. The smallest Vaillant copper pipe diameter $d = 15$ mm is chosen (minimum value 14 mm is necessary for successful drainage [5]). This gives the necessary collector loop **flow rate** $Q = 254$ l/h.

This value is greater than the necessary flow rate of 70÷186 l/h (15÷40 l/h for every m^2 of collector area), and causes the increased expected collector pressure loss $\Delta p_C = 470$ mbar.

The recommended hot water **storage tank** volume is $V_S = 50$ l/m^2 × $A_C = 233$ l. The chosen bivalent (i. e. containing two serpentine heat exchangers) storage tank Vaillant auroSTOR VIH S 300/3 MR [3] has the volume $V_S = 287$ l and the expected pressure loss in heat exchanger $\Delta p_{HE} = 30$ mbar.

With the storage tank situated in basement, and the **drainback tank** in the attic, the total collector circulation pipeline length is assumed to be $L = 60$ m. The assumed length of the upper collector circulation pipeline (above the DT surface) is assumed to be $L_{top} = 10$ m, and the vertical distance between DT surface and the topmost pipeline point is $H_{top} = 2.5$ m (Fig. 1). The DT volume V_D should exceed the volume of the drained water by at least 15 l [5], yielding the value

$$V_D = 2V_C + L_{top}\,\frac{\pi d^2}{4} + 15\text{ l} = 19.7\text{ l}\,. \tag{3}$$

The chosen DT HTP SSU-10 DB has the volume $V_D = 37.9$ l and the tank height $H_D = 508$ mm. The height of the air column inside the DT during operation is supposed to be $H_{air} = 0.5 \times H_D = 254$ mm (Fig. 1 – the tank is half full).

Accepting the kinematic viscosity coefficient (water at 60 ^{0}C) value of $\upsilon = 0.48\times10^{-6}$ m^2/s, the Reynolds number in the pipe is **Re** $= v_P d/\upsilon = 1.25\times10^4$. With the mean roughness height for copper pipes of $k = 0.002$ mm, the Swamee-Jane turbulent flow formula [6] yields the friction factor $\lambda = 0.029$. The local pressure losses in the collector loop are accounted for by increasing the major losses by 50%. Then the necessary circulation pump head H turns out to be

$$H = 1.5\lambda\,\frac{L}{d}\,\frac{{v_P}^2}{2g} + \frac{\Delta p_C + \Delta p_{HE}}{\rho g} + H_{air} = 6.75\text{ m}\,, \tag{4}$$

while the necessary pump power P_P becomes

$$P_P = \frac{\rho g Q H}{\eta_P} = 15.6\text{ W}\,, \tag{5}$$

where the pump efficiency is assumed to be $\eta_P = 0.3$. On the assumption that the pump operates 8 hours a day on average, the minimum pump yearly energy consumption would total to 164 MJ (45.6 kWh).

Assuming the unchanged flow rate Q during startup, the required maximum pump head (point 2 in Fig. 2) would amount to $H_{max} = 8.88$ m (with the elevation gain $H_{top} = 2.5$ m and the pipe length L-$L_{top}/2 = 55$ m). The corresponding necessary maximum pump power consumption is $P_{max} = 20.5$ W, which represents the increase in required pump head and power of 31%. With the crude assumption of constant flow rate Q during startup, the startup period T would last

$$T = \frac{V_W - \frac{L_{top}\pi d^2}{2 \quad 4}}{Q} = 54 \text{ s} . \tag{6}$$

If the AC motor driven circulation pump Shinhoo GPD25-9Z is chosen for both pump heads, the circulation flow rate will increase approximately to 290 l/h, the pump head to 8.70 m, and the power consumption to 22.9 W (47% increase), while the startup values obtained earlier (Q, H_{max}, P_{max}) remain practically unchanged. The pump had to be oversized to allow for the increased startup head (H_{max}), which causes the increase in power consumption. This problem appears in DSs as a consequence of the siphon effect, when a single centrifugal pump is used at constant speed. With lower position of the DT (greater value of H_{top} in Fig 1), this problem intensifies. The problem can be solved by adapting the pump speed, by connecting an additional startup booster pump in series, or by using a positive displacement pump [7]. If a single constant speed centrifugal pump is used, the power consumption is greater during the circulation than during the startup procedure, so that the siphon effect obviously proves harmful.

In order to reduce the circulation power consumption, it is favorable to disable the siphon formation by installing a vacuum breaker valve at the top position in the pipeline. This also increases the pressure in collectors and thus prevents possible evaporation. Moreover, without the siphon, the air removal from the downcomer pipe becomes unnecessary, and so does the high water velocity. So, if the minimum flow rate $Q = 15$ l/h/m^2 $\times$ $A_C = 70$ l/h is adopted, the pressure losses diminish to the following values: $\Delta p_C = 50$ mbar, heat exchanger pressure loss $\Delta p_{HE} = 10$ mbar, friction factor $\lambda = 0.043$, which yields the new necessary pump head value of $H = 3.26$ m. In this case, the circulation head and startup head have the same value, so a single constant speed centrifugal pump is perfectly adequate. The necessary power input becomes 2.1 W, and the yearly power consumption reduces to 22 MJ (6 kWh).

The low pump power consumption even allows putting the DT in the cellar (the DT is often integrated in the storage tank). It is assumed that the water column height will therefore increase for additional 9 m. In that case, the necessary pump head would become $H = 12.2$ m (with the total water column height of 11.5 m and the pipe length $L/2 = 30$ m). The necessary pump power input would then rise to 7.74 W and the yearly power consumption to 81 MJ (22.6 kWh).

Table 1: Overview of calculated circulation parameters

Pump parameter	With siphon		Without siphon – necessary	
	Necessary	Oversized pump	DT in attic	DT in cellar
Flow rate	254 l/h	290 l/h	70 l/h	70 l/h
Pump head	6.75 m	8.70 m	3.26 m	12.2 m
Power	15.6 W	22.9 W	2.1 W	7.7 W
Energy per year	45.6 kWh	66.9 kWh	6.0 kWh	22.6 kWh

The application of a PV circulation pump instead of the AC motor driven pump saves the energy costs and uses completely renewable solar energy. In the periods of greater solar irradiation, a greater circulation flow becomes necessary for the collector heat removal. Along with this increased need, the PV pump flow will inherently rise with increased irradiation. In periods of lower sunlight, the PV pump will conveniently operate at reduced speed.

The appropriate solar circulation pump Thermo Dynamics Ltd. P50140EM-12 V DC, together with the corresponding PV module Thermo-Dynamics PV20, 20W, 12 V DC can be applied for the family house considered above. It is a direct drive solar positive displacement vane pump, so a pump bypass with a check valve is necessary for the draining process. Equipped with a controller, a linear current booster, and driven by a brushless DC motor, the pump will operate exactly in the specified operation point (Q = 254 l/h; H = 6.75 m – system with the DT) whenever the irradiation is sufficiently large. It is also capable to provide the increased necessary head during the filling phase.

4. CONCLUSION

The approximate design calculations of a solar water heating DS were carried out for a typical family house in Zagreb. The essential system elements were chosen, and the necessary parameters for a single AC driven constant speed circulation pump were estimated. The necessary average pump power consumption turned out to be 15.6 W, with the assessed yearly consumption of 45.6 kWh. As usual, the startup procedure required an oversized pump, which caused a substantial (47%) increase in power consumption.

If the siphon formation is prevented, a high flow velocity becomes unnecessary. Then the required pump power reduces almost 8 times (to 2.1 W or 6 kWh a year). Unexpectedly, the siphon proves counterproductive. In addition, without the siphon effect, it becomes unnecessary to oversize the pump.

As an alternative, a PV pump application is proposed. Using the free and renewable solar energy, it saves all pump energy costs. It is capable to carry out the filling procedure without oversizing, avoiding the increase in circulation power

consumption. Finally, like solar collectors, it also has irradiation dependent output, so that the flow rate increases exactly when needed.

REFERENCES

[1] *Priprema PTV solarnim kolektorima – Poticanje energetske efikasnosti u Hrvatskoj*, *Available from* http://www.enu.fzoeu.hr/ee-savjeti/priprema-potrosne-tople-vode/priprema-ptv-solarnim-kolektorima, *Accessed:* 2020-10-02
[2] Kulišić, P.: Sunčana energija, in *Tehnička enciklopedija – svezak 12*, Leksikografski zavod Miroslav Krleža, ISBN 9789536036509, Zagreb, (1992), pp. 423-441
[3] Projektantske podloge – Solarni sustavi – 092016, Vaillant d.o.o., Zagreb, (2016), *Available from* https://www.vaillant.hr/downloads/pli/2016-09-solar-projektantske-podloge-823384.pdf, *Accessed:* 2022-05-02
[4] Mbakwe, S.: Design and application of a photovoltaic powered domestic solar water heating system in Regina, SK., Canada, *Proceedings of 2016 IEEE Electrical Power and Energy Conference (EPEC)*, pp. 1-8, ISBN: 9781509019205, Ottawa, October 2016, IEEE, Piscataway NJ (2016)
[5] Ramlow, B.; Nusz, B: *Solar Water Heating*, New Society Publishers, ISBN: 978-0-86571-668-1, Gabriola Island, Canada (2010)
[6] Darcy friction factor formulae, Wikipedia, *Available from* https://en.wikipedia.org/wiki/Darcy_friction_factor_formulae, *Accessed:*2022-07-06
[7] Botpaev, R. et al.: Drainback solar thermal systems: A review, *Sol. Energy*, pp. 41-60, **Vol.** 128 (2016), ISSN 0038-092X

TURBOPUMP AFFINITY LAWS AND RADIAL IMPELLER TRIMMING

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Abstract: *Theoretical basis of hydrodynamic affinity laws for turbopumps is explained and the laws are then formulated. Firefighters typically use centrifugal water pumps. The performance of these specific pumps can be adapted by impeller trimming. Although geometric similarity is not strictly maintained after trimming, it is permissible to apply affinity laws for miniature trim values. This work examines the agreement of experimental results with affinity law predictions for a trimmed constant width impeller of a centrifugal pump.*

Keywords: *pump affinity, centrifugal pump, firefighting pump, impeller trimming*

1. INTRODUCTION

Fire pumps and mine rescue pumps are typically centrifugal type pumps. Firefighting vehicles have PTO (power take-off) driven pumps. The necessary pump speed is achieved by using the adequate PTO mechanism that connects the pump to the engine. Beside the speed adjustment, the reduction of a centrifugal pump impeller diameter (impeller trimming) can be carried out to reduce the pump performance. The reduction of pump performance is necessary when excessive pump discharge must be avoided to prevent cavitation and damage to the pump. In addition, the pump head reduction may be necessary in order not to exceed the pressure ratings of the installed fire-protection systems. The turbopump affinity laws are formulated in this work. The accuracy of the affinity law based predictions is experimentally investigated for a trimmed pump impeller.

2. AFFINITY LAWS FOR TURBOPUMPS

Similarity rules for a physical phenomenon ensue from the chosen mathematical model of that particular phenomenon. Turbopump similarity conditions normally do not require that any of the usual dimensionless numbers (Reynolds, Froude, Strouhal, or Mach) be

identical for the prototype and the model (P&M). This means that the effects of gravity, friction, unsteadiness, and compressibility are disregarded (partial similarity). The corresponding mathematical model for ideal liquid consists of the Euler equation and the continuity equation, which combine four physical quantities (density ρ, position vector x_i, velocity vector v_j, and pressure p). In order to complete the mathematical problem, the geometric domain and boundary conditions must be specified. Usually, velocity and pressure are chosen as unknown variables. In that case, the necessary boundary conditions include the specification of velocity vectors at inlet/outlet boundaries, normal velocity components at solid boundaries, and pressure in one point.

When the equations, the domain, and the boundary conditions are transformed into dimensionless form, they become valid for a whole group of mutually similar situations. The unique dimensionless solution of the mathematical problem is then also valid for the whole group.

The four quantities contain three basic dimensions (M, L, T). In accordance with dimensional analysis, three characteristic values can be chosen to express the mathematical problem in dimensionless form. Those are ρ_C, $x_C = D_2$ (impeller outlet diameter – index 2 for outlet), $v_C = u_2$ (circumferential speed at impeller outlet $u = \pi Dn/60$, n denotes rpm). The dimensionless quantities (denoted by overbar) and dimensionless Euler and continuity equations are

$$\bar{\rho} = \frac{\rho}{\rho_C}; \quad \bar{x}_i = \frac{x_i}{D_2}; \quad \bar{v}_i = \frac{v_i}{u_2}; \quad \bar{p} = \frac{p}{\rho_C u_2^2}; \tag{1}$$

$$\bar{\rho}\bar{v}_j \frac{\partial \bar{v}_i}{\partial \bar{x}_j} + \frac{\partial \bar{p}}{\partial \bar{x}_i} = 0; \quad \frac{\partial \bar{v}_j}{\partial \bar{x}_j} = 0 \tag{2}$$

Similar physical situations are geometrically, kinematically and dynamically similar. This means that all similarity coefficients (c) have constant values in all similar points of the P&M (see below).

The identical dimensionless physical domain imposes the requirement that *geometric similarity* must be preserved for the P&M. Therefore, $\bar{x}_i = x_{iP}/D_{2P} = x_{iM}/D_{2M}$, (indices P = prototype, M = model) for every dimensionless point $\bar{x}_i$. This leads to the condition that the similarity coefficient for length $c_L = x_{iP}/x_{iM} = D_{2P}/D_{2M}$ must be the same for every dimensionless point in the whole domain. Corresponding relations apply for other similarity coefficients. The pairs of points (x_{iP}, x_{iM}) that satisfy the above relation are called *similar (homologous) points*.

As velocity field represents a part of the solution of the mathematical problem, it is necessary to specify velocity vectors and ensure the *kinematic similarity* only at the boundaries i. e. at impeller inlet (index 1) and outlet (index 2). All circumferential velocities (impeller speeds) already have the constant ratio equal to the similarity coefficient for velocities $c_v = u_P/u_M = u_{2P}/u_{2M} = D_{2P}/D_{2M} = c_L$. The geometrical similarity guarantees the same blade angles β along the blade for the P&M. It is necessary to ensure the similarity of velocity triangles (Fig. 1). To this end, it is sufficient to additionally ensure that the meridional velocity component v_m satisfies the same ratio $v_{mP}/v_{mM} = u_{2P}/u_{2M} = c_v$ at inlet and outlet. Due to the continuity equation, the flow rate $Q = Av_m$ = const. along the impeller (A is the flow surface). Together with the geometric similarity which causes that $A_{2P}/A_{2M} = A_{1P}/A_{1M} = D_{2P}^2/D_{2M}^2$, this leads to

$v_{m1P}/v_{m1M} = v_{m2P}/v_{m2M}$. Therefore it is sufficient to ensure only the meridional component similarity either at impeller inlet or outlet.

It is customary to express this requirement using the flow rate Q. Obviously the similarity flow rate coefficient must have the value $c_Q = Q_P/Q_M = (D_{2P}^2 u_{2P}) / (D_{2M}^2 u_{2M})$. Using the rotational speed n, this leads to the first pump affinity law $Q_P/Q_M = (D_{2P}^3 n_P) / (D_{2M}^3 n_M)$. The dimensionless *flow coefficient* is defined as $\varphi = Q/(u_2 S_C)$, with the characteristic area $S_C = \pi D_2^2/4$. The request $\varphi_P = \varphi_M$ represents an alternative expression of the first law requirement. It is important to stress that the same pump ($D_{2P} = D_{2M}$) can be brought to work in mutually similar situations ($\varphi_P = \varphi_M$) by modulating Q and n in accordance with the first similarity law.

There are no requirements regarding *dynamic similarity*. The incompressible liquid has constant density, so the characteristic density ρ_C takes the values of ρ_P and ρ_M for the P&M respectively. Therefore, the similarity coefficient for density will have the constant value $c_\rho = \rho_P/\rho_M$ in every dimensionless point.

The pressure field is a part of the solution of the mathematical problem, so it is necessary to define the pressure value p_0 in one point (boundary condition). The pressure gradient in Euler equation has the same value if differential pressure $p_d = p - p_0$ is used instead of p (i. e. $\partial p/\partial x_i = \partial p_d/\partial x_i$). Therefore, the choice of p_0 does not affect the velocity field and differential pressure field. If the chosen p_0 value is increased by a certain amount, this will only increase all pressure field values for the same amount. Therefore, p_0 is often chosen arbitrarily.

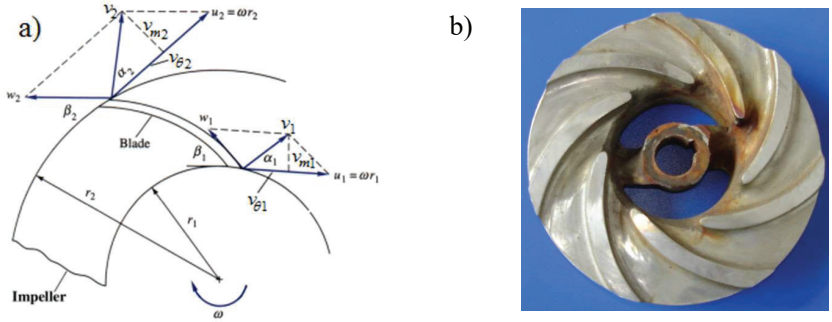

Figure 1: a) Impeller blade with velocity triangles [1], b) Investigated impeller $D_2 = 130$ mm [2]

In summary, when geometric similarity and the request $\varphi_P = \varphi_M$ are satisfied, the similarity of the P&M is achieved. In similar situations, all dimensionless parameters theoretically have the same value for the P&M. Therefore, all dimensionless pump characteristic curves (pump head ψ, power λ, efficiency η, and NPSH σ) depend only on φ.

With that in mind, further pump similarity laws are derived by dimensional analysis or by using the dimensionless form of definition formulas. The second pump similarity law can be derived from the Euler main turbomachine equation $v_{\theta 2}u_2 - v_{\theta 1}u_1 = gH$, where v_θ is the circumferential velocity component, and H is the pump head. The third pump similarity

law can be derived from the pump power definition $P = \rho gHQ/\eta$, where η denotes the pump efficiency (efficiency is already dimensionless and therefore acquires the same value for the P&M when $\varphi_P = \varphi_M$).

The three pump affinity laws are:

$$\frac{Q_P}{Q_M} = \frac{D_{2P}^3 n_P}{D_{2M}^3 n_M}; \quad \frac{H_P}{H_M} = \frac{D_{2P}^2 n_P^2}{D_{2M}^2 n_M^2}; \quad \frac{P_P}{P_M} = \frac{\rho_P D_{2P}^5 n_P^3}{\rho_M D_{2M}^5 n_M^3}. \tag{3}$$

The dimensionless head coefficient is $\psi = 2gH/u_2^2$, and the dimensionless power coefficient is $\lambda = 2P/(\rho_C u_2^3 S)$.

3. IMPELLER TRIMMING

The pump discharge and power consumption can be reduced by increasing the flow resistance (flow control valve), by the pump speed reduction, or by impeller trimming. In the trimming procedure, the centrifugal pump impeller is first machined to a smaller outlet diameter and then installed in the unaltered casing. Although trimming disrupts the P&M geometric similarity before (model) and after the cut (prototype), the similarity laws are generally accepted for small cuts and the blades with nearly constant angle β in the vicinity of the outlet. It is recommended not to exceed the 10-15% (maximally 30%) reduction of the original diameter [3]. Greater cuts cause the uncertainty of similarity based predictions, as well as a considerable reduction of pump efficiency due to the impeller-casing mismatch.

With the assumption of constant blade angle β, the effort to maintain the similarity of the outlet velocity triangle requires the similarity of meridional velocity component v_m. This is accomplished by choosing the actual flow surface as the characteristic surface (S_C=A). If impeller width b is constant along the flow channel, $S_C = \pi D_2 b$. However, in most pump designs, $v_m \approx$const, along the impeller channel. This is equivalent to the condition $S_C = A$ = const (i. e. Db = const). The flow coefficient $\varphi = Q/(u_2 S_C)$ is defined using the corresponding new characteristic surface S_C. The similarity condition $\varphi_P = \varphi_M$ then leads to the modified definitions of the first affinity law:

$$\frac{Q_P}{Q_M} = \frac{D_{2P}^2 n_P}{D_{2M}^2 n_M} \text{ if } b = \text{const}; \frac{Q_P}{Q_M} = \frac{D_{2P} n_P}{D_{2M} n_M} \quad \text{if } S_C = A = \text{const}, \tag{4}$$

4. EXPERIMENT

The pump performance tests of the centrifugal pump Jedinstvo Ib 190 were carried out at the Faculty of Mechanical Engineering and Naval Architecture, Zagreb [4]. The impeller had seven single radius curved blades and a constant impeller width b = 4 mm, with the corresponding characteristic surface $S_C = \pi D_2 b$. The impeller was trimmed in 10

mm diameter steps from the initial diameter D_2 = 190 mm to 130 mm (total 31.6% reduction of impeller diameter) and successively tested.

The test installation was devised in accordance with ISO 3555-1977, class B standard. The total experimental uncertainty limits at 95% statistical certainty were estimated as ±0.549% for discharge Q and ±0.631% for head H [2].

The test results are summarized in the head-discharge (H-Q) diagram (Fig. 2). The regression H-Q lines for individual impeller diameters are represented by dashed lines. The solid lines depict affinity law predictions based on the regression line of the initial (D_2=190mm) impeller. They stretch until they reach the Q-value which corresponds to the maximum measured φ-value of the initial impeller (to avoid extrapolation). It can be observed that the disagreement with the affinity low grows for smaller impellers and with increased discharge.

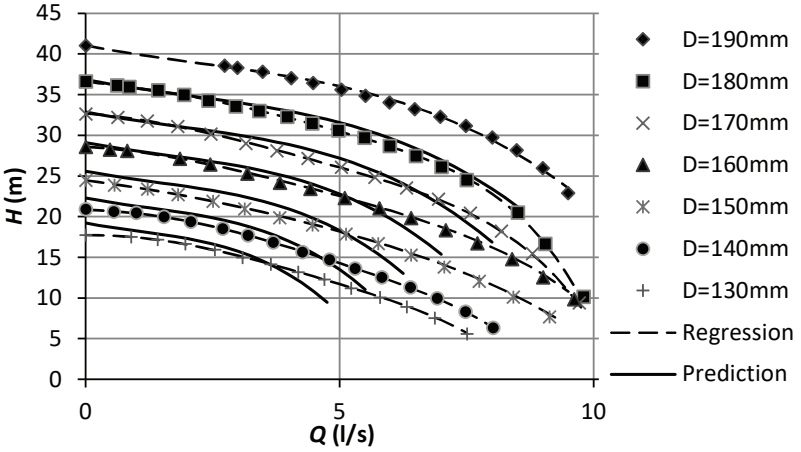

Figure 2: Experimental results depicted in head–discharge diagram

Table 1 shows the decrease of coefficient of determination (R^2) of affinity law predictions (solid lines in fig. 2) with diameter reduction. The regression lines of individual impellers (dashed lines in fig. 2) demonstrate the high values of R^2 and the high measuring accuracy.

Table 1: Coefficients of determination (R^2) for prediction and individual regressions

D	190 mm	180 mm	170 mm	160 mm	150 mm	140 mm	130 mm
R^2 prediction	0.9967	0.9794	0.9652	0.8931	0.8042	0.8649	0.6843
R^2 regression	0.9967	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999

The same tendencies can be observed in the dimensionless head-discharge (ψ-φ) diagram (Fig. 3). Predictions based on the regression line of the initial impeller (solid line) can be used for small diameter reductions. Taking into account all recorded points (for all impellers), but only within the φ-range of the recordings of initial impeller, the regression line of the initial impeller has the determination coefficient R^2 = 0.9291. Because of the

pronounced scatter of points at large φ-values, the single quadratic regression function for all recorded points (dashed line) has the modest $R^2 = 0.9484$.

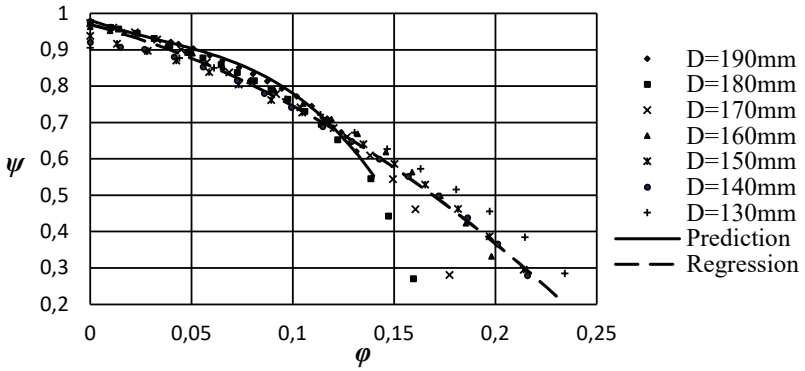

Figure 3: Experimental results depicted in head – discharge diagram

5. CONCLUSION

The hydrodynamic similarity laws for turbopumps are formulated and thoroughly explained, along with their modification for impeller trimming. A constant width impeller of a centrifugal pump was trimmed in successive 10 mm-steps, and the pump performance experimentally investigated for every successive cut. With greater cuts, the affinity law predictions increasingly deviated from the experimental results, as expected. In addition, the experimental results for various impeller diameters showed the increased discrepancy with the increase of the pump flow rate.

REFERENCES

[1] White, F. M.: *Fluid Mechanics 4th ed.*, McGraw-Hill, ISBN 9780070697164, Boston, (1998)
[2] Šavar, M. et al: Improving centrifugal pump efficiency by impeller trimming, *Desalination*, **Vol.** 249 (2009), pp. 654–659, ISSN 0011-9164
[3] Abelin, M. S. et al: *Improving Pumping System Performance*, National Renewable Energy Laboratory, Golden CO USA, (2006) *Available from* https://www.energy.gov/sites/prod/files/2014/05/f16/pump.pdf, *Accessed:* 2022-05-25
[4] Fancev, M., Korbar, R., Šavar, M., Franjić, K.: *Hidrodinamička ispitivanja centrifugalne pumpe Jedinstvo Ib/130-190*, Internal report nos ZEP/TS/114, ZEP/TS/113, ZEP/TS/111, ZEP/TS/110, ZEP/TS/109, ZEP/TS/108, ZEP/TS/107, ZEP/TS/120, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, (1987)

INSPECTION AND TESTING OF THE WORKING EQUIPMENT AND TESTING OF THE PHYSICAL FACTORS OF THE PLATFORM WORKING ENVIRONMENT

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Absstract: This paper will describe the inspection and testing of the work equipment and the examination of the physical factors of the working environment of the platform. Inspection of the working environment was carried out in accordance with the relevant regulations and norms. Measuring of temperature, relative humidity and air flow speed is carried out at the permanent workplace of the worker, or at the place where the worker spends most of his working time. At the workplace, an assessment of the level of exposure of employees to noise was made and an analysis of work activities during the working day was made.

Keywords: offshore drilling rig, handling hazards, physical factors of the working environment.

1.INTRODUCTION

In the operational process of exploration and exploitation of hydrocarbons,onshore drilling rigs and offshore rigs are used, Figure 1. Offshore drilling rig, hereinafter referred to as the platform, is a set of machines, devices and tools that forma technical-technological unit for the purpose of creating and equipping the well channel. Upon arrival at the drilling location, it is stabilized using three 139-meter- long legs, which rest on the bottom, and the platform is raised to a height above sea level. The accommodation capacity of the platform is 100 people. The platform offers the possibility of staying on it, has accommodation facilities, hygienic conditions, meets the nutritional needs of the crew and necessary external contractors, and in addition offers facilities for leisure, day stays, gym, table football, etc.

Figure 1: The Jack up oil platform

Source: https://lidermedia.hr/1000-najvecih/ina-osigurala-novu-proizvodnju-plina-iz-jadrana-141647

It is extremely important that the work equipment is in a correct and safe condition, because the occurrence of a small incident caused by the insecurity of the work equipment can lead to a major accident. If there is a fire or any other incident that cannot be brought under control in a short time, the consequences can be huge. The platform is a separate object, and the evacuation of the platform and the stay of people in the open sea is the worst scenario. It is also important that the working environment is within satisfactory parameters, because in the event of a serious injury at work, going ashore is limited. There is a doctor present on the platform, but in the case of a more demanding medical intervention, there are limited resources to provide it. To avoid this, daily exercises are carried out in case of fire, eruption, first aid and the appearance of dangerous gases.

The regulations establishing the obligation to inspect and test work equipment andtest the physical factors of the work environment are [1, 2, 3]:

1. Law on Safety at Work,
2. Rulebook on inspection and testing of work equipment,
3. Rulebook on testing the physical factors of the working environment.

The regulations and norms according to the requirements of which the assessment of permissible values for certain harmful effects in the working environment is given are [4, 5, 6, 7, 8]:

1. User risk assessment,
2 Ordinance on occupational safety for workplaces,
3. Rulebook on the protection of workers from exposure to noise at work,
4. Determination of exposure to noise at work - engineering method,
5. Workplace lighting – internal working proctor,
6. Workplace lighting – external working proctor.

On the platform there are ninety-three pieces of work equipment subject to inspection and testing according to the Ordinance on inspection and testing of work equipment, fifty-eight pieces of safety valves, forty-three pressure gauges and sixty-one pressure cylinders. When examining the physical factors of the working environment, the American Bureau of Shipping (ABS) standard is also taken into account, which prescribes stricter conditions than the valid Regulations and norms [9]. Due to the extensiveness of the Record on inspection and testing of work equipment and the Record on examination of physical factors of the working environment, in the example, one part of the work equipment subject to inspection, and the room where that part of the work equipment is located, will be processed.

2. EXPERIMENTAL SECTION

2.1. Inspection and testing of the mud pump

The mud pump serves for the circulation of the working medium (mud) in the well and its purpose is to bring the drilled material to the surface, which is further purified by vibrating screens, and is returned to the well as a clean fluid, Picture 2. Mud is a fluid whose base is water, and is mixed with various chemical substances. The mud also serves to control the physical condition of the well, to cool the drill bitand to control the channel in case of occurrence of hydrocarbons. The platform contains three weeping pumps, which are located in a soundproof room. The dimensions of the pump are three meters wide, seven meters long, the height in someparts exceeds two meters, and the weight is 26,000 kg and the working pressure can reach up to 280 bar.
The discharge pump is started via a remote control panel located in the driller's workplac. The mud pump consists of a triplex pump, six electric motors, two indicators and a safety valve. The mud pump is powered by electricity, uses mineral oil, mud and there is a possibility of occurrence of hydrocarbons in the mud. The inspection of the mechanical part of the work equipment consists of identifying the equipment and its parts by means of serial numbers, looking at the completeness of the work equipment, the presence of barriers, the presence and correctness of emergency extinguishing devices, hermeticity, i.e. impermeability, the presence and

visibility of warning safety signs. The inspection of the electrical part is performed in accordance with the EX requirements (spaces threatened by an explosive atmosphere), which also include the requirements of electrical measurements prescribed during the inspection and testing of work equipment [10]. The documentation of the parts that are subject to testing must be valid, such as a safety valve. The serial number of the part and the number of the test report are stated in the report. At the end of the record, an assessment is made on the correctness or incorrectness of the work equipment.

Picture 2.: The Mud pump

Source: https://www.jereh-oilfield.com/products/solid-control-system/mud-pump-parts.htm

2.1. Examination of the physical factors of the working environment of the mud pump room

Testing of the working environment was carried out in accordance with the relevant Regulations and norms, and the requirements prescribed by the ABS were also taken into account. According to the ABS standard, some workplaces must meetstricter conditions regarding the level of illumination. The examination of the physicalfactors of the working environment begins with the determination of the external microclimate conditions during the examination, Picture 3. The closest official measuring station is most often taken.

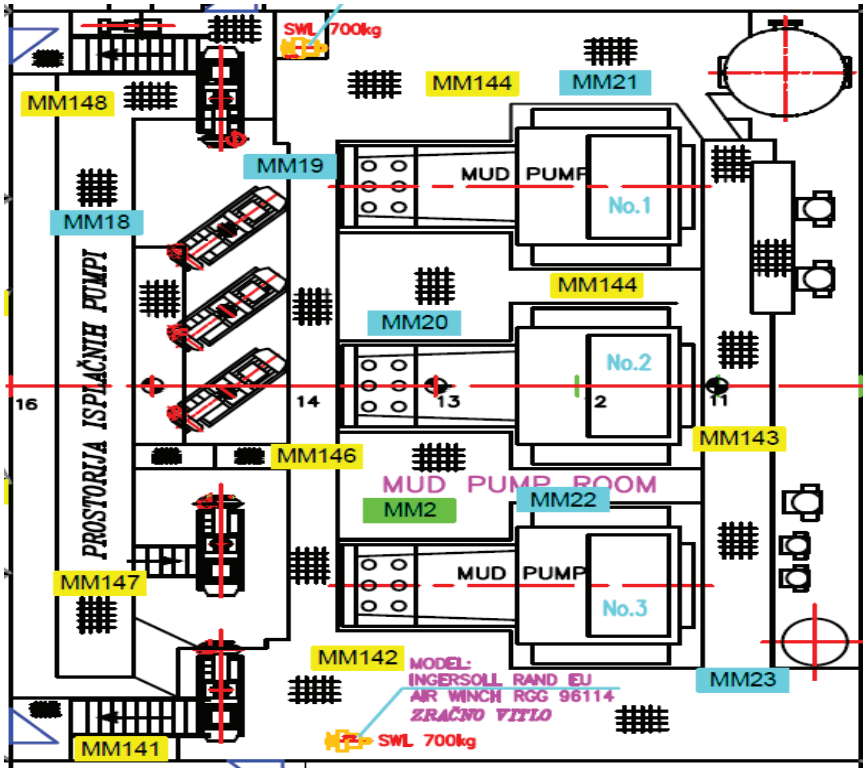
Testing of temperature, relative humidity and air flow speed is carried out at the permanent places of work, i.e. at the places where the worker spends the majority of the working time, whereby the following is determined:

1. Does the air temperature meet the microclimate conditions for thermal comfort during work due to the action of the heat source, i.e. due to heatremoval from the environment in the case of cooling devices.
2. Whether due to the process of operation of heat sources or cooling devices, the relative humidity and air flow speed meet the microclimaticconditions for thermal comfort during work.

The microclimate values were measured in the room: temperature t = 24.3°C; air flow speed v = 0.09 m/s; relative humidity φrh = 58.4 %. The noise test is carried out in order to determine the harmfulness of the noise level in the places of permanent and temporary residence of workers when all machines and devices and other sources of noise that are used at the same time are in operation. A workspace is any open or closed space where people work. Harmful effects of noise mean noise that interferes with various types of activities, speech communication, communication by means of communication, reception of sound signals and damages the sense of hearing. Depending on the type of workplace, the measurement can be performed in one or more places, as well as in characteristic places in the room. In the workplace, noise is measured at the height of the worker's head, if the process requires the presence of the worker, the microphone is placed at a distance of approx. 10 cm from the worker's ear.

Noise values were measured in the room: measuring point 18 (MM18) = 94.4 dB; MM 19 = 94.3 dB; MM 20 = 94.2 dB; MM 21 = 93 dB; MM 22 = 89.9 dB; MM 23 = 87.6 dB. The weeping pump room is a soundproof room where three pumps are located. Due to the dimensions of the room, noise was measured at six locations. In all six places, the noise level exceeds the permitted values. The noise level outside the soundproof room of the mud pumps is satisfactory. In order to be able to assess the level of exposure of employees to noise in the workplace, it is necessary to make an analysis of work activities during the working day. Workers doing the same job or working in the same space are expected to have similar exposure to noise during the

work day. The activities were determined in a conversation with employees and a superior.



Picture 3. Schematic view of the mud pump room with marked measuring points. The green mark represents the measuring point of the microclimate, the blue mark represents the measuring point of the noise level and the yellow mark represents the measuring point of the illuminance value.

In the analysis, we will process one employee. Employee spend one hour a day in the room of the mud pumps. After calculating the exposure to noise during working hours in places where the noise level exceeds the permitted level of equivalent noise, the noise level was still determined to be higher than the permitted level of 89.6 dB. It was concluded that the noise level in the room of the mud pumps exceeds the permitted value, and the employee was assigned and given equipment in the form of hearing protection plugs that reduce the noise level by at least 31.0 dB. The illuminance test was performed at a height of approximately 0.85 m from the floor level of the work room/subfloor, that is, on the work surface.

In the room of the mud pumps, the level of illumination was determined: Measuring point 142 (MM 142) = 418.3 lux; MM 143 = 515.2 lux; MM 144 = 500lux; MM 145 = 578.9lux; MM 146 = 551.4lux; MM 147 = 587lux; MM 148 = 564.2 lux. The reference value of illuminance is 300 lux, and the lighting inside the room of the mud pumps is satisfactory. At the end, the conclusion is made with the obligatory attachment of a draft of the test object with marked measurement points.

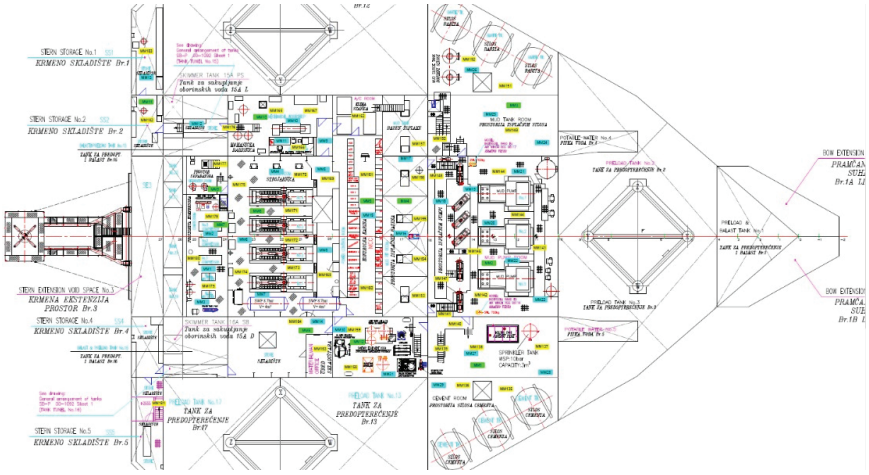


Figure 4. Schematic view of the platform with marked measurement points

2.DISCUSSION AND CONCLUSIONS

Platforms are used in the process of exploration and exploitation of hydrocarbons. There are ninety-three pieces of work equipment on the platform subject to inspection and testing according to the Rulebook on inspection and testingof work equipment. It is important that the work equipment is in a correct and safe condition, because insecurity or an incident can lead to a major accident. Oneworkplace was analyzed called workplace 1. It was concluded that the noise level in the room of the MUD pumps exceeds the permissible value and that it is necessary touse equipment in the form of hearing protection plugs that reduce the noise level by at least 31.0 dB. The illuminance level of 300 lux has been determined in the room ofthe mud pumps, and the lighting inside the room of the mud pumps is satisfactory.

REFERENCE

[1] Zakon o zaštiti na radu (NN 71/14, 118/14, 154/14, 94/18, 96/18).

[2] Pravilnik o pregledu i ispitivanju radne opreme (NN 16/16).

[3] Pravilnik o ispitivanju fizikalnih čimbenika radnog okoliša (NN 16/16).

[4] Pravilnik o zaštiti na radu za mjesta rada (NN 105/220).

[5] Pravilnik o zaštiti radnika od izloženosti buci na radu (NN 46/2008).

[6] Određivanje izloženosti buci na radu – inženjerska metoda EN ISO 9612:2009.

[7] Rasvjeta radnih mjesta – unutarnji radni prostor HRN EN 12464-1_2012.

[8] Rasvjeta radnih mjesta – vanjski radni prostor HRN EN12464-2_2014.

[9] American Bureaou of Shipping: Crew habitability on mobile offshore drilling units, February 2016.

[10] Pravilnik o najmanjim zahtjevima sigurnosti i zaštite zdravlja radnika te tehničkom nadgledanju postrojenja, opreme, instalacija i uređaja u prostorima ugroženim eksplozivnom atmosferom (NN 39/2006).

[11] Mijović, B. (2019) *Održavanje strojeva i uređaja.* izdavač: Veleučilište u Karlovcu

[12] https://lidermedia.hr/1000-najvecih/ina-osigurala-novu-proizvodnju-plina-iz-jadrana-141647

[13] https://www.jereh-oilfield.com/products/solid-control-system/mud-pump-parts.htm

WEAR TESTING OF MULTILAYER FLOOR COVERINGS CONDITIONED BY THE FINAL COATING

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Abstract: *Drvoproizvod d.d. is one of the leading exporters of parquet and wooden floors (rustic floors, multilayer wooden floors) in the Republic of Croatia. With the continuous development of the product, the final surface treatments have also been developed. All surface finishes are currently oiled floors that are oiled with oxidative oils. Also, the argument of environmental protection and human health was emphasized, because floors do not have to be changed, wood is better usable, life extension due to durability of surface treatment does not require frequent changes of parquet and thus protects forests and preserves biosystems. Based on the above facts, this paper will examine the wear of floor coverings depending on which topcoat is used.*

Keywords: *wooden floors, surface wear, Taber test, the wear index*

1. INTRODUCTION

Wood as a technical material has unique properties. It is a renewable, completely recyclable, natural and technically versatile material. As such, it is widely used. It can be used in processed and unprocessed state. In early human history, along with stone and clay, wood was the most important material. Today, wood is tried to be replaced with other materials such as polymers, composites and other similar materilas, but it still remains in use due to its excellent properties. Wood has specific physical,

mechanical, chemical and technological properties. In addition to the advantages, wood as a material has disadvantages, such as anisotropic structure, internal irregularities, moisture absorption, collection and swelling. One of the most important natural disadvantages of wood is its dimensional limitations. Due to its biological origin, wood is subject to biological degradation. All these shortcomings can be minimized by various procedures [1].

2. TECHNICAL REQUIREMENTS

With the continuous development of parquet, finishing surfaces were also developed. Since the goal of the company is to expand to important world markets its production plant must have parquets that are finished in a large number of colors. Technological innovation aims to achieve greater ability to adapt the product to customers, thereby extending the use value of the product and environmental friendliness. This achieves greater environmental protection, because the rootstocks do not have to be changed, wood is better usable, prolonging life due to durability of surface treatment does not require frequent changes of parquet and thus preserves forests and preserves biosystems. During the implementation of the project Development and application of surface treatments of the multi-layer floor of the Divine Parquet line, laboratory validation of the innovative surface treatment of the multilayer floor was performed.

2.1. Parquet testing procedure

Parquet testing was performed on 30 different samples on which the wear index, surface roughness, gloss and Brinell hardness were measured. In this paper, we will pay special attention to the wear of the surface, given that from the aspect of protection at work, this is a more important indicator in the case of slippery surface.

Prior to the start of the test, all samples were numbered and weighed on a Uni Bloc AUW220D Shimadzu analytical balance used for precise laboratory weighing to four decimal places.

Figure 1: Taber test

After weighing, the examination of wear, ie abrasion of the surface, the so-called The taber test shown in Figure 1.

A wear test device is used to provide comparative data on the wear resistance of materials. It is important to recognize that there may be several factors that contribute to material wear and tear in actual use. Experiments should be conducted before predictions can be drawn from laboratory tests. This helps to establish a relationship between laboratory abrasion testing and actual wear in the intended end use. Consideration of additional factors is usually required in the calculation of projected durabilities from specific consumption data. "Wear resistance" is often referred to in terms of the number of cycles to produce a certain degree or amount of abrasion and "durability" (defined as the ability to withstand deterioration or wear during use, including the consequences of abrasion).

2.1. Parquet testing procedure

As stated at the beginning of the work, all samples before testing were weighed on the analytical balance, because the samples were weighed after each wear cycle and the weight loss and wear index were calculated. After all the samples were tested, the problem was how to assess when the so-called wear point was reached, which serves as a measure of the resistance of the varnish / oil to abrasion. Methylene blue ($C_{16}H_{18}CIN_3S$) was used as an auxiliary agent, the application of which on the sample creates a contrast between the varnish and the wood, so it is easier to determine the

consumption of the varnish. If the surface is damaged, methylene blue will stain the wood, which is a sign that the surface protection agent has been used up.

Figure 2*:* Parquet samples after using methylene blue

Figure 2 shows an example of the use of methylene blue. Both samples of parquet were tested at 6000 rpm, then coated with methylene blue, and according to the above figures, it can be concluded that the surface coating is worn.

All parquet samples were tested on 250, 500, 1000, 2000, 3000 and 6000 passes. From the obtained results it can be concluded that with more porlas the wear index decreases, which is a very good indicator because at 6000 passes the weight loss in all samples is very small, and thus the wear index is lower. Figure 3 shows a diagram of the wear index for each individual parquet sample. In the diagram, each color represents one pattern.

The weight loss test method is a quantifiable method that records the weight loss of the test specimen due to abrasion. Weigh the test specimen before and after testing to obtain the initial and final weight values. The difference between these two values F_{total}, will be the weight loss.

$$F_{total} = A - B \quad (1)$$

Where, A=weight of test specimen before abrasion, mg

B=weight of test specimen after abrasion, mg

$$Taber\ Wear\ Index = \frac{F_{total} x 1000\ cycles}{n} \quad (2)$$

Figure 3: Wear index diagram

3. CONCLUSION

Weighing of individual samples of parquet that have been subjected to testing on the Taber test clearly shows that with the increase in the number of passes there is an increased loss of mass. The weight loss of all samples is extremely small, which is a good indicator, because according to the formula, the wear index is calculated, and the lower the index, the better the wear resistance.

Drvoproizvod d.d. is FSC (The Forest Stewardship Council) certified, which is an indicator of promoting environmentally responsible, socially beneficial and economically sustainable management of the world's forest resources.

In the future, more attention should be paid to natural dyes, because the production of synthetic dyes is often not environmentally friendly and their use can be potentially harmful to health. There are natural colors that are tested like rose hips, beets and mushrooms. However, there are disadvantages to using natural paints, because they do not penetrate the wood and thus paint only the surface. Therefore, further research is needed to produce resistant natural dyes [2].

REFERENCES

[1] Lacković, V., Zagorec, M.: Trajnost parketa u zgradama, *Građevinar 56*, **Vol.**(2004) No.555-560
[2] Hrovatin, K., Hrovatin, J.: Bio-based Methods with Potentials for Application in Wooden Furniture Industry*, Drvna industrija* 71, **Vol.**(2020) No.301-308

APPLICATION OF ALARM SYSTEMS IN BUSINESS SPACE

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Abstract

This paper is about alarm systems in business properties. Nowadays, almost every business facility uses technical and mechanical protection, which are used to detect unauthorized entry into the protected area by sound or light. Their main goal is to slow down, detect and if possible, stop unauthorized entry into the protected facility. The paper also describes the degrees of protection that protect various objects depending on the degree of threat, as well as various types of detectors and video surveillance that contribute to even greater object security. If alarm systems are used correctly, the risk of a harmful event is reduced to the lowest level.
Keywords: *Alarm systems, security, degrees of protection, protected area*

1. INTRODUCTION

Nowadays, business and protection without an alarm system is almost impossible. It is also applied to residential, military and industrial facilities, as well as in the automotive industry, all with the aim of preventing theft or destruction of property, and controlling unauthorized access. Alarm systems are often integrated together with other technical protection systems, such as video surveillance, fire alarm or access control, which creates an integrated technical protection system. Their interaction provides additional data when determining the cause of system activation.

2. Alarm security systems

Alarm systems are the basis of all technical protection and include electronic protection of the facility with components intended for timely detection, recording, signaling and notification to the protection user of the occurrence of harmful events on the protected facility.

Almost all objects are suitable for the use of anti-burglary protection systems, and they are most often used to protect apartments, houses, bank branches, post offices, exchange offices, gas stations, betting shops and other objects. In order to use the full potential of the anti-burglary protection system, it is necessary to regularly maintain the system, to use it properly, and to use the quality of the anti-burglary equipment.

Alarm systems are divided into: wired systems, wireless systems and integrated systems.

The basic elements of the alarm system are:

- anti-burglary control panel with backup power supply and communicator;
- keyboard/remote control;
- motion and contact detectors;
- alarm siren with sound and light signaling [2]

3. Detectors

Detectors or alarm sensors are elements for detecting conditions and movements in space. They are the main part of any protective technical system, by means of which the resulting changes that activate the alarm are detected. They can be wired and wireless at 433 or 868 MHz frequency. Detectors are an extremely important factor in the protection of persons and all forms of property. Timely detection of heat, fire and smoke can prevent significant financial damage and reduce the possibility of people getting hurt. Types of detectors: magnetic switches, wall vibration detectors, passive

infrared detectors (PIR sensor), ultrasonic detectors, microwave detector, dual technology detectors, video detector and smoke detector. [3]

4. Video surveillance

Video surveillance is a technical protection system that is necessary in all areas where a higher level of security is to be ensured. It provides us with a basis for technical protection in protecting people and their property and minimizes abuse. Today, video surveillance is most often used as part of the technical protection of residential buildings and small shops, shopping centers, hotels, banks, hospitals, tourist facilities, airports, office buildings, industrial buildings and various open spaces. By integrating the video surveillance system with access control, fire alarm and anti-burglary, perimetric protection and license plate recognition systems, even better technical protection results are achieved. Video surveillance consists of a video camera, a video surveillance recorder and a cable. The video surveillance recorder (DVR[1], NVR[2], CMS[3]) stores the image from the video surveillance cameras on the hard disk and sends it to the system user. The cable is used to connect the camera and recorder and transmits the video signal. The quality of the image from the camera depends on the quality or saturation of the copper in the cable. An essential item of any video surveillance is a monitor, because high image quality is the most important thing for every user of a video system. If the quality or resolution of the monitor is bad, it will spoil the image of even the best cameras or a central device for displaying multiple cameras at the same time, where the quality of the display is even more important. [3]

[1] DVR - digital video recorder; an electronic device that records video in digital format to a disk drive, USB flash drive, SD memory card, SSD, or other local or networked mass storage device.
[2] NVR - network video recorder; a specialized computer system that includes a software program that records video in digital form to a disk drive, USB flash drive, SD memory card, or other mass storage device.
[3] CMS - Engl. Content management system; a system that enables content management, refers to any solution that enables classification, organization, linking and any other form of content editing.

With the development of technology, video surveillance has become simpler, more reliable and cheaper, and these are also the main reasons why video surveillance is increasingly used in technical protection. Video surveillance systems have many uses. Some of them are: deterring the intention of harmful action towards the protected object, analysis of the commission of harmful action within the protected object, identification of the person who committed the harmful action, and control of work processes. Alarms can trigger a variety of camera events such as: general motion, missing object, foreign object, loss of focus, camera overlap, and video dropout. In order for the protection system to fulfill its function and be cost-effective, its reliability must be ensured, malfunctions must be quickly eliminated, users trained for use and equipment that technologically enables remote maintenance and adjustment must be used. [4]

Types of security cameras

a) Wired cameras
b) Wireless cameras
c) Internal cameras
d) Cameras with a built-in motion detector
e) Adjustable cameras for video surveillance
f) External video cameras [5]

5. Biometric locks

Biometrics is the science of procedures for the unique recognition of people, based on the comparison of one or more innate physical characteristics. It deals with the identification of individuals, based on their biological or behavioral characteristics. It is very often used in the fields of medical diagnostics, IT security, private protection, monitoring of movement in certain public spaces (authentication), identification of persons for non-criminal purposes, such as monitoring elections, proving paternity,

etc. Biometric technology uses the unique features of the biological characteristics of a human being, that is, characteristics of the bearer that are not alienable and cannot be simply copied. [6]

In order for a specific feature to be used in the identification process, certain criteria must be met. Some of them are:

- uniqueness (every person must have it)
- individuality (must be different for each person)
- durability and immutability
- the possibility of extracting from the totality of features (due to the possible creation of databases)
- simple collection and use. [7]

5.1. Principle of operation of biometric locks

Biometrics is used for simpler protections, such as the protection of a mobile device, a tablet via a fingerprint, while biometric locks are an excellent protection, given that the biometric characteristics are unique and inalienable. They are excellent protection against theft and there is no risk of losing keys, cards, pendants and the like. They open very quickly, some in less than a second. They can be placed in a house, apartment or business building. In the event of a power outage, the locks are installed with an alternative door opening system that requires a mechanical key, digital code or card access. There is no risk of an unauthorized person entering the protected room using someone else's card. There are two models of biometric locks, contactless and touch. Contactless biometric locks work on the principle of eye, voice or facial recognition, while touch biometric locks use only fingerprints to enter the room. If a person is recognized by the computer system and is allowed to enter, the door opens. [8]

The most important technologies for biometric identification systems are:

a) Fingerprint identification

b) Identification of palm and finger prints

c) Identification of characteristic facial features

d) Identification of the pupil of the eye

e) Voice identification

6. Access control system

One of the most important elements of the technical protection system is access control. The goal of access and passage control is to protect a business or residential building from unauthorized entry, monitor entry and exit, and thus increase the level of security. Passage control also monitors the removal or introduction of illegal materials from or into the space. It can be used to protect the entire facility or to protect specially protected units, but also to prove identity for entering protected areas, cars, access to computers or protected data. In combination with access control systems, video surveillance systems, digital recording and data storage are used to raise security to a higher level.

Properly designed, implemented and maintained access control systems and working time records provide the most information about movement within the protected area, work habits and employee discipline, with relatively small financial allocations compared to other technical protection systems. The previously described factors have a significant impact on increasing the level of safety of all persons who are permanently or occasionally inside the protected area, which is also the task of the protection system.

In order to identify users, RFID[4] (Radio-frequency identification) contactless cards that have a built-in chip for access control are most often used. In addition to RFID cards, RFID labels, bracelets, pendants and dual cards are also used. [9]

[4] RFID in translation from English means radio frequency identification

7. CONCLUSION

The percentage of thefts and burglaries increases drastically from year to year, so the human need for professional protection of their property increases accordingly. There are various alarm systems that ensure our safety and peace of mind, but if the systems are not maintained and serviced, they will not be operational, which reduces their effectiveness. The use of anti-burglary alarm systems significantly reduces the possibility of things being stolen or the devastation of the fenced area, and sometimes just a warning that the object is under video surveillance drives criminals away. New technology and new systems give us the ability to monitor the entire protection system. I think that nowadays it is necessary to invest in a better quality camera in order to more easily identify the perpetrator if damage is committed. Every business or residential building should at least have a smoke detector because they are the most important part of the fire alarm system because the reaction to the occurrence of a fire depends on the speed of detection, and less damage to the space and to people's health.

8. LITERATURE

1. https://krobel.hr/tehnicka-zastita/alarmni-sustav

2. https://raptor.hr/kategorija-proizvoda/tehnicka-zastita/alarmni-sustavi

3. https://www.protrade-int.com/integracija-sustava

4. http://www.z-1.hr/videonadzor.html

5. http://protuprovala.hr/video-nadzor

6. Dešlimunović Davor: "Suvremeni koncepti i uređaji zaštite", I.T. Graf, Zagreb, (2002.)

7. Želimir Radmilović: Stručni članak: „Biometrijska identifikacija, Policija i sigurnost, Zagreb, (2008.)

8. https://www.prozorivrata.com/sta-je-i-kako-radi-biometrijska-brava

9. Dešlimunović Davor.: "Menadžment zaštite i sigurnosti", Pragmatekh, Zagreb, (2006.)

MAINTENANCE OF CO_2 LASER CUTTERS

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Abstract: *The aim of this paper is to describe the methods of maintenance, enumerate strategies and present the principle of maintenance of CO2 laser cutters in a manufacturing company, while respecting the rules of safety at work. The development and division of maintenance strategies, as well as possible hazards and safety rules when working with a laser cutter are described. Features, maintenance technologies as well as the impact of information systems are defined. In addition to the described laser cutting technologies, the basic components of the CO2 laser cutter are listed and defined. An overview of the steps during service as well as the technical documentation of the machine and the recommended intervals of regular and preventive maintenance by the manufacturer are presented.*

Keywords: *maintenance, maintenance strategy, CO2 laser technology, preventive maintenance intervals, EHS.*

1. INTRODUCTION - ABOUT MACHINE MAINTENANCE IN GENERAL

The maintenance of equipment in the process industry is extremely important. Machinery and equipment increase their chances of sudden failure with increasing working hours, which if not anticipated in time can result in downtime, causing huge losses and delays in the company's further plans.

Maintenance must be performed at the prescribed intervals for each machine and piece of equipment. The more technologically advanced the machine, the greater the need for more educated personnel to maintain such equipment. Due to the loss of warranty, some components of complex machines must not be opened without the presence of an authorized service center.

2. WORKING PRINCIPLE AND APPLICATION OF CO_2 LASERS

Laser cutters based on CO_2 technology consist of a main part of the machine with a cutting head, a workbench located on the guides and receiving cutting plates.

The task of the operator is to load the program for cutting, placing and removing new plates that will be processed by the machine, and daily or weekly cleaning of the machine after the shift.

3. HAZARDS WHEN WORKING WITH LASER METAL CUTTERS

In the metalworking industry, any device or work-tool poses a potential hazard to the worker. The danger is greater if protective equipment for work is not used in accordance with the Ordinance on the use of personal protective equipment and the law on occupational safety and if it is used by persons who are not professionally trained to work with them.

3.1. Jobs with special working conditions

Jobs with special working conditions are jobs that are performed in extreme working conditions or involve a distinct degree of possible threat to the health of workers and persons in their working environment, and therefore impose special responsibility for working in a safe manner.

The employer is obliged to conduct training to work in a safe manner.

3.2. Operator protection

Manufacturers of CNC machines strive to minimize the risk of danger with various design solutions of the machine itself or additional upgrades in the vicinity of the machine (various partitions, laser beams, cabins...).

During indoor laser processing, the operator is physically separated during the machine operation, usually by a sliding door with a large window. The enclosed space significantly reduces the amount of dust around the machine and reduces the noise level.

The machine is equipped with a light beam that spreads around the workbench and is turned on when cutting starts. If this beam is interrupted, the machine automatically stops working.

3.3. Risk evaluation

A risk assessment should be done. The risk assessment must be recorded in written and electronic form and must be available to the worker at the place of work. The risk assessment can be made by the employer himself or it can be made by an authorized person. An assessment is made by the person who makes it (the employer himself or an authorized person) and the workers or their representative (representative of workers).

3.4. Mandatory personal protective equipment when handling lasers

When handling lasers, the manufacturer recommends certain protective equipment, which is then supplemented in accordance with other operating conditions.

The recommended protective equipment according to the laser manufacturer is:

- leather protective gloves,
- protective goggles (recommended when cleaning the inside of the machine regularly),
- ear protection products (as needed),
- shoes with a protective toe cap.

3.5. Laser radiation hazards

The CO_2 laser produces invisible light (electromagnetic radiation) with high energy. Endangerment of humans can occur directly but even by the reflection of laser radiation. Light can cause thermal damage (burns, tissue destruction). The length of the laser wave beam is 10.6 μm and belongs to the laser class 4.

When adjusting the beam or resonator work, personnel must be equipped with eye protection goggles that comply with EN 60825-1.

During normal operation of the machine, the air travels through light tunnels through the mirror and cannot escape outside that space as long as the machine is used under normal conditions for which it is intended. There is a sticker on the body of the machine that warns of caution from laser beam radiation.

4. EXPERIMENTAL PART - OVERVIEW OF THE PROCESS OF REGULAR MAINTENANCE OF CO_2 LASERS

Regular annual service of the laser cutter is performed after 2000 working hours or a period of one year. In addition to the regular annual service, minor

periodic interventions are performed on the machine during the rest of the year, according to the maintenance instructions in the service manual.

Small interventions are most often cleaning and control of moving parts, which are then lubricated, and cleaning or blowing out filter elements.

One of the most important steps is to regularly empty the container in a compact pollinator (at least once a week). If the operator neglects this step, a potential explosion or fire may occur in the joint reaction of aluminum and steel dust. The operator must be careful after each cutting of aluminum or steel to avoid mixing the two dusts together.

When delivering such machines, the manufacturer delivers detailed maintenance documentation and diagrams or schematics of electrical installations in the machine. In addition to this documentation, the machine has an electronic service record, which stores interventions and working hours, as well as errors from the past that the machine recorded during operation. The machine itself warns of the regular annual service.

4.1. Beginning of service intervention - connecting the diagnostic device

Regular annual service begins with a call to a company authorized to service such machines. It is important to plan eight free hours of the machine in the production plant for the needs of service.

The service technician starts the maintenance by connecting the diagnostics to the machine.

The operating hours are checked, the gas pressure in the machine resonator is checked, and the calibration of the default settings is checked: how much is set the allowable cutting power, and the speed of movement of the laser head.

4.2. Visual inspection of components

If the service technician does not detect any extraordinary errors in the diagnostics, he continues his procedure according to the regular instructions and starts the visual inspection of the most important components such as the laser head, and the vertical and horizontal guides of the laser head.

The control is also performed on the machine control unit where the cutting parameters can be controlled in real time. The service technician, through the diagnostic device, checks whether all the keys are in function, and whether the screen displays the correct data.

4.3. Replacement of worn-out components

In the technical and service documentation, there are written in detail the necessary procedures related to the working hours of the machine. Depending on the

hours worked by the machine, the operator throughout the year performs one part of the project. The second part is performed during regular service for 2000 hours worked.

During the annual service, replacement of worn-out components is carried out according to the service instructions.

Then all components for which replacement is prescribed after 2,000 operating hours of the machine have been replaced, as well as those for which the service technician determines that they are too much worn-out for safe operation.

In addition to regular components (filters, cooling water), nozzles from the laser head, some pushbuttons, damaged laser head cover due to unintentional collisions with the product during machine operation, and protective glass on the machine housing itself are most often replaced.

4.4. Cleaning the machine components

When cutting metal plates, fine metal dust is created which collects in the machine trough. Part of this dust will always find its way to the machine's sliding tracks, which are lubricated with special oils and greases.

At each regular service, the service technician disassembles the guide covers and performs the process of degreasing the old grease with special solvents, and then re-lubricating them. This step is of great importance in the maintenance of such machines. Any forced displacement of the guides during the operation would directly affect the laser head position and impair the quality of the cut, and thus the dimensional accuracy of the product.

It is necessary to inspect the condition of the mirror in the resonator of the machine. Worn and blurred mirror impairs the quality of the laser beam and reduces its intensity, at the same time affecting the poorer efficiency of the machine.

When a new nozzle is installed, the laser head of the machine loses its calibration and must be reset to zero. The service technician calibrates the laser head using a fine-tuning potentiometer. The machine operator also often performs minor calibrations. Sometimes nozzles have to be changed prematurely. It all depends on the mechanical properties of the material, which are being cut on the machine.

After the service technician has inspected, cleaned and replaced the main components on which the quality and accuracy of the machine depend the most, less demanding steps are taken, such as inspection of cooling water conductivity and water replacement as well as cleaning of the cooling system of the machine resonator.

When changing the cooling water, a special biocide agent is poured into the machine, which cleans the cooling system and eliminates the possibility of the development of algae and microorganisms within the cooling circuit. When pouring new cooling water, demineralized water with the lowest possible conductivity and carbonate content up to 100 mg/L is used. Pouring ordinary tap water would cause

limescale to settle inside the resonator and other parts of the laser. The cooling flow would slow down, and potentially completely clog causing the resonator failure.

4.5. Starting the machine and test run

Together, the operator and the service technician start the machine after the service procedure has been completed. A plate of plain structural steel is placed and a test piece for dimensional control is cut. If the laser head guides are in good condition and the machine itself is regularly serviced, the accuracy of the measurements of each cut product should be within 1/100 mm. During the test cut, the service technician monitors the axis displacements and the operation of the machine on the diagnostic device. If the machine reports a malfunction, it will be printed in a code, which the service technician can easily find in the service book and see in which part of the machine the fault occurs.

After the service procedure, a service order with a description of repairs and replaced parts is filled in, signed by the service technician and the person in charge of maintenance at the company.

4.6. Sending the sample to the measurement laboratory

Sending a sample of material cut after a service procedure is an additional service that the customer of the service procedure may or may not choose.

It is important if high accuracy and precision of the cut parts is required.

When making most parts, an average cut accuracy of 1/10 millimeter will be satisfactory. Older variants of the machines can also achieve this. Newer laser cutters have a declared accuracy of 1/100 mm. With such machines, as a precaution, check once a year whether these cutting performances are still possible. The wear of the sliding tracks, the worn nozzles on the laser head, and the worn mirrors in the resonator will significantly affect the accuracy and cutting power of the CO_2 laser cutters.

5. CONCLUSION

Choosing a fleet maintenance strategy mostly depends on the company that will select and combine different models and maintenance strategies depending on the type of machinery they own. A good company strategy and organization will increase productivity, market competitiveness and reduce potential losses due to machine downtime.

Maintenance of CO_2 laser cutters is important to work according to the prescribed maintenance plan. The complexity of these machines will lead to the fact

that the machine will very quickly lose the cutting power and dimensional accuracy of the cut if the prescribed maintenance intervals are not observed.

The high purchase price of such machines does not allow a frivolous approach to maintenance, because the machine is most cost-effective only when it works regularly and correctly, or in other words, fulfills its function. It is good that the operator participates in the maintenance of the machine, because in case of failures, it can significantly help the external service in diagnosing and quick troubleshooting.

REFERENCES

[1] Frković, D.: *Održavanje i gospodarenje imovinom,* Hrvatsko društvo održavatelja, ISBN 9789535521945, Zagreb, (2016)

[2] Inženjerski priručnik / IP4 Proizvodno strojarstvo, Sv. 1: Materijali, Školska Knjiga, ISBN 9789530316652, Zagreb, (1999)

[3] Leibinger-Kammüller, N.: *The laser as a tool*, Trumpf GmbH + Co. KG, Ditzigen, (2007)

[4] *Upute za rad TruLaser 3030/3040/3060*, Trumpf GmbH + Co. KG, Ditzigen, (2006)

[5] *Uvjeti za postavljanje stroja TruLaser 3020*, Trumpf GmbH+Co. KG, Ditzigen, (2008)

[6] Dunaj-Mutak, Lj.: *Sigurnost i zaštita pri radu u industriji*, ZIRS, ISBN 9536412349 Zagreb, (2000)

TRADITIONAL FREE FORGING

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Abstract: *This paper describes the experimental application of traditional free forging in the production of "Bowie" knives, while respecting the rules of safety at work. After forging, laboratory measurements of forged material were performed, as well as practical sharpness tests with various quality control tests. According to the performed experimental part, the obtained results were analysed, on the basis of which a conclusion was made.*

Keywords: *free forging, knife, blade, bowie, hardening, tempering, safety rules.*

1. INTRODUCTION - GENERAL ABOUT FORGING

Forging is a skill known since ancient times and one of the fundamental industrial activities in metal processing and mechanical engineering. Some metals and alloys can be forged in the cold state. However, in most cases material is processed by forging in white or red heat (low-carbon and high-carbon steel) or slightly red heat (aluminium, copper, brass, bronze). Heating reduces the yielding stress and increases the deformability [1].

2. SAFETY AT WORK

Accidents that involve not only temporary disability, but also partial or complete disability are possible when performing blacksmithing and locksmithing. The most common of these are: carbon monoxide poisoning emitted from the furnace when heating metals, hand burns due to careless handling of heated parts, manual cuts due to careless handling of parts and workpieces with grinders, bruises on the legs from tools and heavy parts if they are not well attached or if they accidentally fall, eye irritation and injury by shavings in the process of work, bruises on the hands due to the hammer bouncing when hitting the workpiece with a hammer and electric shock when using tools with faulty power supply.

3. EXPERIMENTAL PART

In the experimental part, the blade forging process was performed. The experimental work can be divided into two parts:

- production of blades from steel 38Si6 and 60WCrV7;
- blade testing by implementing sharpness and hardness tests.

Using the theory of forging, two “Bowie” knives will be made of 38Si6 and 60WCrV7 steel. Each will be tested separately for sharpness and hardness tests.

3.1. “Bowie” knife

The “Bowie” is a large knife with a recognizable blade shape, named by James Bowie (died at the Battle of the Alamo). It appeared in the United States of America (USA) in the 1930s and it is considered one of the symbols of the USA. The exact design of the product is not known. It is assumed that the blade was bevelled at the tip of the knife. The arm guard is S-shaped or flat, made of brass, bronze or aluminium. The flat handrail is made of wood or horn. The linings are fastened with screws, sometimes with rivets. Approximate dimensions: length 24 cm, width 3.8 cm. An interesting fact is that the first knife of American astronauts was just a scaled-down version of the Bowie knife.

3.2. Blade making

According to the conceptual drawing, two "Bowie" knives are made of steel 38Si6 and 60WCrV7. Heating on a blacksmith's fire to a red-orange-yellow color (up to ~ 1050 ° C) gradually forms a bar material using the main blacksmith operations. The material is shaped into an approximate shape of the given sketch. The workpiece is heated part by part. The heated part of the material is placed on the anvil and by striking the hammer it achieves an approximate shape of the blade.

Figure 1: Free Forging

After forging, the part of the material that is excess in shape and form with regard to dimensions and a given sketch, is cut with an angle grinder. On a belt sander, the workpiece is pre-sanded and prepared for hardening in oil.

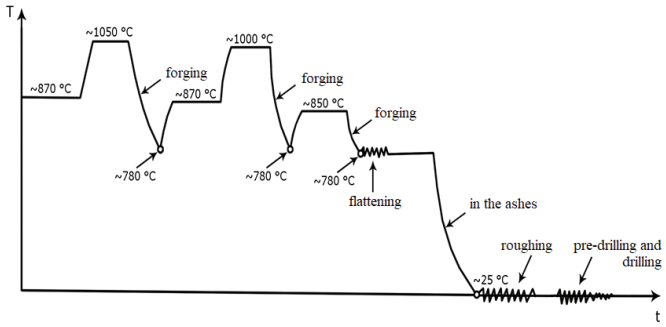

Figure 2: T-t diagram at hardening

After the planned grinding, a 1:1 scale sketch of a knife shape is pasted on the workpiece, and the excess material is cut out. The process is finalised by grinding the cut shape.

Planned grinding shows how straight the workpiece has been forged. Based on the assessment, it should be seen whether the workpiece needs to be re-levelled by forging or it is enough to just grind it. If there is no delamination or cracks in the material, the hardening process is started.

Figure 3: Demonstration of grinding, shape cutting and hardening in oil

Hardening is performed by heating the workpiece up to a temperature of 850 °C to 900 °C and subsequent quenching in oil. The workpiece remains in the oil up to 50 °C, then it is removed from the cooling medium (oil). After that, the workpiece is visually inspected and tested with a file.

If the workpiece is bent, layered or cracked, the workpiece is invalid and defective. The bent workpiece could possibly be repaired by straightening. In the event of delamination or cracking, the workpiece is immediately declared scrap.

After the visual inspection, a file inspection is performed. If the file slides on the hardened surface, the hardening process is successful and the next step is taken. If the hardening process fails, the file will be notched into the material. The hardening process must be repeated.

The next processing step is low-temperature tempering of the steel. The transformation of tetragonal martensite into cubic takes place in order to obtain an increase in the toughness of the tempered martensite, a decrease in residual stresses and a decrease in hardness, where the latter is undesirable, but also inevitable. The tempering is performed by

heating the material to temperatures up to 250 ° C and keeping it at that temperature for one hour. After tempering, cooling takes place in the oven. After cooling, the blade is finely sharpened. In the end, a two-part handle was made as well as an "S" shaped hand guard. The two-part handle is cut from wood (cherry wood). The handles are ground and fastened to the knife handle with metal pins and glue. The "S" shaped shield is made by casting aluminium in a mould with fine sand according to the drawing. After cooling, the shield is sanded and glued to the body of the knife. Blade quality control follows.

Figure 4: Shield mould making, casting and final shape after sanding

Figure 5: Glued shield to the body and final shape after grinding

3.3. Quality control

3.3.1. Introduction to quality control

Quality control will be carried out through a sharpness experiment and a strength (hardness) experiment. In the sharpness experiment, five apples were placed on a flat surface. Apples were cut with one strong swipe of a previously produced knife. The behaviour of the blade during the cut and the amount of apples cut was observed. In the experiment, the strength and hardness of the blade were tested on a copper tube by pounding a hammer on the knife - five times. At the end of the test, the blade and the body of the knife were analysed, namely the part on which we pounded with a hammer. Possible damages (delamination, dents and cracks) were observed. After the tests, the analysis of the obtained results and the conclusion followed, as well as the definition of the procedure on how to eliminate the damage if it occurs.

3.3.2. Sharpness experiment

The apples are lined up one after the other and cut with a strong swing. The quantity of sliced apples is observed and it is compared which of the two blades performs better in exploitation. The first knife with which the incision was made was made of 60WCrV7 (tool

steel). During the tests, the knife made of 60WCrV7 steel cut the apple and a half, which is satisfactory considering that the kitchen knife cannot cut one apple. The blade has no damage and behaves well in swing.

Figure 6: The first (60WCrV7) and the second knife (38Si6)

In order to eliminate the influence of human error on the results of the experiment, it was decided to repeat the experiment. There is no significant deviation in the results of the second attempt either. The second test knife is made of 38Si6 (spring steel). During the tests, the knife made of 38Si6 steel cut two and a half apples. When comparing the results of the first and the second knife, the second knife or 38Si6 shows a better result in terms of the number of apples cut. The experiment was repeated twice to ignore the influence of the human factor. In the repeated experiment, even better results were obtained. Three apples were cut, and the fourth was cut in half. The blade is undamaged and durable even after the repeated experiment. In the conducted experiment, both knives achieve the expected results. However, according to the amount of cut apples, the knife from spring steel is far better.

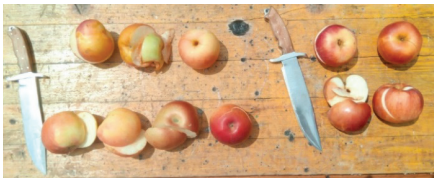

Figure 7: Total result of cut apples, left 38Si6 (spring steel), right 60WCrV7 (tool steel)

3.3.3. Strength and hardness experiment

The second test of quality control is the strength experiment. The test was performed on a copper tube. A rubber hammer strikes a knife mounted on a copper tube. Each knife was struck five times. The tool steel 60WCrV7 was tested first. Visual inspection showed that there was no damage or dents on the blade. The blade is durable, sharp and ready for further use. The same test procedure was performed on a 38Si6 (spring steel) knife. The test results obtained were identical to ones obtained during the testing of the first knife. Visual inspection showed no damage on the blade, and a dent appeared on the copper pipe.

Figure 8: Knives and copper tubes - above 60WCrV7, below 38Si6

Upon completion of the experiments, it is evident that both knives are of more than satisfactory quality. The blades do not show any surface damage, delamination or cracking. Given this outcome of the experiments, it is concluded that the processes of production and heat treatment of selected steels were successfully performed.

4. CONCLUSION

The aim of the work was to make two Bowie knives with two different materials, by the process of free forging in the traditional way without the use of modern measuring devices and heating exclusively on coal. Free forging without the use of modern machines is hard and arduous work. In order to forge the forge, it takes a few days of forging and shaping with a furnace that radiates heat. Heavy hammers and robust tools are used. The knives are made according to the sketch. In experimental work, it has been proven that both knives are more than satisfactory in performance. Good sharpness, high strength and good sharpness retention are just some of the features that the produced knives have. This proves that all instructions and rules of heat treatment were followed during the processing and production of knives.

5. REFERENCES

[1] Horvat, Oto F.: *Mehanička tehnologija*, Tehnička knjiga Zagreb, Zagreb, (1950)

[2] Cebalo, R.: *Obrada materijala*, Viša tehnička strojarska škola, Karlovac, (1980)

[3] Interno: *Slobodno kovanje čelika*, Fakultet strojarstva i brodogradnje, Zagreb, (2005)

[4] Hribar, J.: *Plastična obrada metala*, Fakultet strojarstva i brodogradnje, Zagreb, (1975)

[5] Hanzliček, J.; Dvoržak D.; Belovsky, V.: *Ručna obrada metala*, Beograd, (1948)

[6] Litić, P.; Tucaković, K.: *Čelični materijali*, Metalbiro, Zagreb, (1978)

[7] https://www.bladehq.com/item--Condor-Undertaker-Bowie-Fixed-Blade--68099 Accessed: 2022-05-25

[8] Grizelj, B.: *Oblikovanje metala deformiranjem*, Strojarski fakultet u Slavonskom brodu, ISBN 978-953-6048-88-5, Slavonski Brod, (2018)

[9] Kraut, B.: *Strojarski priručnik*, Kratis, ISBN 953-97119-1-6, Zagreb, (1997)

INFRARED RADIATION: APPLICATIONS AND PROTECTION

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Abstract: *Radiation is the emission or transmission of energy in the form of waves or particles. It is often categorized as either ionizing or non-ionizing. Ionizing radiation has sufficiently high energy to ionize atoms. The kinetic energy of particles of non-ionizing radiation is too small to ionize atoms. Non-ionizing radiation includes the spectrum of ultraviolet (UV), visible light, infrared (IR), microwave (MW), radio frequency (RF), and extremely low frequency (ELF). In this paper, we first describe IR radiation characteristics and applications and then we describe protection methods against IR radiation.*

Keywords: *non-ionizing radiation, infrared radiation, detectors, infrared thermography, protection*

1. INTRODUCTION

Electromagnetic (EM) radiation is the propagation of electromagnetic waves - synchronized oscillations of electric and magnetic fields - through space at the speed of light. It includes all types of electromagnetic waves, from low-frequency waves to microwaves and the optical spectrum to high-frequency X-rays and gamma rays. Part of the wavelengths from 380 nanometers to 760 nanometers belongs to visible light, and each wavelength within this range has one color [1]. The entire color spectrum is contained in the white light of the sun. In general, the electromagnetic spectrum can be divided into ionizing and non-ionizing radiation. Ionizing radiation is radiation whose energy is sufficient to remove tightly bound electrons from the orbit of the atom when interacting with it, thus ionizing the atom [2]. Ionizing radiation can be a product of nuclear fission, nuclear fusion, radioactive decay, extremely hot objects, and accelerated charges. Ionizing radiation includes X-rays (X-rays), gamma rays, and cosmic rays, which can harm human cells. Lower energy rays include radio waves, visible light, microwaves, infrared and ultraviolet rays,

which do not have the power to ionize an atom and are called non-ionizing rays. Infrared radiation is widely used because it is almost harmless to humans and the environment. Human health can only be affected by long-term exposure, but there are various measures and protection methods to prevent this.

2. INFRARED RADIATION

This type of radiation is invisible to the human eye, but we can feel it as heat. In the electromagnetic spectrum, infrared radiation is located below visible light and above microwaves. The wavelength is between 1000 μm and 760 nm. The red color in visible light has the longest wavelength, i.e. the lowest frequency.

Infrared radiation can be absorbed or reflected, depending on the nature of the matter it encounters. Water vapor, carbon dioxide, and ozone absorb infrared radiation effectively. When infrared radiation interacts with matter, the transmitted energy of the radiation usually manifests itself in an increase in the temperature of the matter. This increase causes secondary phenomena, a change in many properties of matter: body volume, pressure, refractive index, dielectricity, electrical conductivity, and chemical properties. The occurrence of secondary radiation is also possible. [3]

3. APPLICATIONS OF INFRARED RADIATION

Infrared radiation is used for various purposes. The most common are thermal sensors, thermal imaging, night vision, spectroscopy, meteorology, and communications.

Infrared thermography is a non-contact method of measuring temperature and its distribution on the surface of the body, based on measuring the intensity of infrared radiation from the surface of the observed body [4]. Temperature measurement is based on measuring the intensity of infrared radiation of a certain wavelength emitted from the surface of the observed body, which is converted into a visible image in the form of a temperature field using an IR camera.

Infrared thermography is widely used in medicine to detect diseases. It is a non-contact and non-invasive procedure, adapted to the patient, which can be used to localize and detect thermal irregularities. It is frequently used in sports medicine. Thermography is the most important method for detecting breast cancer. Tumors usually have an increased blood supply and metabolic rate, resulting in high temperatures in these areas, which is why infrared thermography can detect them.

The skin is the largest organ in the human body and serves as a barrier between the environment and the internal organs of the body. An imbalance in the system or external influences can lead to various skin diseases such as rashes, itching,

allergies, and cancer. Skin diseases usually cause inflammation, which causes an abnormal temperature pattern on the skin surface. Infrared thermography serves as a tool for the early detection of oncological diseases of the skin.

Thermography provides us with a method of visualizing the vascular network. It determines the relationship between the difference in skin temperature and blood flow. The oscillations of the blood flow are the source of the heat waves that spread from the vessels to the skin surface. Using thermography, a spectral filtering technique has been developed to process blood flow [5].

The application of infrared technology in the industry is for fault diagnosis and verification of measures taken to prevent the occurrence of a fault or accident. Infrared camera systems detect leaks in pipes and insulation and detect pipe blockages. Many pipes are insulated with temperature-resistant stone, so infrared technology can also be used to confirm that the insulation is still intact. Electrical and mechanical problems result from hot spots that indicate loose electrical connections, faulty components, improper installation of components, overloaded motors or pumps, misaligned connections, and other undesirable conditions. Material thinning may be observed as heat is dissipated more quickly from the surface of thicker parts. Defects can be detected as heat flow from the surface of the solid is affected by internal defects such as decay, voids, or inclusions.

The field of electrical engineering is relatively challenging, as there is no single technical standard for assessing the correctness of electrical installations based on thermograms. Several organizations have developed their maintenance methodology over the years.

The standard diagnostic tool for integrated circuit inspection is microscopic thermal testing. Faults such as drain current, short circuits, and low impedance generation in MOSFET transistors result in heat sources. Even the normal operation of an integrated circuit can lead to, usually lower, characteristic local heating, which can be used to analyze the correctness of the circuit.

Infrared spectroscopy is an instrumental method for detecting or identifying the functional groups present in a molecule. Since each molecule has a different infrared spectrum, infrared spectroscopy is used to identify substances. Molecules vibrate at different frequencies because their structures are different. This technique is used in organic and inorganic chemistry, petrochemistry, the pharmaceutical industry, and food analysis.[6]

Infrared communication is used in today's technology, for example, to give commands to robots. This includes household devices that we use every day. Each device has an infrared transmitter and receiver. Through this receiver, the device receives a signal from a remote control. The frequency of the transmitter is usually 38 kHz, as it rarely occurs in nature and therefore cannot be confused with the environment. The receiving diode detects all frequencies of infrared light, but lets through only 38 kHz. It then amplifies the modular signal and converts it into a binary signal that transmits data to the circuit board [7].

Safety in the workplace is becoming an increasingly important concept in the world. There are fewer injuries that occur at work and fewer sick and annual leave are taken at work. As a result, workplace efficiency is higher, the company is more

successful and better, and employees are happier. In today's world, many physical and other jobs have been replaced by a robot, machines, or devices. Some of them work on the principle of infrared rays, which means that the commands are given to the robots through remote controls. It is useful that a human does not have to do physical work, but a robot does it for him. With infrared radiation, it is possible to find out where energy losses from power plants, pipe installations, and elements occur. With the help of an infrared camera and computer infrared analysis in parallel with technical documentation, the exact location of the leak or crack can be determined. This is often used for underground pipelines. Often the temperature is an important parameter of production processes, so production can be monitored in this way. The use of thermography also comes into play in fire protection, where aerial images can be used to detect fires or monitor fire areas. When moving through smoke-filled rooms, thermography is used.

To obtain the most accurate and precise weather forecasts possible, meteorologists obtain infrared images from meteorological satellites equipped with radiometers. Using these images, meteorologists can determine the type and height of clouds, the temperature of water and land surfaces, and make long-term and short-term weather forecasts and predictions. The advantage of infrared imaging is that clouds can be seen even at night. The atmosphere gets colder as altitude increases, so higher clouds are also colder.

This technology is essential both at sea and on land. In seafaring, it can accurately track ocean currents by observing the mixing of seawater at different temperatures and detect various problems such as hurricanes. It is also important in agriculture, for which meteorological forecasts are crucial so that farmers can plan their work.

4. INFRARED RADIATION PROTECTION

Most IR is emitted by the Sun but with technological advances, artificial devices increase the appearance of radiation. The most common disease caused by IR is cataracts. Prolonged exposure causes irreversible damage to the lens of the eye. Small amounts of IR can cause symptoms such as irritation, redness of the eyes, swelling of the eyes, or bleeding. In addition to damaging the human eye, infrared radiation can have significant effects on human skin. Intense radiation can cause burns or blisters on the skin. The effect on the skin depends on the total dose of radiation, which depends on the intensity, duration of exposure, and wavelength of the radiation.

To prevent contact of an employer with IR, it is necessary to install filtering screens and curtains and to build special rooms. When installing barriers and directing the rays, it should be taken into consideration that infrared rays can be reflected from shiny surfaces, so the place where the radiation is directed should be dull and not shiny. The warning and hazard signs should be placed in the workplace.

IR only affects the surface of the human body, as it does not have enough energy to penetrate the inside of the body. Long-term exposure can also have harmful effects on the eyes. To prevent this, measures for protection from infrared radiation and non-ionizing radiation have been introduced [8]:

1. Setting limits and controlling human exposure to non-ionizing radiation,
2. Calculating and evaluating radiation levels in the vicinity of sources of non-ionizing radiation,
3. Measurement of radiation levels in the vicinity of sources of non-ionizing radiation,
4. Time limitation of exposure of persons to non-ionizing radiation,
5. Labeling of sources of non-ionizing radiation and the rooms in which they are located,
6. Use of protective equipment when working with sources of non-ionizing radiation or when working in areas with non-ionizing radiation,
7. Establishment of conditions for accommodation, procurement, and use of sources of non-ionizing radiation,
8. Education and professional training of personnel concerning protection from non-ionizing radiation,
9. Determination and monitoring of the health of persons exposed to non-ionizing radiation at their workplaces,
10. Personal and mutual protection of persons from exposure to non-ionizing radiation,
11. Provision of skilled personnel, technical, financial, and other conditions for the implementation of protective measures against non-ionizing radiation,
12. Maintenance of records on sources of non-ionizing radiation and the exposure of persons to sources of non-ionizing radiation,
13. Monitoring of sources of non-ionizing radiation and the application of protective measures [8].

If exposure to infrared radiation cannot be controlled, personal protective equipment and personal protective devices should be used. Protective eyewear, visors, and protective clothing are used to reduce exposure to light.

5. CONCLUSION

The use of IR is widespread. We use IR in spectroscopy, communications, meteorology, and most commonly in infrared thermography. In medicine, we use it to detect various diseases, and in construction and industry to detect defects, which can be very important for the continuous operation of the equipment. With the development of technology, the application of infrared radiation is also developing, and so the properties of infrared radiation are more and more researched and studied,

and attempts are made to reduce the negative influence of radiation on biological tissue. By applying the measures required by law, using personal protective equipment, and setting up protective measures in the workplace, people working with infrared radiation should not be at risk.

REFERENCES

[1] spektar. Hrvatska enciklopedija, mrežno izdanje. Leksikografski zavod Miroslav Krleža, 2021. *Available from* http://www.enciklopedija.hr/Natuknica.aspx?ID=57368 *Accessed:* 2022-07-10

[2] Britannica, T. Editors of Encyclopaedia ionization energy. Encyclopedia Britannica. *Available from* https://www.britannica.com/science/ionization-energy *Accessed:* 2022-07-19

[3] Bramson, M. A.: *Infrared Radiation,* Springer New York, 978-1-4757-0911-7, NY, (1968)

[4] Andrassy, M.; I. Boras, I.; Švaić,: S. *Osnove termografije s primjenom*, Kigen, Zagreb, (2008)

[5] Eddie, Y. K.; Etehadtavakol, M.: *Application of Infrared to Biomedical Sciences*, Springer, 978-981-10-3147-2, (2017)

[6] Stuart, B. H.: *Infrared Spectroscopy: Fundamentals and Applications,* John Wiley & Sons, Ltd, 9780470854273, (2004)

[7] Barry, J. R.: *Wireless Infrared Communications*, Springer, 0792394763, (1994)

[8] Zakon o zaštiti od neionizirajućeg zračenja, čl.7.7, *Available from* https://www.zakon.hr/z/347/Zakon-o-za%C5%A1titi-od-neioniziraju%C4%87eg-zra%C4%8Denja *Accessed:* 2022-07-10.

5

ERGONOMICS

APPLICATION OF COMPUTERS IN IMPROVING THE LIFE AND WORK OF PERSONS WITH DYSLEXIA

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Abstract: *Learning challenges are one of the key factors of dyslexia, according to a review of the literature. It all starts with determining a person's level of difficulty and then devising a support program that is targeted to the various ages of dyslexic individuals. Because of the numerous computer applications developed to assist and overcome difficulties, this set of measures and procedures is very interesting and diverse. Dyslexic people have specific problems and limitations, but they show greater creativity and a tendency to explore the unknown. A positive attitude and support, firstly from parents and teachers throughout education and later from colleagues and associates in a personalized work environment, is one of the most effective forms of support in terms of occupational safety. This allows dyslexic persons to be included while the rest of society continues to evolve and progress in the direction of the establishment of inclusive and universally built workplaces.*

Keywords: *dyslexia, teaching methods, computer applications, help programs, inclusive and universally designed work places.*

1. INTRODUCTION

The word dyslexia come from the Greek word "dys" which means weak, bad, inappropriate, and the word "lexsis" which means language, word. Dyslexia is not a disease but can be defined as a complex syndrome consisting of various neurological and psychopathological phenomena. Dyslexia is generally defined as a learning difficulty with problems with reading, writing, spelling, phonological word processing, and text comprehension. People with dyslexia read more slowly and have a lot of mistakes and an insufficient understanding of what they read. Foreign authors also define dyslexia as a learning difficulty where there are problems with word recognition, and the ability to decode. The definition of dyslexia is mostly the

same and it can be concluded that dyslexia is not a disease, but an inherited, genetic condition that occurs in different people. [1]

The main goal of this paper is to show how to make it easier for people with dyslexia to show their intellectual abilities and skills and to contribute to the development of society through their diversity. Therefore, based on the collected information and knowledge about people with dyslexia, we will present the most common problems that such people face and list ways to help and computer programs that will allow them to solve or reduce this disorder.

2. METHODS

The applied research methodology includes analysis of available written and online sources, student experiences from contacts with dyslexic fellow students, teaching experiences with students suffering from this problem, as well as the experience of a family doctor whose parents often bring school children due to concentration problems when learning at home and attending school classes. Relevant data was gathered on the primary characteristics or "symptoms" of dyslexia, as well as some of dyslexic people's positive abilities. Following that, study was conducted on available computer applications that allow persons with dyslexia to show their intellectual abilities and skills while also contributing to society's development through their variety.

3. CHARACTERISTICS OF DYSLEXIA

The American Psychiatric Association (APA) in its Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [2] cites dyslexia as dominant among so-called learning disorders. It states the prevalence of specific learning impairment from 5 to 15% among school-age children in different languages and cultures. The prevalence in adults is unknown, but it is estimated at 4%. The ratio of boys to girls is 3:1. Dyslexia is defined as a specific learning difficulty that mainly affects the development of literacy and language skills. It has been present since birth and has lifelong consequences. It is characterized by difficulties in phonological processing, rapid naming, working memory, processing speed, and automation of skills that are not aligned with other cognitive abilities. Conventional teaching methods do not produce good results, but intervention procedures, information technology assistance, and advisory support can mitigate the effects. The support of parents, as well as the living, school, and job environments, are the foundations of success. When defining this disorder, its weaknesses and strengths must always be taken into account. Weaknesses are: reading and writing with many mistakes and very slow, not understanding what is read, fatigue in reading and writing situations, inability to organize thoughts while writing, and poor verbal memory. The strengths of the

profiles of such people are often: good imaginative capacity, originality and creativity, good visualization skills, and an "artistic" way of thinking. In severe cases, dyslexia may be accompanied by dysgraphia and dyscalculia. Dysgraphia is a learning difficulty that affects the skill of writing. It is manifested by difficulties in spelling, poor handwriting, and problems shaping thoughts in writing. Students with writing disorders will need special conditions and adjustments during learning as well as additional practice to reach the appropriate level of writing. A person with dysgraphia may write in the opposite direction, and have trouble remembering what graphemes look like or how they are formed. It can be hard to remember when to use which type of grapheme (lowercase and uppercase) and can omit words in writing or write them with a series of mistakes. Dyscalculia is a condition that affects the ability to acquire mathematical skills. Students with dyscalculia may have difficulty understanding simple numerical concepts, a lack of intuitive sense of numbers, and difficulty learning numerical facts and procedures. Figure 1 shows a typical dyslexic writing disorder in school children (left) and a specific font developed for dyslexic people to make reading easier i.e., letter recognition (right) [3, 4].

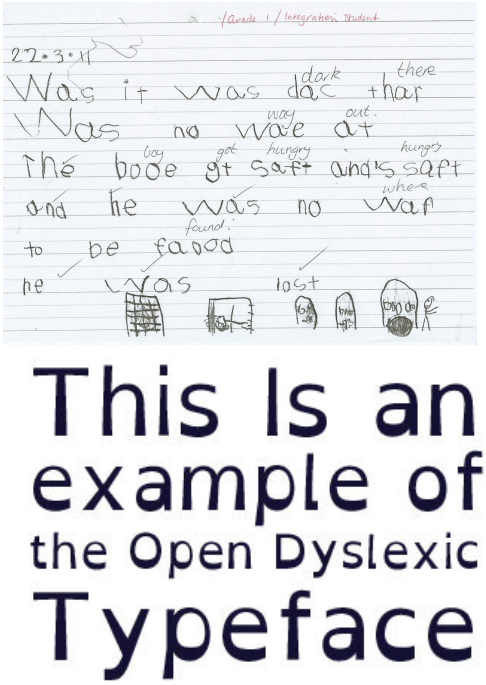

Figure 1: Characteristic writing disorder [3] (left) and OpenDyslexic font [4] (right).

In a case study example, one of the authors of this paper was asked to adjust the higher education exam form for a person suffering from all three disorders. The

teacher made three versions of the form printed in different fonts: Arial 12, Arial 14, and OpenDyslexic 14. The student was offered to choose the version that suits her best. She chose the version printed in the OpenDyslexic 14 font. She noted that in the case of standard fonts, the most important thing for her is that the font size is 14 dots or more and that these are fonts without dashes (serifs) such as Arial or Calibri.

4. PROGRAM SUPPORT FOR ASSISTANCE IN LEARNING AND WORK

Program support for assistance in learning and work can be grouped into three groups according to the age of dyslexic people. The first group is intended for dyslexic students in primary and secondary schools. It includes programs such as OG, Texthelp, ABC MAESTRO, BrowseAloud, Inspiration, Wordshark, Alphabetic Phonics, and Dragon Naturally Speaking. The OG program (Orton-Gillingham Approach) [5] is a direct, structured, prescribed way of teaching reading and writing. The purpose of this program is to help the student read and write normally. It enables composing songs, recognizing words, conveys interestingly teaching parts to make them easier to remember, and emphasizes language patterns and phonemic awareness. The approach relies mainly on the auditory, visual, and kinesthetic aspects of computer peripherals [2]. Texthelp [6] is intended to assist in essay writing. It allows children with dyslexia to read and spell. This program is supported on MAC, Windows, and Android operating systems, and functionally supports Google Chrome applications, and language learning, and contains STEM themes. Some of the tools within Texthelp are: Read & write, Equatlo, Snapverter. Texthelp can predict words by giving ten menu options, it also contains a Wizard that allows the user to define all words. The manufacturer of this program is Texthelp Ltd. There are versions for personal use and institutional for school use [6]. ABC MAESTRO [7] is a program that helps in writing, typing and reading. It is interesting for children because of the so-called Clevy keyboard that comes in different colors (Figure 2) that allows them to learn in an interesting way.

Figure 2: Clevy keyboard [7]

Blue on the keyboard indicates letters, numbers are highlighted in red, navigation keys are highlighted in green, and punctuation marks are highlighted in orange. The keyboard is waterproof and exists in wired and wireless Bluetooth versions. The ABC program rewards a child with certain stickers when a child achieves a certain success. BrowseAloud [8] is a program that allows people with dyslexia to access websites easily. Provides support for reading aloud in 99 languages by converting text to speech with web page translation. Website Simplifier removes ads and anything that can interfere with reading. BroseAloud has recently been taken over by Texthelp Ltd. as an integral part of its application. Inspiration [9] is a program that helps to develop ideas and organize thoughts with the help of diagrams, mental maps, presentations, and graphic organizers so that the student can better understand concepts and data. It is one of the better programs since children with dyslexia in most cases think first in pictures and then in words [2]. It supports the creation of a smart map, which enables visual thinking and the display of diagrams and maps that are automatically updated. More than 3,000 images can be selected from the Inspiration symbol library, and users can add their own images. The writing process can be started quickly by adding new symbols. Diagrams and outlines can be transferred to a Word, PDF, PowerPoint, or graphic file. Wordshark [10] is a program that uses access to learning styles and is intended for children aged 5-15. It contains more than 60 games designed to help with reading and writing and about 9,000 pre-recorded words. Additional words can be added. The games are designed to be interesting and are made like card games, maze movement, alphabet games, and many other interesting games. It is easy to use, flexible, easily adapts to the needs of students, and can motivate even the most uninterested students. Alphabetic Phonics [11] is intended for learning spelling, reading manuscripts, involving students in visual and auditory learning, and written expression. It is based on the Orton - Gillingham [5] method for teaching students with dyslexia and poor decoding skills. The curriculum includes three teaching methods: multisensory techniques, guided discovery, and the daily introduction of concepts. It includes ten different activities such as alphabet, reading, spelling, letter review, listening, and more. Dragon Naturally Speaking [12] is a speech recognition program. It is used by people with dyslexia who have spelling problems, and it is also useful for people who cannot type. This software works by converting voice notes into a document via a microphone and saving them to a computer.

Maystudybar, Natural Reader, Omoreader, and Learning Ally are among the more well-known programs intended for dyslexics in higher education. MyStudyBar [13] helps high school students with dyslexia to read, write and learn. It consists of a toolbar with six sections: planning, reading, writing, vision, and help. These tools allow the student to research, plan, and structure. It helps students practice typing skills, organize their ideas, and use more colors for better concentration. The Natural Reader web application [14] is used to convert text to voice. It has a large selection of speech speed, language, and accents. The application has special categories for students and professionals. It supports 100 voice types and eight different languages. OmoReader [15] is a relatively new program that helps in the reading process. An

Omotype font has been created to make it easier to read. In addition, the application allows you to break words into syllables and include a line in the background of the text to make it easier to follow the lines while reading. Learning Ally [16] is an application that contains a large number of audiobooks (more than 80,000) and is intended for students who learn through listening. In some books, important parts can be marked to make them easier for students to remember.

In order to achieve successful collaboration with adults with dyslexia, it is primarily necessary to be familiar with the difficulties they face in the workplace. Every employer has a responsibility to demonstrate to a person with dyslexia that they believe in them and their ability to perform effectively and competently [2]. In addition to the customized work environment and pace of work for the successful conduct of correspondence and processing of various documents, the Omoguru program and the already mentioned Dragon Naturraly Speaking are recommended. The Omoguru [15] application makes it easier to better understand text and focus on reading. It also allows the font to be customized and makes it easier to read. It contains more than 45,000 books, and any textual content can be added into the application.

5. CONCLUSION

Dyslexia is a disorder, which manifests itself through difficulty in handling words, and writing has its challenges. However, various methods and their systematic application can achieve excellent results. The digital age in which we live significantly contributes to the range of possibilities in facilitating the life and work of people with dyslexia. Specially designed computer programs enable them a higher degree of self-esteem, knowledge, and better interaction with society i.e., a better quality of life. Despite advances in technology, the importance of the human factor should be emphasized. The environment mustn't stigmatize people with dyslexia as less valuable. They are different from others because they have difficulty, but with the help of experts and technology, they can successfully overcome it. There is a need to provide professionals in educational institutions and workplaces for people with dyslexia who will be educated about their difficulties and help them in their development and progress. Dyslexics can not only achieve their personal and professional goals, but they can also be more creative and sophisticated than their colleagues because of their diversity.

REFERENCES

[1] Berbić Kolar, E.; Gligorić, I.M.; Zečević, M.: *Disleksija i disgrafija: određenja, pristupi i smjernice*, Sveučilište J. J. Strossmayera u Osijeku , (2018)

[2] American Psychiatric Association: *The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)*, APA, ISBN 978-0-89042-554-1, (2013)

[3] Arthur, E.: Teach to Learn - Analysing Written Samples, *Available from:* http://toteachandlearn.weebly.com/university-assignments/analysing-writing-samples *Accessed:* 2022-05-25

[4] LearningAlly: Dyslexia - Does Font Really Matter?, *Available from:* https://learningally.org/Blog/dyslexia-does-font-really-matter *Accessed:* 2022-05-25

[5] Orton-Gillingham Academy: Academy of Orton-Gillingham Practitioners and Educators. *Available from:* https://www.ortonacademy.org/resources/ *Accessed:* 2022-05-15

[6] Texthelp: Texthelp - World Leaders In Assistive Technology and Edtech Software, *Available from:* https://www.texthelp.com/ *Accessed:* 2022-05-15

[7] E – glas: ABC Maestro – čitanje i pisanje na zabavan način, *Available from:* https://www.eglas.hr/abc-maestro/ *Accessed:* 2022-05-15

[8] International Dyslexia Association: BrowseAloud, *Available from:* https://dyslexiaida.org/browsealoud/ *Accessed:* 2022-05-15

[9] Inspiration Software Inc.: Visual Thinking Tools for Academic and Workplace Success, *Available from:* https://www.inspiration-at.com/ *Accessed:* 2022-05-15

[10] Wordshark: Wordshark Online – for school teachers & tutors, *Available from:* https://www.wordshark.co.uk/wordshark/schools/ *Accessed:* 2022-05-20

[11] EPS: Alphabetic Phonics, *Available from:* https://eps.schoolspecialty.com/products/ literacy/learning-differences/alphabetic-phonics/about-the-program Accessed: 2022-05-20_

[12] Nuance: Dragon Naturally Speaking, *Available from:* https://shop.nuance.co.uk/store/nuanceeu/en_GB/Content/pbPage.home *Accessed:* 2022-05-20

[13] EduApps: MyStudyBar, *Available from:* https://www.eduapps.org/mystudybar/ *Accessed:* 2022-05-20

[14] NaturalReader: Powerful Text-to-Speech for at home, work, or on the go, *Available from:* https://www.naturalreaders.com/index.html *Accessed:* 2022-05-30

[15] Omolab: OmoReader, *Available from:* https://www.omolab.com/ *Accessed:* 2022-05-30

[16] LearningAlly: Learning Ally's Audiobook App, *Available from:* https://learningally.org/app *Accessed:* 2022-05-30

ILLUMINATION OF WORKING SPACES WITH COMPUTERS

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Abstract: *Lighting in work areas where a computer is used for more than four hours in a workday shall comply with the Computer Safety and Health Regulations and all applicable regulations for that area. The illuminance of such spaces is prescribed by the instructions of EU Standard 1246-1: 2002, the Occupational Safety and Health Act, and the Occupational Safety and Health Regulations. All parameters prescribed by the law, regulations and EU standards must be tested by a professionally authorized person who performs the parameter tests following the regulation on environmental testing. Working in inadequate conditions leaves marks on the human body that can be physical and psychological. These consequences are called occupational diseases. Occupational diseases must be examined individually for all workplaces and specific solutions must be provided in computer-related problems.*

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***Keywords*:** *computer work, illumination, protection, professional illness*

1. INTRODUCTION

Every employer is required to conduct an occupational environmental health assessment under the Occupational Health and Safety Act [NN 71/14, 118/14, 94/18]. The regulations on environmental audits specify conditions that must be met for the audit to be considered valid. For all workplaces where computer work is performed for more than four hours in a working day, additional analyses must be performed per the regulations of the Occupational Safety and Health Act and the Regulation on Safety and Health at Work with Computers [NN 69/05].

In this work, the results of the performed measurement of the lighting in the rooms where more than four working hours are worked with a computer in one working day are used. In addition, the work used data obtained through an anonymous survey to conduct the analysis. An anonymous survey was conducted with workers who work on computers for more than four hours in a workday. The purpose of the anonymous survey is to check the awareness of workers about the lighting condition of the workrooms where they work at the computer and its impact on their psychophysical health.

1.1 ILLUMINATION

Illuminance represents the intensity of lighting, that is, the amount of light emitted into the illuminated space on a given area, the photometric quantity is illuminated, and as such it must be tested under the Occupational Safety and Health Act to meet one of the main objectives of occupational safety and health, namely to ensure safe and healthy workplaces. The testing of the illumination of the work areas must be carried out per the existing regulations, and the results of these measurements must be recorded in the protocols provided. The result of the performed test is essential for both the employer and the employee, since it depends on the employer whether the employee is allowed to work in such a space, while the employee must make sure that his workplace does not pose any risk to his health. Finally, the performed tests lead to the issuance of a certificate of technical harmlessness of the work area, if the room meets the legally required parameters.

According to the Regulation on Environmental Testing and the Regulation on Safety and Health at Work with Computers, any room in which the employee performs work tasks must have a certain level of illumination. Natural or artificial lighting must ensure sufficient illuminance, which is already at least 300 lux according to the type of activity [1].

1.2 WORKSPACE

The work area is defined as the place where workers perform their work and, as such, must be regulated by laws and legal acts. One of the regulations that govern the work area is the Regulation on the Protection of Workplaces, it prescribes conditions for the heating of rooms, ventilation, lighting, and the dimensions themselves that the room must meet in order to be used as a work area.

1.3 ILLUMINATION IN WORKPLACE

The minimum lighting in the working spaces is prescribed in the Regulation on Safety and Health at Work with Computers, in the regulations in Annex 2 on the working environment, a minimum lighting of 300 lux is prescribed [7]. For indoor lighting, there is also the standard HRN ISO /CIE 8995:2003 [7], which regulates the lighting of workspaces. The standard specifies the minimum lighting required depending on the purpose of the workplace or the type of work performed there. The instructions contained in the standard can be seen in Table 1.

Table 1. Illumination of space according to the purpose of space

Interior type, task or activity	E_m [lx]
Sorting, copying, etc.	300
Write, type, read, process data	500
Conferences and meeting rooms	500
Reception chair	300
Archive space	200

Em [lx] - average horizontal illuminance on the desktop.

There are differences between the instructions prescribed in the Regulation on Safety and Health at Work with Computers and the standard HRN ISO /CIE 8995:2003 [7]. We characterize computer workstations as writing, typing, reading, editing and data workstations, and according to the standard the minimum illumination is at least 500 lx, while the regulation on safety and health at work with computers prescribes that natural or artificial lighting must already provide sufficient illumination of at least 300 lx, depending on the nature of work.

2. CAREER SAFETY WHEN USING A COMPUTER

The computer workplace and occupational safety at the computer workplace are regulated by the Occupational Safety and Health Act and the Occupational Safety and Health Ordinance. The computer workplace in terms of occupational safety and health includes: a computer with a screen, keyboard and/or input device and/or software equipment that provides a link between the device and the worker, accessories, external devices with diskette or other drive, telephone, modem, printer, etc., template holder, work chair, desk or work surface, environment that directly affects the workplace, work tasks of the worker [1].
A VDT worker is any employee who performs VDT tasks for a total of four or more hours in a workday, as defined in Article 3(C). According to Article 3, point C, in order analyses must be carried out for these workers to prepare a risk assessment in order to ensure a healthy and safe workplace for the worker.
Various forms may be used to conduct analyses of workplaces where workers perform VDU tasks for a total of four or more hours in one workday to ensure a safe and healthy workplace.

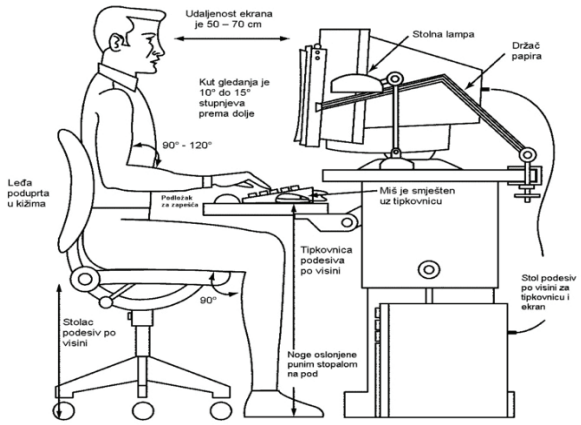

Figure 1: Recommended workplace arrangement

3. ILLUMINATION TEST

Lighting testing in the workrooms is carried out prepare a risk assessment and is required by the Regulation on the preparation of the risk assessment NN 112/2014 [8].
Eighteen workrooms were examined in accordance with Article 50. The Law on Safety and Health at Work, also the examination of the working spaces was carried out following the instructions prescribed in the Regulation on the examination of the working environment NN 16/2016 [9]. To perform the test, a measuring device was used, for which all the documents prescribed in the Regulation on the testing of the working environment NN 16/2016 [9] are available, and thus can be used for the testing of the working environment.
The experimental part of the work was carried out within the HŽ infrastructure at workplaces where employees use a computer at work. The research was conducted in the 18 workrooms where the 25 interviewed workers perform computer work.

Table 1: Illumination Measurement Result

Workspace	Illumination [lx]	Type of lighting fixture
1	566	Fluorescent tube (F39T5/841/HO)
2	240	Fluorescent tube (F39T5/841/HO)
3	369	Fluorescent tube (F39T5/841/HO)
4	268	Fluorescent tube (F39T5/841/HO)
5	361	Fluorescent tube (F39T5/841/HO)
6	420	Fluorescent tube (F39T5/841/HO)

7	418	Fluorescent tube (F39T5/841/HO)
8	441	Fluorescent tube (F39T5/841/HO)
9	190	Fluorescent tube (F39T5/841/HO)
10	480	Fluorescent tube (F39T5/841/HO)
11	284	Fluorescent tube (F39T5/841/HO)
12	810	Fluorescent tube (F39T5/841/HO)
13	802	Fluorescent tube (F39T5/841/HO)
14	321	Fluorescent tube (F39T5/841/HO)
15	341	Fluorescent tube (F39T5/841/HO)
16	307	Fluorescent tube (F39T5/841/HO)
17	321	Fluorescent tube (F39T5/841/HO)
18	410	Fluorescent tube (F39T5/841/HO)

From the results of the lighting measurement, it appears that the rooms marked with serial numbers 2, 4, 9 and 11 do not meet the required minimum values. During the inspection of these rooms, it was found that on average 50% of the fluorescent tubes are not in operation. For example, in rooms 2 and 4 there are a total of 18 fluorescent tubes, of which only 9 are functional. Therefore, we come to the source of the problem or the reason for non-compliance with the prescribed minimum, in rooms 9 and 11 it was found that the lighting fixtures are poorly positioned and on the work surfaces themselves we come to an unsatisfactory result, and in the places under the lighting fixtures themselves were measured for the room under the number 9,458 [lx] and the room under the number 11. 612 [lx].
A large percentage of people who work at computers complain of eye problems causing headaches, eye fatigue, irritation and dry eyes, burning sensation in and around the eye, and blurred vision when working at the computer for long periods. There is also the possibility of ocular fibrillation, which occurs with fatigue and has led to a disturbance in eye pressure. All eye symptoms are due to visual strain, while headaches and fatigue can be due to an irregular posture. All of these symptoms can be prevented by certain preventive measures, some of which are already included in the regulations on safety and health at work with computers and relate to the position of the monitor, the light source, the distance to the keyboard, the height of the desk and many other ergonomic principles.

4. VISION EFFORTS WHEN WORKING ON A COMPUTER

A large percentage of people who work at the computer complain of eye problems that cause headaches, eye fatigue, irritation and dry eyes, burning of the eye and around the eye, and blurring of vision when working for a computer for a long time. There is also a possibility of flickering of the eye, which occurs during fatigue and has resulted in a disorder of eye pressure. All eye symptoms are due to visual

exertion while headaches and fatigue can be due to an irregular position. All of these symptoms can be prevented by certain preventive actions, some of which are already within the Regulations on Safety and Health Protection when working with a computer, related to the position of the monitor, light source, keyboard distance, desk height and many other ergonomic principles.

5. INDOOR LIGHT

Indoor lighting where computers are used is required by HRN EN 12464-1:2008 and the Computer Occupational Safety and Health Regulation, but there is a difference between these two directives that create a dilemma regarding indoor lighting. According to EN 12464-1:2008, there is a more detailed subdivision of the minimum lighting required depending on the type of work being performed, the subdivision is shown in the following table.

Table 2: Illumination requirements according to EN 12464-1:2008 [2]

Work Activity	**$\bar{E}_m$, (lx)**	**UGR_L, (-)**	**R_a [2] (-)**
Recording, copying, etc.	300	19	80
Write, type, read, process data	500	19	80
Technical drawing	700	16	80
CAD workstations	500	19	80
Meeting and meeting rooms	500	19	80
	Maneuverable illumination/lighting		
Application office	300	22	80
Document storage office	200	25	80

The difference arises from the fact that computer work can be characterized as "writing, typing, reading, processing data", for which a minimum value of 500 lx is prescribed, while according to the Regulation on Safety and Health at Work with Computers in the Annex, "natural or artificial lighting must already ensure sufficient illumination of at least 300 lux according to the nature of the work" [7]. A clear picture of how much lighting muse be present then it is expected of employers to have lighting of 300 lx for all types of workplaces, thus meeting the legal minimum.

Indoor lighting must comply with the risk assessment [3] required by the Occupational Safety and Health Act, and also refers to the instructions in the Computer Safety and Health Ordinance. The lighting of work spaces can have an unfavorable psychological impact on workers and shape them for life; likewise, insufficient lighting can significantly affect the visual condition of workers and lead to the development of an occupational disease.

6. CONCLUSION

In addition to measuring the lighting in the rooms where computer work is performed, a survey was conducted among workers on the subject of workplace lighting and occupational safety. The worker survey consisted of twelve questions with two additional topics that addressed the group of workers by gender and age to provide a better analysis of the survey conducted. The survey itself revealed some evidence that workers are not sufficiently familiar with the Occupational Safety and Health Act. In addition to problems related to technical malfunctions and up to 50% of lighting fixtures in the workrooms, there is also the problem of not knowing the basic things related to occupational safety. The results suggest that additional training of workers is needed, as well as additional efforts of the employer himself to provide a sufficient number of lighting fixtures and then repeat the study of physical damage in the workrooms. Through the use of modern methods or the use of various program interfaces, it is now possible to program lighting fixtures and thus provide the worker with a safe and healthy workplace with a high degree of certainty.

REFERENCES

[1] Pravilnik o sigurnosti i zaštiti zdravlja pri radu s računalom [NN 69/05]
[2] Vukić, R.:“Usporedba dosad važećih i novo prihvaćenih normi u području osvijetljenosti unutarnjih i vanjskih prostora u RH”, *Sigurnost : časopis za sigurnost u radnoj i životnoj okolini*, Vol. 52 No. 2, 2010.
[3] Zakon o zaštiti na radu (NN 96/18)
[4] Zakon o zaštiti na radu (NN 71/14)
[5] Zakon o zaštiti na radu (NN 118/14)
[6] Zakon o zaštiti na radu (NN 94/18)
[7] Osvijetljenost radnih mjesta u zatvroenom prostoru (ISO/CIE 8995:2003)
[8] Zakon o zaštiti na radu (NN 112/14)
[9] Zakon o zaštiti na radu (NN 16/16)
[10] Glavaš, H., Čabraja, I., Tačković, K., Petrović, I. (2016) *“Analiza rasvjete unutarnjeg radnog prostora i usklađenosti* sa HRN EN 12464-1”, CIRED 5. (11.) savjetovanje Osijek, 15. - 18. svibnja 2016. / - , 2016

FEM SIMULATED HAND-HELD TRIMMER HANDLES VIBRATION DAMPING WEIGHTS POSITIONING

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Abstract: *This paper focuses on FEM based simulation of damping of hand – held motor trimmer handles vibration with objective to estimate where to place and how massive should be damping weights to maximally reduce amplitude on handles while adding minimum of total weight.*

The vibration source (excitation) is the gasoline two-stroke one-cylinder engine whose free (unbalanced) inertial force and moment have been approximated as harmonic function in time. Only the steady-state solution for the forced vibrations has been considered, since the transition phase is relatively short. Obtained FEM simulation results were validated by implementation of real-time Borg exertion scale.

The results show that the optimal place for weights is just beneath the plastic ergonomically designed parts of handles. In such a way the vibration amplitude has been reduced under the limit level for longer operating time (30 min.)

Keywords: vibration, motor trimmer, damping, weight, hand-held.

1. INTRODUCTION

The hand held machinery often has vibrational action on human hand. Reciprocating engines powering those machines have mostly one cylinder, hence producing intense vibrations. Prolonged vibrations of hands can lead to various syndromes, with, in worst cases, permanent damage to nerves, joints, and so on. Acting on the reduction of reciprocating mechanism's balance is basically impossible. Acting on the construction of such machines with vibration absorbers, with damping weights and similar additional elements is much easier. The main interest here is the analysis of handles vibration of hand held trimmer. Measurement of handles vibration will not be conducted, but rather subjectively compared before and after the

modification trough the Borg scale [9]. It is essentially the subjective scale for vibration sensation, ranging from 1, as barely sensible, to 10, extremely painful.

One way of reducing influence on human hand is the weight type absorbers [2] and another widely investigated is rubber absorbers, depicted in detail in [3,4,5,7,8]. They have used the finite element method in analysis of forced steady – state vibration response. Mostly the researchers use shell or solid elements in FEA software such as ANSYS, SOLIDWORKS and ABAQUS. That approach allows many degrees of freedom and detailed insight into response.

The idea here is to use much easier software, MS Office Excel, readily available to many, and the simplest finite elements so that the system of equations would be as simplest as possible, and yet, giving enough insight into response when weight is added at a chosen position.

2. PROBLEM FORMULATION

The trimmer is being considered as a beam with concentrated masses on which a harmonic inertial force is acting, shown in figure 1a). The main tube has flexible rigidity EI, as marked in the figure, to which handles tube is rigidly connected, shown as the perpendicular line to the main tube. At the top of handles tube are the handles, a rectangle. The trimmer's center of gravity is denoted "C.o.G.". The two "lighter" parallel lines at each side from the C.o.G. represent straps, which will be points of constraints in the model. Concentrated masses consist of the engine and transmission box, denoted as m_1, and the cutting head, denoted as m_2. The main tube has mass m_3. This is the basic problem statement.

According to engine dynamics literature [4] the unbalanced inertial force from the reciprocating mechanism can be simplified in the "first order" calculation as harmonic, acting in the mechanism plane. This is the plane perpendicular to the paper plane and the main tube axis. Hence, only the transversal vibrations have been calculated. Also, the transversal handle vibrations, which is the tip of handles motion parallel to the main tube in figure 1. The base state of vibrations at a given engine rotational speed will be calculated as the reference value, to be compared to the value obtained from a modified trimmer setup.

Modification is presumed in form of added rigidly connected weights at chosen locations to act as vibration dampers, with all the weights show together in figure 1 b). One criteria for choosing weight position and mass is the total increase in trimmer mass (weight). On figure 1 b) all the positions for weights are shown, while not all weights are intended to be added at once. Damping weights are represented by m_4 trough m_7. Position of handles weights in this view is simplified, i.e., one weight is placed below each handle.

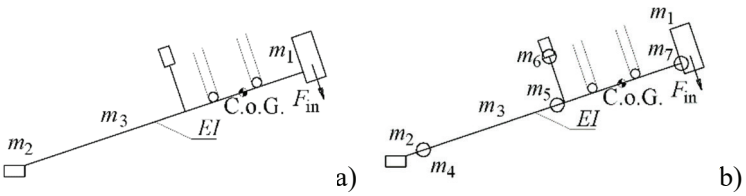

Figure 1: Physical model of a trimmer: a) base state (as is), b) modified state, with added damping weights

2.1. Finite element model system of equations

Discretizing the trimmer and adding constraints, the finite element model is as shown in figure 2. Each non rounded number represents node, each rounded one represents element number, and v_1 through v_{14} represent degrees of freedom, in turn transversal displacment (the even numbers) and the rotational angle (the odd numbers). The underlying theory is Euler – Bernoulli thin beam bending theory [1, 5, 6].

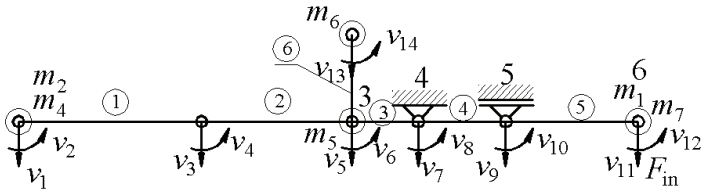

Figure 2: Finite element model of trimmer

Without detailing, the basic beam finite element for steady state harmonic excitation vibration analysis [2, 6, 11] has stiffness and mass matrices in form of

$$\boldsymbol{k}_i = \frac{EI}{l^2}\begin{bmatrix} 12/l & 6 & -12/l & 6 \\ 6 & 4l & -6 & 2l \\ -12/l & -6 & 12/l & -6 \\ 6 & 2l & -6 & 4l \end{bmatrix}, \boldsymbol{m}_i = \rho Al\begin{bmatrix} 13/35 & 11l/210 & 9/70 & -13l/420 \\ 11l/210 & l^2/105 & 13l/420 & -l^2/140 \\ 9/70 & 13l/420 & 13/35 & -11l/210 \\ -13l/420 & -l^2/140 & -11l/210 & l^2/105 \end{bmatrix}, \quad (1)$$

The element 6 is presumed as rigid. Its introduction as deformable is avoided for reason Here it is just shown as element, and its degrees of freedom at the tip, v_{13} and v_{14} will be calculated from while in the model system equation the influence of masses m_6 is introduced into equations for degrees of freedom v_5 and v_6, with direct value of $2m_6$ in the (5,5) position and the mass moment of inertia $2m_6 \cdot (l_6)^2$ in the (5,6) position. The constraints at the straps attachment positions lead to deleting rows and columns

7 i 9 in the system equation matrix. Creation of the system equation matrix is omitted here for the sake of brevity. The solution for a steady-state vibration [6, 10, 11] is obtained from

$$\boldsymbol{v} = (\boldsymbol{K} - \omega^2 \boldsymbol{M})^{-1} \boldsymbol{F} \quad (2)$$

with **K** as the global stiffness matrix, ω the crank shaft angular velocity, **M** the mass matrix, and **F** the force vector.

2.2. Problem parameters used for calculation

The trimmer used for model creation is FX-4MS315. It has maximum engine rotational speed 8 000 min^{-1}, with masses of piston and the translational part of connecting rod mass [4] m_{tr} = 0,25 kg, crank shaft trajectory radius r_{KS} = 0,02 m, main tube is made from aluminum, with outside and inside diameters d_{to} = 0,025 m, d_{ti} = 0,022 m. The trimmer engine and transmission box has mass m_1 = 2,2 kg, the cutting head has mass m_2 = 1,2 kg, and the tube has mass m_3 = 0,51 kg. Handles and the throtle switch have mass 0,8 kg, which is introduced into the global system equation matrix. Lengths of elements are as follows: l_1 = 0,35 m, l_2 = 0,4 m, l_3 = 0,25 m, l_4 = 0,3 m, l_5 = 0,4 m, and l_6 = 0,3 m. Damping weights have been chosen with various masses, of which a few significant in damping influence will be shown in a form of deformed shape.

3. ANALYSIS RESULTS

Following the creation of system equations matrix based on input parameters, including engine properties, geometry main frame parts, constraints and depending on the model, added weights, the steady state response has been calculated by direct method [6], i.e. inversion of **K**-ω^2**M** matrix and multiplying the force vector by it. In the diagrams in figures 3 trough 6, various weight configurations in deformed state, have been shown.

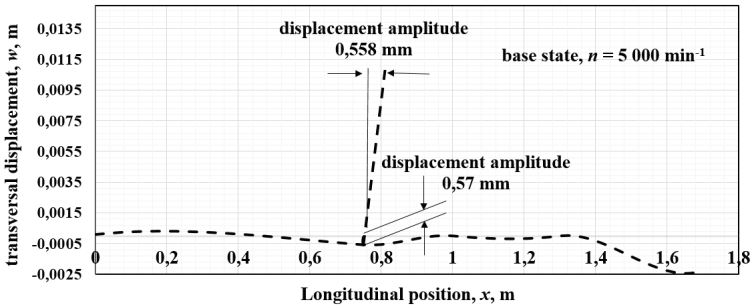

Figure 3: Deformed shape for base state at n = 5 000 min^{-1}

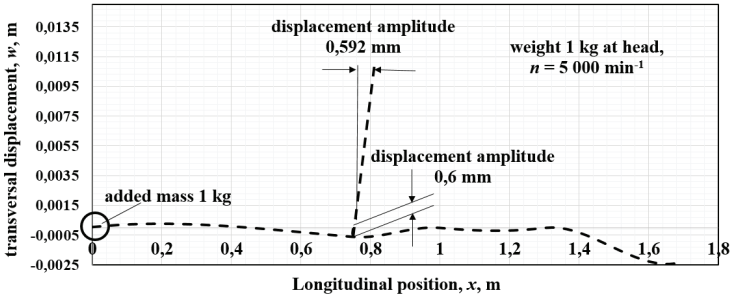

Figure 4: Deformed shape for added 1 kg at head

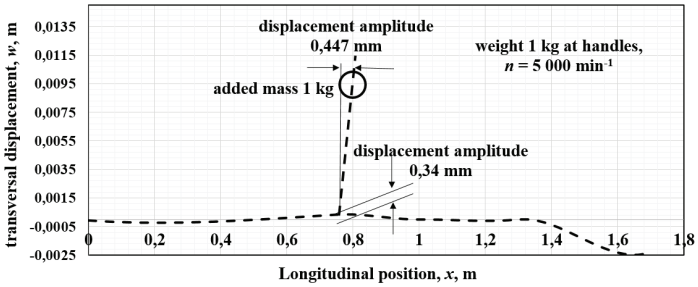

Figure 5: Deformed shape for added total 1 kg at handles

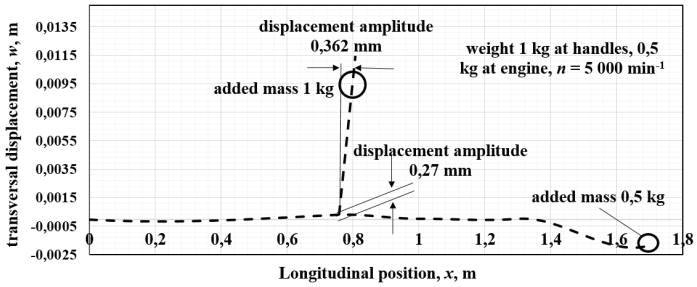

Figure 6: Deformed shape for added total 1 kg at handles and 0,5 kg at engine

It is noticable that in the base state handles experience transversal amplitude of 0,558 mm. If a weight of 1 kg is added to the head position, the amplitude increases to 0,592 mm. Adding a weight of 1 kg (two weights of 0,5 kg at each handle) at handle position, the ampitude decreses to 0,447 mm. Further decrese could be achieved by adding weight at the engine position, however, it increases to total mass futher.

3. CONCLUSION

This paper presents in brief the finite element method steady-state trimmer handles vibration solution and optimization of vibration damping weights position. The system equations have been solved numerically by direct method. The weights were added at the head, handles and engine position. Results shown suggest a significant reduction in transverse handles vibration can be achieved just by adding rigidly connected weight of 1 kg. Further improvement in vibration reduction is the use of rubber dampers, used as handles, as suggested in many scientific papers regarding vibration reduction.

Petrol trimmers considered are powered by two-stroke one-cylinder engine, which is inherently unbalanced. Depending on the engine rotational speed, and the main trimmer tube acing as frame, at some rotational speeds (resonance) the amplitudes, i.e., accelerations, can be very unpleasant even for a short periods of use (seconds).

This approach shows also the easy implementation of the finite element method in steady-state vibration analysis of relatively simple model. The tube has been modeled by 5 basic beam elements. The analysis was performed in MS Office Excel. So, this is also a demonstration of use of the finite element method without the use of sophisticated FEA applications. Authors have validated this approach by testing the aforementioned trimmer with added weights, and comparing the results by the Borg scale [9], without using actual measurement.

REFERENCES

[1] Alfirević, I.: *Nauka o čvrstoći I*, Tehnička knjiga d.d., ISBN 953-172-010-X, Zagreb, (1995)
[2] Hao, Ko Ying; Lee, Xin Mei; Zaidi, Mohd Ripin: Tuned vibration absorber for suppression of hand-arm vibration in electric grass trimmer. *International Journal of Industrial Ergonomics*, Vol. 41, p. 459-470. Elsevier, 2011.
[3] Hill, S. G., Snyder, S. D., Design of an Adaptive Vibration Absorber to Reduce Electrical Transformer Structural Vibration, *Journal of Vibration and Acoustics*, Vol. 124, No. 3, 2002, pp. 606-6011, DOI: 10.1115/1.1500338.
[4] Mahalec, Ivan; Lulić, Zoran; Kozarac, Darko: *Konstrukcije motora* (In Croatian), FSB, Zagreb, 2015.
[5] Group of authors: *Inženjerski priručnik IP1* (In Croatian), Školska knjiga, ISBN 953-0-31662-3, Zagreb, (1996)
[6] Sorić, J.: *Metoda Konačnih Elemenata* (In Croatian); Golden Marketing, Zagreb, Croatia, 2008.
[7] Patil, Sushil Sahebrao: Vibration Suppression of Grass Trimmer Handle using Tunable Vibration Absorber, *International Journal of Advanced Design and Manufacturing Technology*, Vol. 12, No. 2, 2019

[8] Rajbhandary, Paurakh; Leifer, Jack; Weems, Bryan J.: Reduction of Vibration Transmission in String Trimmers, Trinity University, Engineering Faculty Research, San Antonio, 2011.
[9] Rating of perceived exertion: Borg scales, www.heartonline.org.au/resources; *acceced on March 21, 2022*.
[10] Tint, P.; Tarmas, G.; Koppel, T.; Reinhold, K.; Kalle, S.: Vibration and noise caused by lawn maintenance machines in association with risk to health. *Agronomy Research Biosystem Engineering*, Special Issue 1, 251-260, 2012.
[11] Zaman, I., Abdurasad, M.R., Manshoor, B., Khalid, A., Sani, M.S.M.: Study on Dynamic Behaviour of Grass Trimmer Using Finite Element Analysis. *Applied Mechanics and Materials*, DOI: 10.4028/www.scientific.net/AMM.786.383. 2015.

ANALYSIS OF THE STATODYNAMIC LOAD ON WORKERS USING THE RULA METHOD IN THE TECHNOLOGICAL SEWING PROCESS

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***Abstract**: In the technological sewing process, the work is performed in a sitting position, whereas the worker uses the trunk and the hands to handle workpieces, and the feet to control the sewing machine speed. When performing technological sewing operations at the sewing machine, the worker often performs work in a forced posture of the body and head, which leads to non-physiological sitting, isometric load on the lower limbs and significant load on the hands and fingers. An unfavourable working posture leads to load, fatigue and diseases of the musculoskeletal system. By using the ErgoFellow computer system RULA module (Rapid Entire Body Assessment) the working postures of the worker performing the technological operation of sewing the back and front part of the men's jacket in the real production process were analysed. The analysis revealed that the body loads were caused by unfavourable working postures. The results obtained by the analysis indicate the presence of increased forward flexion of the spine and head in certain technological procedures and the load on the upper arm-forearm-hand system. A proposal was made to redesign the existing workplace, which would reduce workload and fatigue and increase productivity.*

***Keywords :** technological process of garment sewing, RULA method, work load*

1. INTRODUCTION

In the technological process of garment sewing, work is carried out on installed production lines with the existing layout of machines and equipment on which individual technological operations are performed depending on the type of garment. Characteristics of work in the sewing process are in the variety and nature of the

workpiece, a high proportion of manual and machine-manual work, low use of the machine, and work itself is done in a sitting posture with a forced spine posture and forward head posture. To perform the sewing process correctly and accurately, the worker must have good visual skills (near and distance vision, colour recognition, accommodation and adaptation of the eye), a high level of motor skills and coordination of movements, good tactile skills, and quick reactions to visual and auditory stimuli [1, 2]. When sitting in the technological sewing process, there is a load on the spine in the lumbar, thoracic and cervical areas. When performing the technological operation, there is a rotation of the dorsal part and a torsion in the area of the thoracic and cervical spine, which varies depending on the type of the technological operation, the working method and the height of the worker [3]. The prolonged and long-term physical load on the worker in the work system leads to diseases of the musculoskeletal system (spine, arms and legs). A damage occurs to the joints, ligaments and tendons, inflammation of the tendons on the bones, degeneration of the joints, inflammation of the tendons and wrists. Signs of physical loading include slow movements, awkward and unnecessary movements, spontaneous interruptions, work errors, exhaustion and feelings of discomfort or pain [4-6]. The prevention of workers' workload is achieved through the ergonomic design of the workplace, the use of an appropriate working method and the training of workers [7]. The design of the workplace is based on the adaptation of the workplace to the worker's body measurements, working in the normal reach area with the required focus of vision and arrangement of the field of vision to achieve smooth performance of the activity in the working position with reduced energy consumption of the body [8].

2. RULA (Rapid Entire Body Assessment) METODA

The RULA (Rapid Upper Limb Assessment) method was developed by *McAtamney L.* and *Corlett E.N.* (1993) with the aim of determining the degree of exposure of workers to unfavourable working postures that can lead to musculoskeletal disorders [9]. The RULA method is carried out in four steps:

1. data gathering by using questionnaires about work environment, work tasks and requirements of the production process,
2. recording the work task,
3. analysis and determination of key body movements and postures that cause the load and
4. assessment of body posture and determination of the final loading rate [10, 11].

The ErgoFellow computer system with the module of the RULA method was designed according to the method settings of the authors McAtamney L. and Corlett E.N. In order to assess the working postures of the body when carrying out work tasks, pictorial representations are given for the posture of the arms (upper arm, forearm, hand) and for the body posture (trunk, neck, legs) [7]. According to the RULA method for hand position and depending on the position (angle of the

curvature) five positions of the upper arm (+ three rotation positions), three forearm positions (+ one rotation position), four hand positions (+ one rotation position), two hand rotation positions, one position for the activity and dynamism of the hand and six degrees of arm load when transferring mass are distinguished. Regarding the body posture (angle of the curvature) there are four neck positions (+ 2 positions with respect to forward bending and rotation), four trunk positions (+ 2 positions with respect to bend forward and rotation), two leg positions, one position for body activity and dynamism and six degrees of body load when transferring mass. Based on the analysis of the specific posture per body parts, the ErgoFellow computer system module of the RULA method provides a summary assessment and degree of risk at the workplace. Figure 1 shows the results obtained with the RULA method and their interpretation in relation to body load.

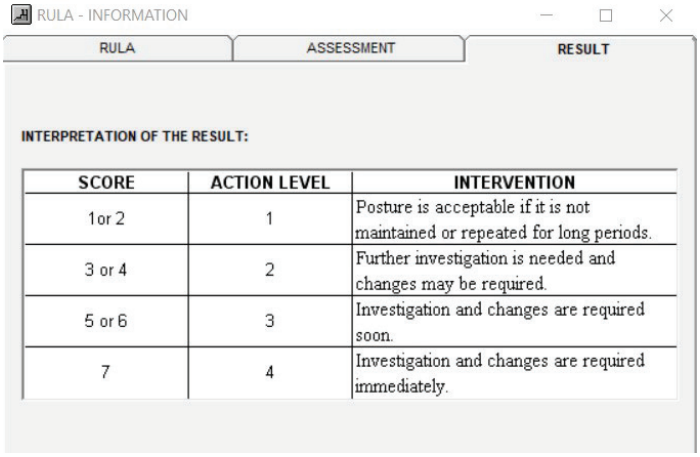


Figure 1: Presentation and interpretation of the results of the workload on the worker's body according to the RULA method [14]

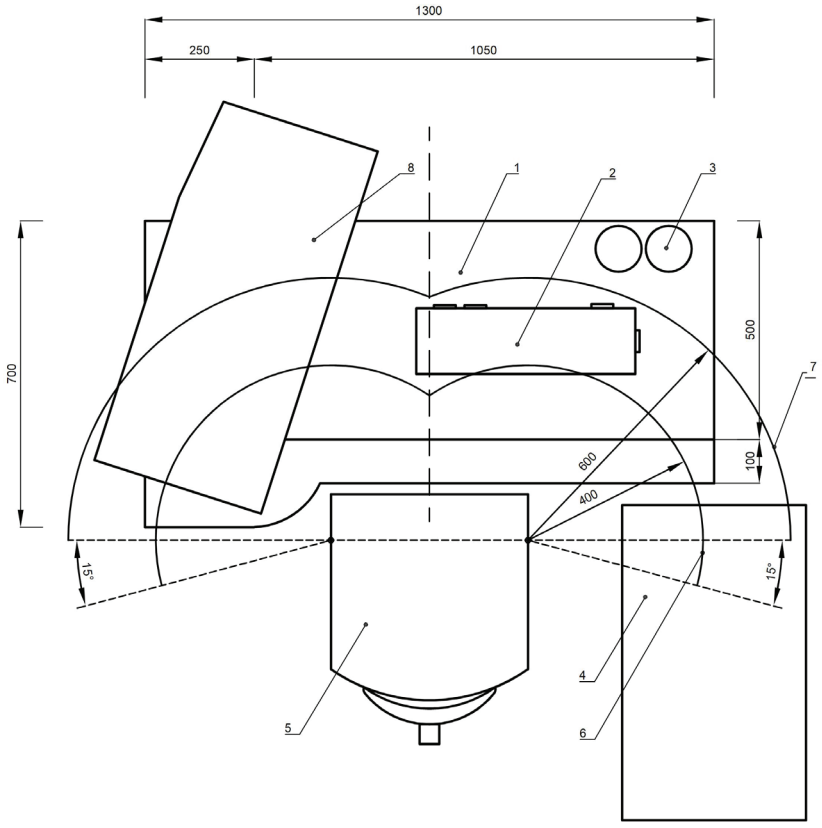
Identifying unfavourable work movements and body postures when performing work tasks is important information for determining the degree of workload on workers and offers the opportunity to eliminate deficiencies at the workplace and to redesign and/or design the workplace accordingly.

3. EXPERIMENTAL PART

In order to study the workload on workers in the real production process, the technological process of sewing the front and back of a men's jacket in the company Varteks, Varaždin, was analysed. The recording was carried out using an EOS 750D camera with EFS18-135 mm built-in lens that has video capability. The workplace was recorded for 20 minutes, which corresponds to 17 repetitions of the technological operation. The worker was recorded in a sagittal plane on the right.

The execution time of the technological operation according to the REFA method was determined to be 69.6 s (1.16 min). The technological operation is performed by a worker with a body height of 178 cm (lower leg length 46 cm) with an adjusted seating height of 56 cm in accordance with the subjective assessment for a comfortable working posture. The height and size of the work desk are designed to facilitate the execution of the technological process with regard to the size of the workpieces belonging to the large size group. Figure 2 shows a designed workplace for carrying out the technological process of sewing the front and back of a men's jacket.

Using the ErgoFellow computer system with the associated RULA module, a workplace load analysis was carried out. The analysis of the technological operation of sewing the back and front of a men's jacket was carried out according to the technological suboperations: taking the back part, taking the front part, putting together, positioning, sewing, alignment during the sewing break, cutting the thread and laying off.



Legend: 1 – work surface, 2 – sewing machine, 3 – sewing thread stand, 4 – auxiliary stand, 5 – industrial chair, 6 – normal reach zone, 7 – maximum reach zone, 8 – auxiliary work surface

Figure 2: Illustration of a designed workplace for performing the technological operation of sewing the back and front of a men's jacket

4. RESULTS AND DISCUSSION

The analysis of the worker's workload for the technological operation of sewing the back and front of a men's jacket according to technological sub-operations is presented in Table 1. Data in Table 1 gives an overview of the working postures, the curvature angles of the dorsal and cervical parts of the spine and the movement angles of the upper arm and forearm for the right and left arm.

Table 1: Representation of the curvature angles of the back (T) and neck (N) of the spine, the required rotation of the head and eye (E) as well as the angles of the upper arm (UA) and forearm (LA).

Technological suboperation	Working posture	Angles of curvature [°]			Angles of the left arm [°]		Angles of the right arm [°]	
		Back (T)	Neck (C)	Rotation of head and eye (E)	Upper arm (UA)	Forearm (LA)	Upper arm (UA)	Forearm (LA)
taking the back part	**middle**	15	10	20	30	75	20	85
taking the front part	**middle**	20	15	20	35	85	15	90
putting together	**forward**	40	32	0	65	85	65	85
positioning	**forward**	35	29	0	60	90	55	80
machine-hand sewing	**forward**	38	33	0	30	70	35	75
alignment during sewing break	**middle**	30	34	0	35	75	25	65
machine-hand sewing	**forward**	38	33	0	30	70	35	75
thread cutting off	**forward**	25	30	0	35	85	40	90
laying off	**backward**	10	10	5	30	65	25	20

The workload was determined on the basis of the determined postures and movements of the worker's body and hands when performing the technological operation with the computer system ErgoFellow module of the RULA method. Figure 3 shows the characteristic working postures of the worker when performing the technological operation, and Figure 4 shows an example of the results of assessing the working posture for the technological suboperation of sewing the back

and front parts of a men's jacket. The results show the body parts with angles of curvature (trunk, neck, legs, upper arm, forearm, hand) as well as the final score.

Taking the front part of a men's jacket

Sewing the back and front part of a men's jacket

Alignment during sewing break

Thread cutting off

Figure 3: View of the characteristic working postures of the worker during the execution of the technological operation of sewing the back and the front of the men's jacket.

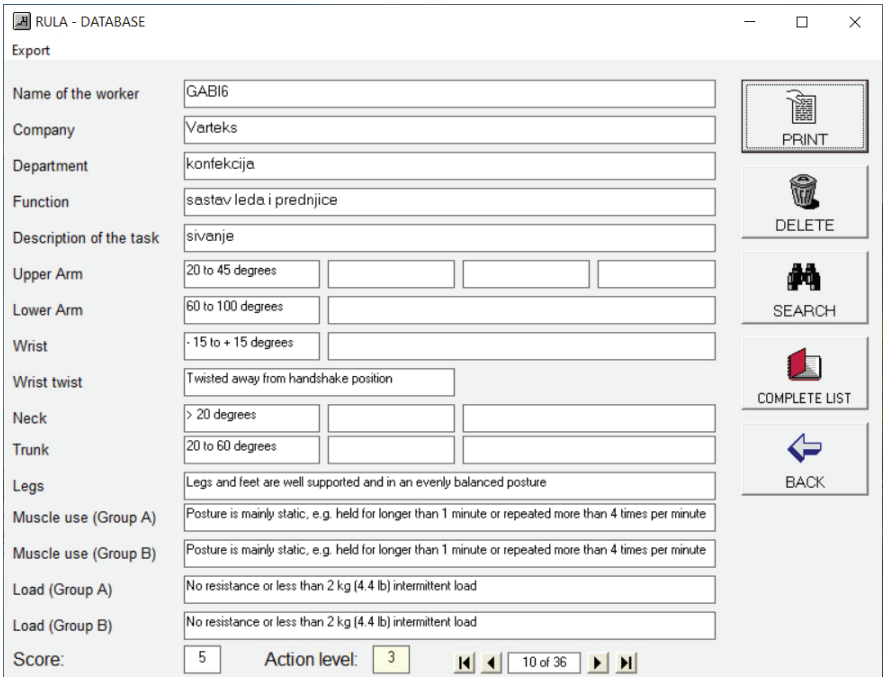


Figure 4: Presentation of the results of the RULA method with the final score and the level of risk for the technological suboperation of sewing the back and front of the men's jacket

Table 2 shows the assessment of worker's load and the risk levels according to the technological sub-operations for the whole technological operation of sewing the back and front of the men's jacket using the RULA method

Table 2: Presentation of the scores for worker's load and risk level according to the RULA method for the technological suboperation of sewing the back and the front of the men's jacket

Technological suboperation	**Score**		**Score for risk level**	**Description of risk level**	**Interpretation**
	left hand	right hand			
taking the back part	3	3	2	medium	Further investigations needed and changes may be required
taking the front part	3	3	2	medium	Further investigation needed and changes may be required
putting together	6	6	3	high	Investigation and changes are required soon

positioning	6	6	3	high	Investigation and changes are required soon
sewing	5	5	3	high	Investigation and changes are required soon
alignment during sewing break	5	5	3	high	Investigation and changes are required soon
sewing	5	5	3	high	Investigation and changes are required soon
cutting off the thread	5	5	3	high	Investigation and changes are required soon
laying off	3	3	2	medium	Further investigations needed and changes may be required

In all technological sub-operations, the angles of the upper and lower arm are unfavourable and the worker puts both feet on the pedal to control the sewing speed. In addition, the hands and body are not loaded by the mass, as a workpiece weighing less than 2 kg is handled, but there are repetitive movements of the hands and body when performing technological operations.

In the technological suboperation of taking the back part and taking the front part of the men's jacket, the worker works in the medium working posture where there is a medium risk (score 2), while during laying off the workpiece she works in the backward posture (score 2). In the technological sub-operation of putting together, positioning, sewing, aligning during sewing, there is a forward flexion of the trunk and head, as well as unfavourable angles of the upper arm-lower arm-hand system. These positions were assessed as a high level of risk (score 3) and the workplace is soon to be redesigned.

In order to reduce the load at the workplace, it is necessary to lower the height of the seat to 53 cm (lower leg length 46 cm + pedal height 2 cm + footwear height 5 cm. This would reduce the angles of the body and arms while performing the technological operation.

5. CONCLUSION

With using the ErgoFellow module RULA computer system, the worker's working postures during the technological process of sewing the back and front of the men's jacket were analysed, and based on the assessments, the need for redesigning the workplace was determined. For technological suboperations, taking the back part, taking the front part and laying off, score 2 (medium risk) was determined, while for technological suboperations, putting together, positioning, sewing and alignment during sewing break. The analysis indicates that it is necessary to redesign the workplace in the form of adapting the seat height to the worker's height.

Redesigning the workplace and applying a more favourable working method as well as rationalising movements in the course of work execution would significantly reduce the unfavourable working postures of the trunk and the head as well as the upper arm forearm hand system.

REFERENCES

[1] Kirin, S.; Hursa Šajatović, A.: Determination of Working Methods and Normal Times of Technological Sewing Operation using MTM System, Tekstilec 63 (2020), 3; 203-215 ISSN 0351 3386, doi:10.14502/Tekstilec2020.63.203-215, SCI IDS Number: NZOWE
[2] Kirin, S.; Hursa Šajatović A.: Defining standard sets of motions in the technological suboperation of sewing using the MTM-System, Tekstil 67 (2018), 7-8; 218-234, ISSN 0492-5882
[3] Ritika Sharma, R., Rani, N.: Ergonomics Followed in Sewing Room in Apparel Industry, Journal of Basic and Applied Engineering Research, 6, (2019), 3, 192-197, e-ISSN: 2350-0255
[4] Shah, Z.A. et al: Prevalence of Musculoskeletal Problems and Awkward Posture in a Pakistani Garments Manufacturing Industry, Melaysian Juornal of Public Health Medicine 16, (2016), 1, 75-79, ISSN 1675-0306
[5] Channa, S.: Effect of Cumulative trauma disorders on worker efficiency in apparel industry of Pakistan: Productivity through human factor, Book of Procceding of 4th International Textile, Clothing & Design Conference - Magic World of Textiles, Dragčević Z. (ed.), 5-8th October 2008, Dubrovnik, Croatia, 542-547, ISSN 1847-7275
[6] Balantič, Z., Polajnar, A., Jevšnik, S.: Ergonomija v teoriji in praksi, Nacionalni inštitut za javno zdravje, Ljubljana, 2016., ISBN 978-961-6911-91-7
[7] Dragčević, Z.; Kirin, S.; Šaravanja, B.: A Method of Workplace Design for Sewing Operations, Books of Proceedings 22nd International DAAAM Symposium „Intelligent Manufacturing & Automation: Power of Knowledge and Creativity“, Katalinić B. (ed.), 23-26th November, 2011, Vienna, Austria, 0379-0380, ISSN 726-9679
[8] Kirin S., Dragčević Z., Firšt Rogale S.: Workplace Redesign in the Computer-Aided Technological Sewing Process, Tekstil, 63, (2014.), 1-2, 14-26
[9] McAtamney, L.; Corrlett, E.N.: RULA: a survey method for the investigation of work-related upper limb disorders, *Applied Ergonomics* 24, (1993), 2, 91-99, ISSN 0003-6870
[10] Kirin, S.; Dragčević, Z.: Investigation of Workload in the Technological Sewing Process Using the RULA Method, *Proceedings of the 9th International Textile, Clothing & Design Conference - Magic World of Textiles*, Dragčević Z. (ed.), 197-202, ISSN 1847-7275, Dubrovnik, Croatia, October 7th-10th, 2018, University of Zagreb, Faculty of Textile Technology, Zagreb (2018)
[11] Stanton, N. et al: Handbook of Human Factors and Ergonomics Metods, CRC PRESS, New York, 2005, ISBN 0415-28700-6

[12] Software Ergonomics - FBF Sistemas, *Available from* https://www.fbfsistemas.com/ergonomics.html, *Accessed:* 2020-05-01

COMPUTER CRIME IN THE CONTEXT OF SECURITY AND PROTECTION

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Abstract: *Computer crime has become synonymous with various intrusions into the computer systems of an individual or legal entity. The reasons for this do not necessarily have to be financial, but also messages of threat, false warnings to citizens, obstruction of the working system of a company or institution, all the way to extremely terrorist activities. Such harmful phenomena may in the economy, in addition to material damage, also endanger the life and health of workers. Based on the assumption that the habits and attitudes of individuals are directly projected onto the collective consciousness of the community, a pilot online study within the working population on security habits and awareness of computer crime dangers was conducted as part of the experimental part of this paper. The results of the research indicate a certain leisure in the approach to protection against cybercrime and the need for continuous education and information about the current situation in this area.*

Keywords: *computer crime, security end protection, online research, prevention, education.*

1. INTRODUCTION

Intensive informatization in order to automate and increase the efficiency of all areas of human activity, has been present worldwide for more than two decades. Its intensity varies depending on the economic capacities of the countries and the current situation in the areas of activity. But what all these areas have in common is that computers and applications are fundamentally changing the flow of work and the organization of jobs [1]. The influence of computers [2] has changed the ways and places where jobs are performed. Accordingly, computers have also brought their own form of susceptibility to crime [1]. These offenses are real problems of growing significance. According to a current review published by the American Bar Association, losses for 70 companies, which annually show the results of the damage caused by cybercrime, range from 145 to 730 million US dollars [1]. When talking about cybercrime, the first thing to think about is methods of manipulating computers such as unauthorized access to the computer system, virus infections,

manipulation of data, Trojan horses, etc. [1, 2]. There are also milder forms of cybercrime such as HOAX. These are e-mails with untrue content, which are sent with the aim of intimidating, misinforming and destabilizing business recipients [2]. As another extreme of these criminal acts, we can mention the violations of the cyberspace of a country (areas that include computer networks of a country) by terrorist groups or other countries, which already affects the area of cyber warfare and defense strategy. In the European Union (EU), the Council of Europe established the Expert Commission on Cybercrime in 1997. Its goal was to develop an international instrument for combating crime in cyberspace. The activities resulted in the extension of criminal law protection to the entire European cyberspace [3], and thus to the Croatian Criminal Code [4]. In 2009, the NATO Center of Excellence conducted a series of global and regional efforts to establish a law manual on cybercrime in order to protect against terrorism and cyber warfare at the global and regional levels. It was promoted in the Estonian capital Tallinn and named the "Tallinn Manual" [5]. The Criminal Code of the Republic of Croatia has been harmonized multiple times in recent years in compliance with EU directives [3, 4]. Computer fraud, among other types of this crime, dominates, according to statistical indicators from 2018 [6], and its occurrence by counties is proportional to the population. Despite all countermeasures and organizational activities [1], cybercrime remains a major problem, and this small detail on the distribution of incidents in Croatian counties suggests that the foundation of defense and suppression lies in the awareness and education of individuals who can protect both his household and the company or institution in which he works and disposes of business resources that may be threatened [1]. Whether he is accountable solely for his business section or perhaps tailors the entire security strategy of a firm or organization, a negligent and uneducated employee is a significant risk factor [1]. Based on the abovementioned, we performed a pilot online survey of security behaviors and awareness of cybercrime risks among the working active population.

The main hypothesis is that by examining habits and attitudes about the dangers of computer crime, we can get a picture of an individual's condition that is directly projected on the collective consciousness of the community, indicating existing problems and preventive action instruments, which is the research's goal.

2. METHODS

The methodology includes conducting theoretical research on the state and current methods of prevention and suppression of computer crime in the world and in our country, as well as conducting experimental research among working citizens who are in daily contact with computer technology, based on knowledge from theoretical research and current practice. In the theoretical research, written and internet sources were used (widely available content and through searches of databases of scientific and professional papers).

During August 2019, an online survey on security and protection or, better said, awareness of risks and habits for working users of computer technology was conducted. As a measurement instrument, the "Google Forms" service was utilized to generate an electronic survey form, the content of which we will provide through the results. The link to the survey was sent to the target audience through email with a cover note. Questions about the respondents' socio-demographic characteristics (gender, age, level of education), computer abilities, and use of social networks were asked at the start of the survey. The second part of the questionnaire covers questions regarding the procedures taken so far to protect and secure computer work, with respondents being asked to rate how careful they are in implementing these measures and activities into practice. The evaluation was done on a 5-point Likert scale. In the third section of the survey, respondents were asked to select the most important method for preventing cybercrime attacks from a list of several options. The fourth section of the questionnaire was designed to elicit respondents' personal experiences with computer fraud and how they dealt with this unpleasant experience. Additional data analysis was performed using an MS Excel spreadsheet with a statistical significance level of $p < 0.05$.

3. RESULTS PRESENTATION AND ANALYSIS

The online survey was not completed by 10 of the total number of respondents (N = 61) who were invited via motivational queries by e-mail. The results of descriptive statistics on the characteristics of the test population are shown in Table 1.

Table 1: Descriptive statistics of the test population

Age / education (cro)	Male		Female		Total	
	n	%	n	%	n	%
18-25	**10**	**19.61%**	**9**	**17.65%**	**19**	**37.25%**
HSD (SSS)	3	5.88%	1	1.96%	4	7.84%
BS (VŠS)	4	7.84%	2	3.92%	6	11.76%
MS (VSS)	1	1.96%	6	11.76%	7	13.73%
MS (mr.sc.)	2	3.92%		0.00%	2	3.92%
26-35	**5**	**9.80%**	**10**	**19.61%**	**15**	**29.41%**
HSD (SSS)	1	1.96%	3	5.88%	4	7.84%
BS (VŠS)	4	7.84%	3	5.88%	7	13.73%
MS (VSS)		0.00%	2	3.92%	2	3.92%
MS (mr.sc.)		0.00%	2	3.92%	2	3.92%
36-45	**1**	**1.96%**	**9**	**17.65%**	**10**	**19.61%**
HSD (SSS)		0.00%	1	1.96%	1	1.96%
BS (VŠS)		0.00%	2	3.92%	2	3.92%
MS (VSS)	1	1.96%	5	9.80%	6	11.76%
MS (mr.sc.)		0.00%	1	1.96%	1	1.96%
46-55	**4**	**7.84%**	**3**	**5.88%**	**7**	**13.73%**

HSD (SSS)	2	3.92%		0.00%	2	3.92%
MS (mr.sc.)	1	1.96%	3	5.88%	4	7.84%
PhD (dr.sc.)	1	1.96%		0.00%	1	1.96%
Total	**20**	**39.22%**	**31**	**60.78%**	**51**	**100.00%**

Table 1 shows that there were more female respondents (60.78%) than male respondents (39.22%). According to the age distribution of the test population, the age group of 18-25 years has the highest percentage of respondents (37.25%), followed by the age group of 26-35 years (29.41%), the age group of 36-45 years (19.61%), and the age group of 46-55 years (13.73%). The age group of 18-25 years is a part of the population that has completed secondary education and started further education, whether it is a higher or higher level of education. It can be noticed that the majority of respondents have a BS (29.41%) and a MS degree (29.41%). A high school diploma (HSD) is held by 21.57%, a former master of science degree (mr.sc.) by 17.65%, and a PhD by 1.96%.

Table 2: Computer skills and access to social networks

Computer skills											
Scale:	not at all		weak		medium		good		very good		---
Item	n	%	n	%	n	%	n	%	n	%	N
HTML	1	2.00%	11	22.00%	18	36.00%	14	28.00%	6	12.00%	50
Excel	0	0.00%	2	4.00%	9	18.00%	24	48.00%	15	30.00%	50
PowerPoint	0	0.00%	1	2.00%	6	12.00%	21	42.00%	22	44.00%	50
Photoshop	4	8.00%	12	24.00%	14	28.00%	12	24.00%	8	16.00%	50
Other	0	0.00%	4	8.00%	20	40.00%	18	36.00%	8	16.00%	50
Access to social networks											
Scale:	never		rarely		sometimes		often		always		---
Item	n	%	n	%	n	%	n	%	n	%	N
Facebook	4	8.16%	3	6.12%	3	6.12%	16	32.65%	23	46.94%	49
Twiter	0	0.00%	37	84.09%	4	9.09%	1	2.27%	2	4.55%	44
Instagram	8	17.39%	2	4.35%	9	19.57%	9	19.57%	18	39.13%	46

Table 3: Security activities and risks when working on a computer

Scale:	never		rarely		sometimes		often		always		
Item	n	%	n	%	n	%	n	%	n	%	N
How often you open suspicious emails (including links and attachments within them)?											
	25	49.02%	16	31.37%	5	9.80%	3	5.88%	2	3.92%	51

Have you been in situation to disclose card information via social media or email?											
	0	0.00%	33	64.71%	10	19.61%	6	11.76%	2	3.92%	51
Do you use public wifi when buying a particular product?											
	0	0.00%	25	49.02%	11	21.57%	6	11.76%	9	17.65%	51
It is common for you to update your antivirus and antispy software.											
	4	7.84%	13	25.49%	11	21.57%	12	23.53%	11	21.57%	51
Do you look for a Verified by visa certificate on the website?											
	8	15.69%	9	17.65%	8	15.69%	14	27.45%	12	23.53%	51
When making a purchase, make sure you leave your information on a secure page labeled https: //											
	4	7.84%	7	13.73%	9	17.65%	17	33.33%	14	27.45%	51
Do you pay attention to spelling mistakes and the use of jargon?											
	0	0.00%	4	7.84%	12	23.53%	15	29.41%	20	39.22%	51

Table 2 presents the data that should generally indicate the level of computer skills and social network access intensity. HTML was purposefully placed as a programming norm, together with two commonly used office programs and one visual application, for the dynamics of presenting the results. The "Other" category includes some of the applications that respondents listed of their choice. The table shows that the respondents' knowledge is weak to medium good for HTML and Adobe Photoshop, while their knowledge of Excel and PowerPoint is good to very good. We conclude that, on average, the respondents are familiar with the computer tasks required in everyday life. In terms of social networks, the three most important social networks are identified (Facebook, Twitter, and Instagram), through which there are numerous chances for online buying and hence a significant risk of cybercrime penetration. In order to acquire the product, the consumer frequently needs to leave personal information. Twitter is the least popular social network, according to Table 2, while Facebook and Instagram are the most popular. Facebook and Instagram allow for several types of product purchases.

Table 3 shows the security activities and hazards associated with working from the account, i.e. the processes involved in implementing personal protection and computer security. According to the survey, the majority of respondents stated that they never open e-mails containing suspicious content, including links and attachments (49.02%), that they rarely disclose card information via social networks (64.71%), and that they rarely use public wifi when purchasing a specific product (49.02%). However, 7.84% never, and 25.49% rarely update antivirus and antispyware programs. The majority of respondents stated that they often (27.45%) or always (23.53%) seek the certificate "Verified by Visa". The majority of respondents often (33.33%) or always (27.45%) make purchases through secure pages, and most always (39.22%) pay attention to suspicious spelling mistakes and jargon.

Table 4 displays the results for selecting one of the best techniques for keeping protection and security on the computer that respondents use in practice. There were some really intriguing and diverse attitudes presented.

Table 4: Application of methods to maintain protection and safety in use

Item	n	%
Use of a prepaid card where the user can limit funds on the account	10	19.61%
Interruption of communication with suspicious ads	3	5.88%
Updated antivirus software and firewall installed	7	13.73%
Use the latest security fixes for your browsers	3	5.88%
Avoid sending private information to phishing mails (pin, account number, etc.)	6	11.76%
Only shop on secure websites.	11	21.57%
Installed anti-spyware software	1	1.96%
Daily check your bank and credit card statements	4	7.84%
When shopping online, use the Verified by Visa or MasterCard secure code	5	9.80%
Update your OS, antivirus, and other security software on a regular basis	1	1.96%
Total (N)	51	

The majority of respondents believe that buying on safe sites (21.57%) is the best method for ensuring computer security, followed by using a so-called prepaid card (19.61%). Updating antivirus software and installing a firewall is the third best option (13.73%). Avoiding phishing traps (11.76%), signing up for and paying using Verified by Visa or MasterCard secure Code whenever possible (9.80%), and frequently monitoring bank statements round out the top five (7.84%). However, what is worrying is that only 5.88% of respondents prioritize the use of the latest security patches for search engines, and the least important for them are regular updates of the operating system and antivirus programs (1.96%) as well as anti-spyware programs (1.96%).

Table 5 shows the results of research on the personal experience of respondents with computer fraud, and Table 6 shows the results of the steps taken in these cases of personal fraud. Table 5 shows that the majority of respondents (35.29%) had been victims of personal computer fraud in the form of participation in a phony prize game. In addition, 21.57 percent of respondents stated they received an email pretending to be from their bank, asking them to confirm their account information. In addition, 21.57% indicated they had dealt with various types of personal computer fraud, and 17.65% said they had dealt with personal fraud through online shopping. The penultimate recorded personal computer fraud was donations (3.9%). It is a very common practice to ask for donations to help a specific person solve a health condition or those who are in difficult social situations, in order to perform certain actions. No personal fraud in the form of accepting a job abroad was recorded.

Table 5: Experience with personal computer fraud

Item	n	%
Online shopping	9	17.65%
Involvement in a fake prize game	18	35.29%
Accepting a job offer abroad	0	0.00%
Donation	2	3.92%
You have received a suspicious e-mail	11	21.57%

Other	11	21.57%
Total (N)	51	

Table 6: The procedures you took in the event of computer fraud

Item	n	%
Informed the competent police station	7	13.73%
Informed the bank	11	21.57%
Tried to solve the problem myself	12	23.53%
Nothing	21	41.18%
Total (N)	51	

In terms of the steps taken by respondents in the case of personal computer fraud (Table 6), it was found that 41.18 % did nothing to resolve the situation of personal fraud. Furthermore, 23.53% of respondents tried to solve the problem themselves, while 21.57% of respondents informed the bank, and only 13.73% the competent police station.

4. CONCLUSION

The findings of this paper's electronic research showed a lot of interesting facts and safety indications. In terms of computer literacy, it was discovered that the respondents are familiar with the most common office software applications. Respondents often make online purchases mainly through three key social networks: Facebook, Twitter and Instagram. When using a computer, they mostly do not open messages with suspicious content as well as links and attachments, rarely reveal bank details via social networks and take care not to use public wifi for online shopping. But what is worrying is that they rarely update the operating system and antivirus programs. It is obvious that they are aware of the existence of the phenomenon of cybercrime and are aware that some things they must not do, but they do not go a step further, and that is the implementation of key software updates. The majority of respondents stated that the best method of protection is to buy on secure sites, and the second in a row is the use of prepaid cards for shopping. Regarding the personal experiences of respondents with computer fraud, the most common case is involvement in a fake prize games and fake e-mail from the bank. It is worrying that most of the respondents did not take any action, instead of submitting reports to the competent bank and the police. And this research suggests that weaknesses in protection are often the result of human error. Hence the necessity of educating citizens personally and as employees about the dangers and measures to protect against computer crime. The costs of public and institutional forms of education are significantly lower than the costs of possible consequences, which in addition to large financial damages can directly or indirectly endanger the lives and health of people-workers and damage to material goods [7, 8]. It would be desirable to undertake a new study on computer crime in the near future that would

include a bigger number of respondents and validate the preliminary findings of this pilot study, particularly taking into account the consequences of the accelerated digital transformation of business during the COVID 19 pandemic.

REFERENCES

[1] Babić, V.: *Kompjuterski kriminal: metodologija kriminalističkih istraživanja, razjašnjavanja i suzbijanja kompjuterskog kriminala*, RABIC, ISBN 978-9958-33-010-0 Sarajevo, BiH, (2009)

[2] Šimundić, S.; Franjić, S. & Vdovjak, K.: HOAX, *Zbornik radova Pravnog fakulteta u Splitu*, **Vol.** 49 (2012), No. 3, pp. 459- 480, ISSN 0584-9063

[3] Kokot, I.: Kaznenopravna zaštita računalnih sustava, *ZPR*, **Vol.** 3 (2014), No. 3, pp. 303-330, ISSN 1848-6118 (Online)

[4] Narodne novine: Kazneni zakon: Članak 271., Zakon o računalnim prijevarama, NN 125/2011, Narodne novine, Zagreb, (2011) *Available from:* https://narodne-novine.nn.hr/clanci/sluzbeni/2011_11_125_2498.html *Accessed:* 2020-03-12.

[5] Schmitt, M. N.: *Tallinn manual on the International Law applicable on cyber warfare*, Cambridge University Press, ISBN-13: 978-1316630372, New York, (2013)

[6] MUP RH: *Statistički pregled temeljnih sigurnosnih pokazatelja i rezultata rada u 2018.godini*, Ministarstvo unutarnjih poslova, Zagreb, (2019) *Available from:* https://mup.gov.hr/UserDocsImages/statistika/2018/Statisticki%20pregled%20temeljnih%20sigurnosnih%20pokazatelja%20i%20r. *Accessed:* 2020-02-10.

[7] Ranabhat, B.; Clements, J.; Gatlin, J.; Kuang-Ting, T. & Yampolskiy, M.: Optimal sabotage attack on composite material parts, *International Journal of Critical Infrastructure Protection*, **Vol.** 26 (2019), ISSN: 1874-5482

[8] Mohr, A.: *3 Ways Cyber-Crime Impacts Business*, Investopedia. *Available from:* https://www.investopedia.com/financial-edge/0112/3-ways-cyber-crime-impacts-business.aspx. *Accessed:* 2020-02-10.

THE EFFECTS OF IONIZING RADIATION ON THE HUMAN BODY

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Abstract : *In this paper we consider the effects of ionizing radiation on the human body. In the first part of the paper we describe the ionizing radiation and how it is produced, its types and sources, the interaction of the ionizing radiation with the material, the type of irradiation, the physical quantities that describe the radiation and the methods of protection against ionizing radiation. Then, the factors that affect the degree of body damage, effects on the cell at the molecule level and the level of cell organelles, and the sensitivity of certain cell types to ionizing radiation are explained. Subsequently, carcinogenesis and radiobiological effects of ionizing radiation are explained. In the last part of the paper we describe and list the consequences of human exposure to ionizing radiation and explain the skin damage and radiation sickness.*

Keywords: ionizing radiation, body damage, cell organelles, carcinogenesis, radiation

1. Introduction

Ionizing radiation is a natural and common phenomenon in the environment. The use of ionizing radiation is increasing and becoming more widespread, and there is no adequate substitute for ionizing radiation in medical diagnosis, therapy, and sterilization of equipment and supplies. The hazards associated with exposure to ionizing radiation cannot be eliminated, but the risks can be limited and reduced through various technical, organizational and administrative measures. For this reason, every state is obliged to establish an orderly, systematic, and high-quality system of protection against ionizing radiation at all levels of society.

2. Types of irradiation, physical quantity and units of measurement

Depending on whether the source of ionizing radiation is outside the body or is introduced into the body in some way (by ingestion, inhalation, intravenously), irradiation may be external or internal. External irradiation occurs when an X-ray tube or accelerator is in operation, and internal irradiation occurs when radioactive

substances are introduced into a person's organism as part of diagnostic procedures in nuclear medicine departments. It is important to emphasize that the human body into which the radionuclide is introduced for its environment is an external source of ionizing radiation.

All matter has its mass, and as ionizing radiation passes through that matter, the radiation emits energy for each kilogram of mass. The ratio of energy emitted to mass is called absorbed dose D; $D=E_{impact}/m$, where impact is energy emitted and m is mass. The unit of measure for absorbed dose is J/kg, or Gray (Gy). Dividing the absorbed dose by the time it was received yields a quantity called the absorbed dose rate, which is measured in Gy/hour.

Not all tissues are equally sensitive to radiation, some tissues are more sensitive and others are less sensitive, and this must be taken into account when evaluating the harmfulness of a particular type of ionizing radiation. Indeed, it does not matter whether the radiation is alpha, beta, or gamma. If the source of alpha radiation is close to the human skin, this has no effect because ionization occurs in the air between the source and the skin, and the energy is absorbed outside the body rather than inside. In the case of gamma radiation close to the body, the ionizing radiation (consisting of photons) is poorly absorbed in the air, which has a lower density than the body, and most of it goes into the tissues and organs. Ionizing radiation (consisting of photons) is attenuated in relation to the absorbed dose and even exits the body and is passed on. So it is a completely different situation when we swallow or inhale alpha or beta radiation, i.e. a particle source, when we swallow or inhale pure gamma radiation. In this case, we have internal irradiation. The energy emitted by the alpha source is completely absorbed near the source itself, then we have intense ionization in a small volume and in the same volume all the energy of the ionizing radiation is released. The high energy, small volume and large absorbed dose are very harmful to this radiation. When gamma radiation is ingested, it emits photons that leave the body, and only a small portion of the energy is retained in the body, so the irradiation dose is lower; with less energy to a larger mass, the ratio is lower. For this reason, external irradiation introduces modification coefficients that depend on the type of radiation, which we call the weight coefficients of radiation, the name W_R. The weight coefficients of radiation for certain types and radiation energies are listed in Table 1.

Table 1. Weight radiation coefficients [5]

TYPE AND ENERGY OF RADIATION	**RADIATION WEIGHT COEFFICIENT, W_R**
Photons, electrons and nuons, all energies	1
Neutrons, energies <10 keV Neutrons, energies >20 MeV	5
Neutrons, energies 10 keV to 100 keV Neutrons, energies >2 MeV to 20 MeV Protons, other than scattered, energy>2	10

MeV	
Alpha particles, fission fragments, heavy cores	20

If we multiply the absorbed dose D by the weight coefficient of radiation W_R, we get an equivalent dose of H for a given tissue: $H_T=W_R*D$. The unit of measurement is 1 sievert, denoted by 1 Sv. The equivalent dose refers to a specific tissue or organ. Each tissue has a different sensitivity to ionizing radiation and is expressed by the tissue weight coefficient, W_T.
If we multiply the absorbed dose D by the weight coefficient of radiation W_R, we obtain an equivalent dose of H for a given tissue: $H_T =W_R*D$.

The unit of measurement is sievert (Sv). The equivalent dose refers to a specific tissue or organ. Each tissue has a different sensitivity to ionizing radiation and is expressed by the tissue weight coefficient, W_T
.

Table 2. Weight tissue coefficients [5]

TISSUE OR ORGAN	TISSUE WEIGHT COEFFICIENT, W_T
Gonads	0,2
Bone marrow	0,12
Colon	0,12
Lung	0,12
Stomach	0,12
Bladder	0,05
Liver	0,05
Esophagus	0.05
Thyroid gland	0,05
Skin	0,01
Bone surface	0,01
Other	0,01

The sum of the product of the tissue weight coefficient and the equivalent dose is called the effective dose, E_T.

2.1. Characteristic radiation doses

In radiology and radiophysics, there are a large number of different doses of ionizing radiation. Two types of doses are distinguished:

- physical dose,
- biological dose.

Physical dose indicates the amount of radiation absorbed in a given time, and biological dose implies physical dose but also different radiation sensitivity (radiosensitivity) of the irradiated tissue (tissue weight coefficient, W_T), dose-time distribution, type of radiation, and other less known factors.
In radiology, radiation doses can be:

- exposure dose,
- absorbed dose,
- equivalent dose,
- effective dose,
- radiation doses of radioactive isotopes.

The exposure dose is the amount of radiation to which a person is exposed. It is defined as the number of ions released when a mass of tissue is irradiated. The old unit of measurement is x-rays; the new unit of measurement is coulombs per kilogram (C/kg).
Exposure doses are measured directly with dosimeters. Absorbed dose D is the amount of energy absorbed (absorbed) by a given mass of tissue. The unit of measurement used for absorbed dose is Gray (Gy) and indicates the dose of radiation from which the amount of energy of 1 joule is absorbed in a tissue mass of 1 kilogram.
Equivalent to the dose H, we call the product of the absorbed dose and the weight coefficient of the radiation W_R. The unit of measurement is Sivert, (Sv). The equivalent dose refers to a specific tissue or organ.
The effective dose of ET is the sum of the product of the weight coefficient of tissues and the equivalent dose. The unit of measurement is Sv, and the effective dose applies to the entire body. The effective dose and equivalent dose are calculated and the absorbed dose is measured.
The radiation dose of the radioactive isotope indicates the number of decays of isotope atoms in a unit of time. The old unit of measure was 1 curie, but now the unit of measure Becquerel (Bq) is used. One Bq represents one decay per second (s^{-1}).
The exposure doses in radiology depend on:

- Type of radiological examination,
- the width of the required radiation beam,

- the volume of the body part irradiated,
- the intensity and penetration depth of the radiation,
- the duration of the recording or reconnaissance,
- the type of equipment used in the radiological examination,
- mode.

The doses of radiation that humans receive or may receive in certain foreseeable or unforeseeable situations are also to be classified as such:

- natural doses,
- permissible doses,
- limit doses,
- critical,
- surreptitious doses.

Doses are the values of dosimetry quantities prescribed by legal acts, which should not be exceeded by human activity. They do not apply to natural irradiation or irradiation for medical purposes. Of the few limits that limit doses in specific situations, the primary dose limits, which apply to the individual, and the approved dose limits, which are usually lower than the primary limits prescribed by governmental institutions responsible for working with sources of ionizing radiation, are important for broader application.

Table 3. Limit doses for staff professionally exposed to ionising radiation [5]

DOSE TYPE	IRRADIATION MODE	VALUE
STOCHASTIC EFFECTS		
Individual annual limit of effective equivalent dose	Uniform, whole body	50 mSv
Effective equivalent dose	uneven	<50 mSv
Annual limit for a particular organ or tissue		
eye lenses and blood-forming organs	uneven	150 mSv
Other organs and tissues	uneven	500 mSv
NONSTOCHASTIC EFFECTS		
Individual annual effective equivalent dose		
eye lenses and blood-forming organs	uneven	150 mSv
Other organs and tissues	uneven	500 mSv

Today it is considered that the critical dose for a human being is over 250 mSv. It is mandatory that after a single intake of such a high dose, a specialist medical examination must be performed.

All doses higher than the critical dose are considered very dangerous, especially if they are absorbed by single irradiation in a short time. Such irradiation occurs in severe accidents at work with radiation sources and in the use of nuclear weapons. It is estimated that after doses exceeding 3 Sv. Therefore, this dose is considered the mortality threshold. The mortality rate is much lower if the entire body is not irradiated, especially if the animal body and head are not irradiated. When the limbs are irradiated while working with radiation sources, severe skin damage occurs, which can develop into malignant tumors but can also be cured. Above 1 Sv, radiation causes a change in the blood count, below 1 Sv.

3. Ways to protect

Protection from ionizing radiation includes all measures and procedures that can reduce radiation exposure when it is desired or necessary. The issue of radiation protection is monitored by a whole range of international professional organizations, which regularly or periodically issue their recommendations. Following these recommendations, our Law on Protection against Ionizing Radiation was adopted with the corresponding accompanying regulations for the implementation of radiation protection.

There are three basic ways to protect yourself from ionizing radiation, namely:

- sufficient distance from the source,
- the shortest possible period of exposure,
- the use of a protective shield.

The property of ionizing radiation, on which an important part of the protection against ionizing radiation is based, is that the intensity of ionizing radiation decreases with a square distance.

If the distance to the source of ionizing radiation increases by a factor of two, the intensity decreases by a factor of four. The irradiation of a person also depends on the duration of exposure to ionizing radiation. Irradiation is proportional to the exposure time, i.e. the longer a person is exposed to ionizing radiation, the stronger his irradiation and vice versa.

The ionizing radiation that passes through matter is attenuated. For this reason, the amount of radiation to which a person is exposed can be significantly reduced by shielding between the source and the person. Also important is the material the shielding is made of, its thickness, the type of ionizing radiation, and how the shielding itself is used. The shielding can be a concrete wall, a layer of lead, protective screens or aprons, or goggles.

3.1. Legislative protection

Legislative protection from ionizing radiation is very important, as strict legal rules

and regulations govern the entire field of protection from ionizing radiation. The basic laws on protection from ionizing radiation in the Republic of Croatia are:

- Act on Protection against Ionizing Radiation and Safety of Sources of Ionizing Radiation (NN 64/2006)
- Ordinance on conditions and measures for protection against ionizing radiation during the performance of activities involving sources of ionizing radiation (NN 58/2018)
- Ordinance on health conditions for workers exposed to radiation and persons trained for activities in the field of radiation exposure (NN 66/2018)
- Ordinance on the organization and implementation of measures for protection against ionizing radiation (NN 28/2015)
- Regulation on the conditions of use of sources of ionizing radiation in medicine and dentistry (NN 89/2013)
- State Plan and Program for Measures for Protection against Ionizing Radiation and Emergency Measures (NN 49/2008).

All this is per the recommendations of the ICRP and the requirements of the European Community.

3.2. Physical - technical protection

The law also defines physical-technical protection, which includes:

- Supervising of the enforcement of legal regulations on the design and construction of radiological facilities,
- departments, and premises in which work is performed with sources of ionizing radiation,
- Design and construction of diagnostic premises,
- Protection of walls, windows and doors of radiological rooms,
- Protection of the floor.

3.3. Chemical protection

Chemical radioprotective agents are chemical substances that reduce the harmful biological effects of radiation. Cysteine and amifostine are used in radiation therapy of tumors. The mechanism of action is based on the so-called "purification" of free radicals and the repair of the damage caused by the action of free radicals. Chemical radioprotective agents are taken before exposure to ionizing radiation, and the latest generations of chemical radioprotective agents are taken after irradiation.

3.4. Biological protection

Increasing the body's biological resistance to radiation is achieved by vitamins, sugars, tannin teas, artificially lowering the temperature of parts of the body exposed to higher doses of radiation, artificially "anemizing" (reducing blood circulation,

artificially anoxying) organs or parts of the body, exposed to higher doses of radiation, as well as rest, good nutrition and rest, and shorter working hours and longer vacations used on two occasions (in summer and winter) for professionals in radiology, radiotherapy and nuclear medicine.
Scientific and research work on the subject of theoretical and practical problems of ionizing radiation on the human body can only avoid the dangers that we know well. Radiobiological scientific research leads to a constant reduction of the permissible doses of radiation for the professionals and the population to which they may be exposed on a monthly, quarterly, yearly, etc. basis.

4. The consequences of human exposure to ionizing radiation.

The severity of biological damage caused by ionizing radiation depends on:

- the type of radiation - each type of radiation has its characteristic radiobiological effectiveness and its radiation weighting factor,
- the temporal distribution of the dose - the biological damage is inversely proportional to the duration of radiation exposure,
- topographic dose distribution - the biological damage is proportional to the volume of the irradiated body,
- absorbed radiation dose - the biological damage is due to the effect of the total radiation to which the body was exposed, regardless of the dose,
- exposure time and tissue volume (effective lifetime dose of radiation),
- individual sensitivity to radiation - each organism reacts differently to radiation (usually for unknown reasons),
- Age - younger people are generally more sensitive to radiation than older people,

and children are three times more sensitive than adults while the fetus is most susceptible to radiation.

Damage caused by ionizing radiation can be divided into:

- somatic damage – acute, chronic, occupational, carcinogenic, leukemogenic, teratogenic,
- genetic damage.

Genetic defects are damage that occurs in the offspring of people whose gonads (sex glands or reproductive glands) were exposed to radiation during the generative (reproductive) period. Undesirable genetic defects are all changes in hereditary characteristics (physical and mental) that lead to a reduction in the physical and mental performance of the offspring. The occurrence of genetic defects is linearly related to the radiation dose to the eggs and sperm.
Mutations caused by radiation are inherited recessively. This means that some hereditary diseases caused by these mutations may occur in the offspring of irradiated individuals if the father and mother were irradiated with approximately

the same dose of radiation at the same location of chromosomes and genes. As a rule, this may not occur in the first generation of offspring, but only from the third generation. The greater the probability of hereditary diseases, the more people, men and women of childbearing age, were exposed to radiation. According to the latest data, about 4,500,000 different X-ray examinations are performed annually in the Republic of Croatia.

5. Conclusion

Ionizing radiation is an integral part of the modern world and a natural and ever-present phenomenon in numerous human activities. Ionizing radiation from artificial sources is becoming increasingly common, and there is no adequate substitute for ionizing radiation in medicine and various activities in diagnosis. Although society benefits greatly from ionizing radiation, it remains very dangerous to human, animal, plant, and environmental life and health. For these reasons, it is important to know and apply the principles and practices of safe use of ionizing radiation sources. Ionizing radiation causes biological damage to humans, and the severity of this damage depends on the type of ionizing radiation, exposure time, absorbed dose, surface area and dose-time distribution, individual sensitivity, and age of the exposed person. Thus, many factors influence what consequences ionizing radiation will have. The risk of ionizing radiation must be limited and reduced by technical, organizational and administrative measures. The systematic organization of measures to protect against ionizing radiation is also referred to as protection against ionizing radiation and applies to all people who may be exposed to radiation or radiation consequences.

REFERENCES

[1] Basta-Juzbašić, A., suradnici, „*Dermatovenerologija"*, Medicinska naklada Zagreb, Zagreb, 2014., ISBN: 978-953-176-662-3
[2] Grgić, S., „*Djelovanje ionizirajućih zračenja na žive stanice"* (III. Simpozij), Ministarstvo zdravstva Republike Hrvatske, HDZZ, Zagreb, 1999.
[3] Hebrang, A., Klarić-Čustović, R., *„Radiologija",* Medicinska naklada Zagreb, Zagreb, 2007., ISBN: 953-176-338-0
[4] Janković, S., „*Uvod u radiologiju*" (interna skripta), Sveučilište u Splitu, Medicinski fakultet, Split, 2014.
[5] Obnova znanja o primjeni mjera radiološke sigurnosti *putem interneta* http://e-ucenje.civilna-zastita.hr/course/index.php?categoryid=15. Accessed on 2018-12-04
[6] Occupational Radiation Protection, www.iaea.org, *Accessed on* 2019-04-17
[7] Radiation Protection of the Public and the Environment, www.iaea.org, *Accessed on* 2019-04-17

ASSESSMENT OF THE WORKING ABILITY OF CHAINSAW WORKERS IN CENTRAL CROATIA

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Abstract: *Work related to wood utilization, especially manual felling and wood processing, is a high-risk work process where the chainsaw, along with the other variables in the working environment, is a key and constant source of risk and danger for forest workers. Based on that, the aim of this paper is to evaluate, analyse and compare selected indicators of working ability (workability index and musculoskeletal disorders) of forest chainsaw workers working in Central Croatia which are employed by the Hrvatske šume Ltd. and by a private forestry contractor. To analyse the working ability among the chainsaw workers in Central Croatia, a three-stage research method was employed: (a) defining a sample; (b) preparation and administration of questionnaire; and (c) data analysis and elaboration. The field part of face-to-face data collection was conducted in the first quarter of 2022. Data analysis was conducted using statistical and descriptive methods. The research results showed a significant difference between the chainsaw workers employed by the company Hrvatske šume Ltd. and chainsaw workers employed by private forestry contractors regarding compared working ability indicators. Based on the obtained results, for the advancement of ergonomic conditions in motor-manual operation, discussion and conclusion part of the paper provide examples of good practice for safety culture improvements and guidelines for further research tasks.*

Keywords: *forestry, chainsaw, workability, musculoskeletal disorders, Central Croatia*

1. INTRODUCTION

Forest workers, especially loggers, are exposed to a number of dangers that most often result in the development of occupational diseases and / or injuries that cause high medical costs, which can burden the worker and company management economically and psychologically [1, 2], especially if they work contrary to the prescribed safety rules at work. Motor-manual felling and wood processing is a high-risk work process where the chainsaw, in connection to other variables in the working environment, is a key and constant source of risk and danger for forest chainsaw workers [3].

In many forestry works, regardless of the certain degree of mechanization, the human body is a basic source of work energy because the motor-manual operation is still heavily represented in the production process. For example, in Croatia timber extraction is mechanized, while felling and processing are mostly motor-manual and carried out by using chainsaws [4]; only 3%–4% of wood is felled fully mechanized in state forests [5]. Operators' effectiveness in forest operations, motor-manual or mechanized, is related to numerous parameters such as work intensity, age and work experience, health condition, motivation and work competencies, work technique and workability, etc. It has been established that significant overloads during physical work can result in the appearance of musculoskeletal disorder (MSD) symptoms among loggers [6]. Consequently, operators' wellbeing status researched through musculoskeletal disorders can significantly limit employee efficiency and, by interaction with other variables in the working environment, constitute one of the main causes of premature loss of working ability for chainsaw forest workers.

Contrary to the above, good personal predispositions, such as professional work skills, motivation and good health, increase an individual's resilience and prolong workability as the operating environment and the nature of work change [7, 8]. Pursuant to the foregoing, the aim of the paper is the investigation and comparison of the detected MSD symptoms in chainsaw workers, which are employed by the Hrvatske šume Ltd. (HŠ) and by a private forestry contractor, according to the workers' responses and determined workability index.

2. MATERIALS AND METHODS

To analyse the working ability and detect MSD symptoms among the chainsaw workers in Central Croatia, a three-stage research method was employed: (a) defining a sample; (b) preparation and administration of questionnaire; and (c) data analysis and elaboration. For sampling professional chainsaw workers in Central Croatia, a random stratified sample was used for face-to-face survey. Within this sample, a population element was grouped into homogeneous groups or stratums (5 groups consisting of Forest Administrations Koprivnica, Bjelovar, Zagreb, Karlovac and Sisak i.e. native forest offices (which are the structural and organizational part of the company Hrvatske šume Ltd.) and one additional group consisting of licensed timber harvesting contractors). The resulting number of sampling workers within each stratum was selected by a simple random sample, where all members of the stratum have an equal chance of being selected, using the "Research Randomizer" calculator.

The used questionnaire consisted of 3 parts: (a) a general section on the respondent and the working tool (chainsaw); (b) assessment of the Workability Index (7 standardized questions); and (c) the Standardized Nordic Questionnaire (27 short questions versus nine body parts). The Standardized Nordic Questionnaire [9] was used as a medium to detect musculoskeletal disorder symptoms in chainsaw workers and the Workability Index (WAI) questionnaire [10] was used as a medium for workability self-evaluation.

Field surveys and data collection were conducted during the first quarter of 2022. Two continuous variables, MSD Score and WAI Score, were created for each respondent by summing the number of anatomical areas with a reported MSD or given points for specific indicator regarding workability. Also, MSD K-Score was created for each respondent based on the positive answers obtained in the second part (yes/no for inability to perform daily work) and the third part (yes/no for symptoms during the last 7 days) of the questionnaire. Data processing was performed using the descriptive method and method of analysis, synthesis and comparison. The method of analysis and synthesis was used in the process of writing the paper, where the various sources were ultimately summarized in a single text. Descriptive method and method of comparison was applied in the practical part of the paper in the presentation and comparison of the results regarding workability index and the determined frequency of MSD symptoms in relation to the employer.

3. RESEARCH RESULTS

Total number of sampled workers was 65, all male gender and more than 67 % with high school education. From the total number, 29.23% are employed by a private contractor in forestry, and 70.77% are employed by sampled Forest Administrations which are spatially located in central Croatia (table 1) and represent organizational units of the Hrvatske šume Ltd.; a company that manages state forests in the Republic of Croatia. Distribution regarding age and work experience of the chainsaw workers involved versus employer corresponded well to the age distribution of the general population.

Table 1: General information about the sampled chainsaw workers in central Croatia

Profile of interviewees		HŠ Forest Administrations in central Croatia		Private forest company	
		46 (70.77%)		19 (29.23%)	
		n	%	n	%
Gender	Male	46	100.00	19	100.00
Age groups	≥ 29	16	34.80	5	26.30
	30 – 39	15	32.60	5	26.30
	40 – 49	13	28.30	6	31.60
	≤ 50	2	4.30	3	15.80
Chainsaw work experience groups	≥ 5	30	65.20	10	52.60
	6 – 15	10	21.70	7	36.80
	≤16	6	13.10	2	10.60
Level of	Primary school or lower	12	26.10	9	47.40

education	High school or higher	34	73.90	10	52.60
Minor injuries at work	No injuries	24	52.20	12	63.20
	Once	13	28.30	6	31.50
	Twice	5	10.90	1	5.30
	Three or more times	4	8.60	0	0.00
Severe injuries at work	No injuries	38	82.60	18	94.70
	Once	5	10.80	1	5.30
	Twice	1	2.20	0	0.00
	Three or more times	2	4.40	0	0.00
Working hours per week	Eight hours	46	100.00	4	21.10
	Nine or more hours	0	0.00	15	78.90

The percentages of MSD symptoms reported by chainsaw workers employed in central Croatia is presented in table 2. The anatomical area with the highest 12-month period prevalence of MSD symptoms for all sampled chainsaw workers (table 2) was low back (73.80%), followed by the shoulders (47.70%), neck (41.50%) and upper back/knees (33.80%). The lowest 12-month period prevalence of MSD symptoms for all chainsaw workers (table 2) was elbows and hips/thighs. The chainsaw workers employed by Hrvatske šume Ltd. had a higher prevalence of MSD symptoms in almost all anatomical locations compare to chainsaw workers employed by private forest contractor (Table 2).

Table 2: The percentage of chainsaw workers in central Croatia reporting musculoskeletal symptoms (one-year period prevalence)

Anatomical location of MSD symptoms	All responses (n=65)		HŠ Forest Administrations in central Croatia (n=46)		Private forest company (n=19)	
	No, (%)	Yes, (%)	No, (%)	Yes, (%)	No, (%)	Yes, (%)
Neck	38 (58.50)	27 (41.50)	21 (45.70)	25 (54.30)	17 (89.50)	2 (10.50)
Shoulders	34 (52.30)	31 (47.70)	22 (47.80)	24 (52.20)	12 (63.20)	7 (36.80)
Elbows	57 (87.70)	8 (12.30)	39 (84.80)	7 (15.20)	18 (94.70)	1 (5.30)
Wrist/Hands	45 (69.20)	20 (30.80)	28 (60.90)	18 (39.10)	17 (89.50)	2 (10.50)
Upper Back	43 (66.20)	22 (33.80)	28 (60.90)	18 (39.10)	15 (78.90)	4 (21.10)
Lower Back	17 (26.20)	48 (73.80)	10 (21.70)	36 (78.30)	7 (36.80)	12 (63.20)
Hip/Thighs	55 (84.60)	10 (15.40)	39 (84.80)	7 (15.20)	16 (84.20)	3 (15.80)
Knees	43 (66.20)	22 (33.80)	31 (67.40)	15 (32.60)	17 (89.50)	2 (10.50)
Feet	46 (70.80)	19 (29.20)	30 (65.20)	16 (34.80)	16 (84.20)	3 (15.80)
MSD Score (Mean number)	3.18		3.61		2.16	
MSD K-Score (Mean number)	4.19		4.80		2.73	

Using nonparametric Mann-Whitney U test significant differences were found in the MSD Score (table 2) between chainsaw workers employed by Hrvatske šume Ltd. (Md=4.00, n=46) and chainsaw workers employed by private forest contractor (Md=2.00, n=19) U=274.50, z=-2.364, p=0.02. Also, differences were found in the MSD K-Score (table 2) between chainsaw workers employed by Hrvatske šume Ltd. (Md=5.03, n=46) and chainsaw workers employed by private forest contractor (Md=2.68, n=19) U=284.00, z=-2.211, p=0.03.

Mean workability index (table 3) among all sampled chainsaw workers in central Croatia was 35.49 points falling into the upper limit of the rank »moderate«. Analysed according to the share of each group, 4.60% of respondents reached the rank »excellent«, 43.10% »good«, 44.60% »moderate« and 7.70% »poor«. Mean score of chainsaw workers' workability index, employed in the sampled Forest Administrations of Hrvatske šume Ltd. and in private companies, is shown in Table 3. Regarding WAI Score (table 3), U test resulted with significant difference between chainsaw workers employed in Hrvatske šume Ltd. and chainsaw workers employed by private forest contractor (U=280.50, z=-2.263, p=0.03).

Table 3: Descriptive values of the workability indicator for chainsaw workers in central Croatia

WAI indicators		HŠ Forest Administrations in central Croatia				Private forest company			
		M	SD	Min.	Max.	M	SD	Min.	Max.
Q1	Comparation of WA with the lifetime best	7.67	1.89	4	10	8.00	1.73	4	10
Q2	WA in relation to the demands of the job	6.83	1.69	2	10	7.16	1.95	4	10
Q3	Number of current diseases	5.37	1.34	0	6	5.47	0.91	3	6
Q4	Interference of health problems	4.74	1.45	1	6	4.74	1.66	1	6
Q5	Sick leave during the past year	3.54	1.39	1	5	4.32	1.25	1	5
Q6	Own prognosis of WA	4.04	1.75	1	7	5.05	1.55	3	7
Q7	Mental resources	2.37	0.93	1	4	3.00	1.16	1	4
WAI Score		34.57	5.86	13	45	37.74	4.84	26	44

Value of MSD Score and K-Score for chainsaw workers was compared through binary WAI variable (group 1: restore or improve their workability (n=34); group 2: maintain their workability (n=31)). Using the Mann-Whitney U test a statistically significant difference was found for MSD Score (U=262.50, z=-3.505, p=0.00) and MSD K-Score (U=243.50, z=-3.730, p=0.00) variable. The average MSD Score per sampled worker which need to restore or improve its workability is 4.09 and 2.19 for worker which needs to maintain its workability. The average MSD K-Score per sampled worker which need to restore or improve its workability is 5.54 and 2.72 for worker which needs to maintain its workability.

4. CONCLUSIONS

Despite numerous innovations and technological advances within the forestry sector globally, in the Croatia Republic there is still a significant share of motor-manual felling and wood processing where the chainsaw worker is exposed to the greatest risk. Improving the state of health protection and safety during forest work is an important link in the production process of wood utilization, but also in the fulfilment of the goals of sustainable forest resource management.

Regarding the aspect of descriptive indicators of sampled workers, based on the measured and expected frequency, it can be concluded that chainsaw workers employed by private forestry contractor work more hours per week and have lower level of education compared to workers employed in sampled administrations of the company Hrvatske šume Ltd.

The physical wellbeing among the chainsaw workers was addressed through the prevalence of musculoskeletal disorder symptoms and workability score value. Regarding musculoskeletal disorder symptoms, the anatomical area with the highest 12-month period prevalence of MSD symptoms for all sampled chainsaw workers in central Croatia (table 2) is low back (73.80%), followed by the shoulders (47.70%), neck (41.50%) and upper back/knees (33.80%). In current sample chainsaw workers employed by Hrvatske šume Ltd. had a higher prevalence of MSD symptoms in almost all anatomical locations compared to chainsaw workers employed by private forest contractor. Regarding the mean WAI Score for the present study, a slightly lower WAI Score was recorded for chainsaw workers employed by Hrvatske šume Ltd. versus private forest companies. Based upon binary WAI variable for the prevalence of MSD symptoms (value of MSD Score and K-Score), it can be concluded that obtained result is correlated with descriptive indicators where younger workers with less chainsaw work experience have a lower prevalence of MSD symptoms and better WAI Score.

Although technological advances and workplace safety management systems have greatly contributed to creating a safer world, the introduction and improvement of a workplace safety culture is key to further improvements (Kim et al. 2016). One possible solution is to implement a system of incentives / rewards for good safety behaviour, which can encourage chainsaw workers to see the system of occupational safety measures not only as a "rule" but as a value that has benefited their work. Another solution is development of educational programs related to the MSD risks for professional chainsaw workers or implementation of in-service training on issues such as working position, working conditions, lifestyle and habits in order to change behaviour that will reduce occupational risks.

ACKNOWLEDGEMENTS

The research was funded by the Croatian Science Foundation within the Project "Increasing the Competitiveness of Forestry Sector Through Development of Safety Culture (ForSaf2024)", project number IP-2020-02-7637.

REFERENCES

[1] LaBelle, J.: What do accident truly cost?, *Professional Safety*, 45(2000), pp. 38–42.

[2] Shalini, R.: Economic cost of occupational accidents: Evidence from a small island economy, *Safety Science,* 47(2009), pp. 973–979.

[3] Landekić, M.; Šporčić, M.; Bačić, M.; Pandur, Z.; Bakarić, M.: Workability and Physical Wellbeing among the Chainsaw Workers in Croatia, *Croat. J. of Forest Eng.*, 1(2023), (in the process of being published)

[4] Mederski, P.S.; Borz, S.A.; Đuka, A.; Lazdinš, A.: Challenges in Forestry and Forest Engineering–Case Studies from Four Countries in East Europe, *Croat. J. For. Eng.*, 42(2021), pp. 117–134., https://doi.org/10.5552/crojfe.2021.838

[5] Landekić, M.; Martinić, I.; Mijoč, D.; Bakarić, M.; Šporčić, M.: Injury Patterns among Forestry Workers in Croatia, *Forests*, 12(2021), 1356, https://doi.org/10.3390/f12101356

[6] Ashby, L.; Bentley, T.; Parker, R.: Musculoskeletal disorder in silviculture and logging 1995-1999, *Centre Of Human Factors and Ergonomics (COHFE) Report*, 2(2001), pp. 2–8.

[7] Tengland, P.A.: The Concept of Work Ability, *J. Occup. Rehabil*, 21 (2011), pp. 275–285., https://doi.org/10.1007/s10926-010-9269-x

[8] Tengland, P.-A.: A qualitative approach to assessing work ability, *Work*, 44(2013), pp. 393–404., https://doi.org/10.3233/WOR-2012-1361

[9] Kuorinka, L.; Jonson, B.; Kilbom, A.; Viterberg, H.; Bierning-Sorensen, F.; Andersson, G.; Jorgense, K.: Standardised Nordic questionnaires for the analyisis of muskuloskeletal symptoms, *Appl. Ergon.*, 18 (1987), pp. 233–237.

[10] Tuomi, K.; Ilmarinen, J.; Jahkola, A.; Katajarinne, L.; Tulkki, A.: Work Ability Indeks. Finnish Institute of Occupational Health, Helsinki 1998, *Available from* http://www.scribd.com/doc /52853348/Work-Abilty-Indeks-Book, 2022-01-15

[11] Kim, Y.; Park, J.; Park, M.: Creating a Culture of Prevention in Occupational Safety and Health Practice, *Safety and Health at Work* 7 (2016), pp. 89-96.

WEB GIS APPLICATION "ECOLOGICAL MAP OF THE CITY OF ZAGREB" – CITY OPERATIONAL TOOL

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Abstract:

The effect of environmental factors on health depends on the space and time of their action, the intensity of exposure, mutual interactions as well as the target population on which it affects. The web GIS application "Ecological Map of the City of Zagreb" (https://ekokartazagreb.stampar.hr) is an operational tool with which the relevant city offices can functionally manage land, space, protection of living and working environment and take even better care of the health of citizens. The web GIS application "Ecological Map" integrates and displays the results of monitoring environmental factors in a simple, easy-to-understand way. Citizens have access to information on the state of the environment through layers of air, water, pollen, weather and soil.

Keywords: *Eco map, air quality, water quality, soil, pollen*

1. INTRODUCTION

Ecological way of thinking and acting is an imperative in all aspects of life of the city and its inhabitants. In the area of the City of Zagreb, a number of tests and monitoring of the health safety of environmental factors are carried out in order to assess the impact on human health and the state of the environment. The results of the survey are used by different competent City Offices in their areas of work, but unfortunately, the data are not consolidated in one place, which makes it difficult to access data that are crucial for policy and program implementation and in the process of operational land, space and living and working environment management. In addition, there is no comprehensive overview of the "zero state" of the environment that is necessary as a basis for action and remediation in case of pollution and incidents and a basis for risk assessment for human health. Due to the poor availability of data, the citizens of the City of Zagreb are not familiar with the scope of all tests and monitoring conducted by the City of Zagreb in cooperation with relevant institutions and efforts to protect health and the environment.

The main goal of the Ecological Map of the City of Zagreb is to consolidate existing data on the state of the environment (air, water, soil, pollen) and upgrade

them with additional data that will serve the competent offices of the City of Zagreb as a functional tool in planning, building and using land of the City of Zagreb and the citizens of the City of Zagreb as transparent, clear information on the state of the environment.

Ecological map is a dynamic tool with continuous data entry based on regular monitoring, episodic measurements, new data from different sectors of environmental testing such as air quality monitoring using low cost sensors that allow real-time data detection and monitoring of changes in the defined time interval.

2. LAYERS OF THE ECOLOGICAL MAP OF THE CITY OF ZAGREB

The Ecological Map of the City of Zagreb currently shows five components of the environment in five layers (Figure 1), namely:

- Air
- Water
- Soil
- Pollen
- Weather data

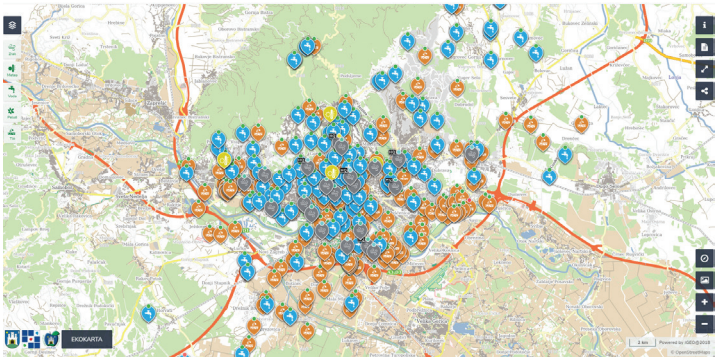

Figure 1: Layers of the Ecological Map of the City of Zagreb

2.1. Air layer – air quality

To monitor air quality, a total of 14 low – cost sensors are currently installed at various locations in the city. The ecological map also shows the results of measurements from seven already existing air quality monitoring stations that

monitor air quality by reference methods. Categorization of air quality (conformity assessment) is given on the basis of measurement results of air quality monitoring stations, while data from low-cost sensors are informative (mainly for displaying the Air Quality Index (AQI) for citizens). In order for citizens to be able to distinguish data obtained from low-cost sensors from data obtained from air quality monitoring stations, the stations have been awarded the HQ-high quality label on the ecological map.

For all low cost sensors and air quality monitoring stations, data on six air pollutants are available: nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ground level ozone (O_3), carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2,5}$) (Figure 2).

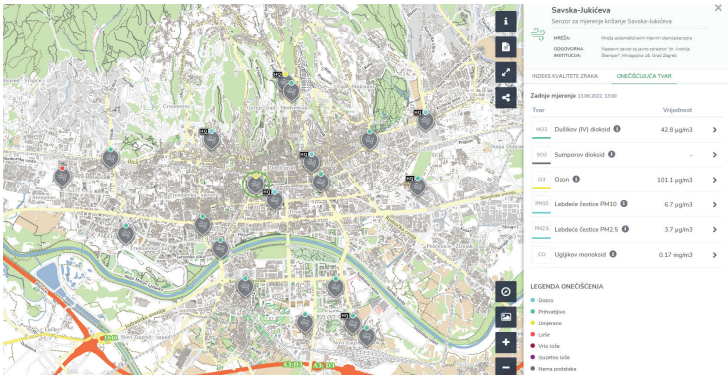

Figure 2: Measuring pollutants

To show the current state of air quality, the European Air Quality Index is used, which enables a better understanding of the current state of air quality in the City of Zagreb. The European Air Quality Index is updated every hour and, depending on its level, health messages are displayed at each of the low-cost sensors / stations, providing recommendations for the general population and for vulnerable groups of citizens (Figure 3).

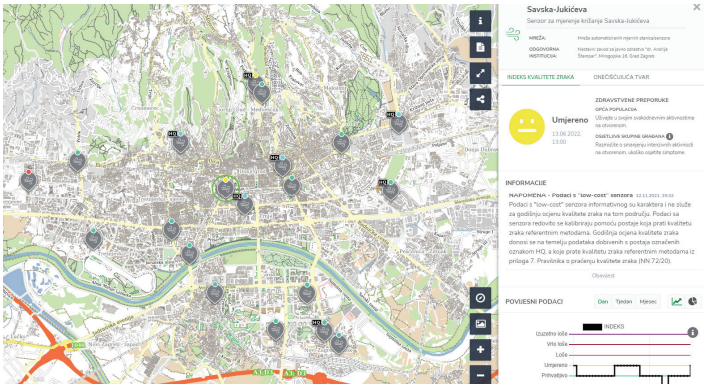

Figure 3: European Air Quality Index

To set up an effective trial to compare low-cost sensor performance and complete the scaling exercise against a reference station, the following conditions must be adhered to in order to complete a valid comparison of low-cost sensor and reference/equivalence instruments. Not complying with these conditions will likely cause poor correlation which may lead to poor scaling of results.

- A reliable reference station (maintained and ideally certified) should be chosen as the trial location, in an environment where there is some pollution, e.g.: ideally at least several weekly peaks above 10 ppb for gas parameters and 10 µg/m^3 for particle fractions.

- All low-cost sensors being co-located for scaling or validation should be placed next to the reference station inlet, ideally immediately adjacent or no further than 1m apart (Figure 5).

- Low-cost sensors should be mounted away from any reflective or known oxidising surfaces or air conditioning exhausts which cause the low-cost sensors local environment to be different from ambient, i.e. 0.5m or greater from the floor.

- Low-cost sensor should be placed in a position with free movement of air, i.e. not affected by turbulence from local barriers.

2.2. Water layer – water quality

Water monitoring in the City of Zagreb has been carried out for many years, and data from 2014 and 2015 were used to establish the appearance of the data on the application (Figure 4).

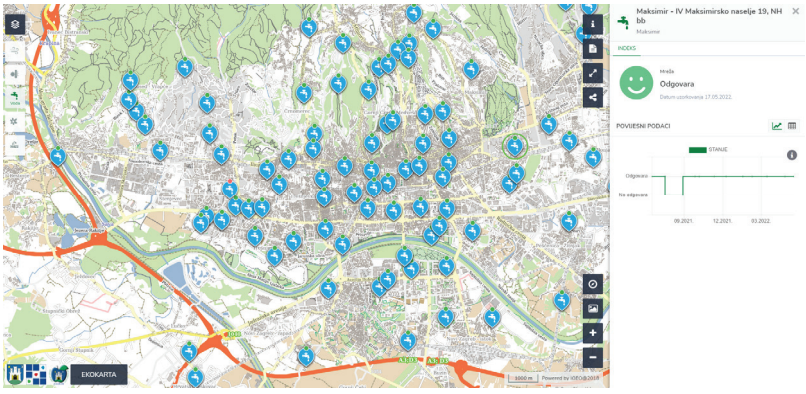

Figure 4: Water layer – water quality

Water testing for human consumption from the public water supply system

Water monitoring for human consumption includes systematic monitoring of the health safety of water for human consumption in order to determine its compliance

with the prescribed values, and includes monitoring of the central water supply system and local waterworks and monitoring of local water sources in the City of Zagreb. The monitoring program covers all city districts, monitoring points are permanent (locations with coordinates), and the selection took into account water supply zones and spatial distribution. Sampling points are distributed in water supply zones according to the amount of water delivered for each individual zone. Each city district is represented by three points on consumer faucets in public buildings and three points on hydrants of the distribution network. Monitoring is also carried out on all six collection hydrants and 30 water reservoirs, regardless of the city districts in which they are located. Sampling dynamics is at least once a month at each point. The number of samples is determined on the basis of the Plan for monitoring the health safety of water for human consumption for each year. Looking at the example of 2021, the sampled number from the central water supply system is 4488 samples.

Bathing water from the city baths of Lakes Jarun and Bundek during the bathing season (June 1 to September 15)

Bathing water quality testing is performed throughout the bathing season. In 2021, 169 samples were sampled during the bathing season, which officially lasts from 01.06. to 09/15/2021 years. On Lake Jarun, samples are taken from five beaches at a total of 16 points, while at Lake Bundek water is taken from three beaches at a total of three points.

Health safety *testing of pool waters*

Sampling and testing of water from swimming pools for sports and recreation, rehabilitation pools, swimming pools in hotels, schools and kindergartens is performed. In 2021, the sampled number of pool water samples is 397.

2.3. Soil layer – soil quality

Soil monitoring is a legal obligation and an activity that builds on monitoring the quality of other environmental media, primarily water and air. Monitoring the condition of the soil is more complex precisely because of the number of uses and the large number of sources of pollution or other means of soil quality degradation. In the City of Zagreb, it is associated with sustainable drinking water supply, health aspects of direct intake, proximity to landfills or sources of industrial pollution, food production in urban and suburban areas, recreational and sports areas, and aesthetic effects in parks and city parks are not negligible. contamination e.g. by salinizing the soil along roads after treatment during the winter. The goals of the program in the City of Zagreb are achieved in several phases: by determining the current state of soil quality in the entire area within the administrative boundaries of the City of Zagreb, identifying locations where pre-defined criteria and legislation need to establish monitoring and defining methods and indicators locations and conduct the first monitoring. The narrower urban area, which includes the areas of Zagreb's city

districts, is covered by a systematic network of sampling density of an average of 1 sample of the surface soil layer (0.05 m - 0.20 m) per 4 km^2. The monitoring is planned to cover seven categories of urban land use: School playgrounds, Kindergartens, Public children's playgrounds, Areas for sports and recreation, Public green areas within residential areas, Public areas (tree lines and green areas along roads, areas nearby) industrial and commercial facilities, areas near landfills and similar environmentally hazardous facilities, etc. (agricultural land, water protection areas) The Ecological Map also includes the existing program "City Gardens" which indicates whether and, if so, to what extent, soil pollution in the area of the city gardens of the City of Zagreb (Figure 5).

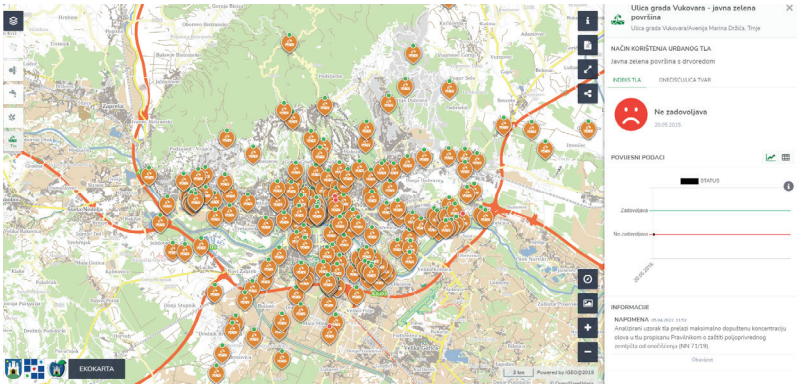

Figure 5: Soil layer – soil quality

2.4. Pollen layer

Measurement of allergen pollen concentrations in the air is performed by a standardized volumetric method. The measuring stations are located on the roof of the building of the Andrija Stampar Teaching Institute of Public Health (location north) and on the roof of the building of the Health Center Siget (location south). The Eco Map of the City of Zagreb page shows the pollen forecast with the level of sensitivity of individual allergens (Figure 6).

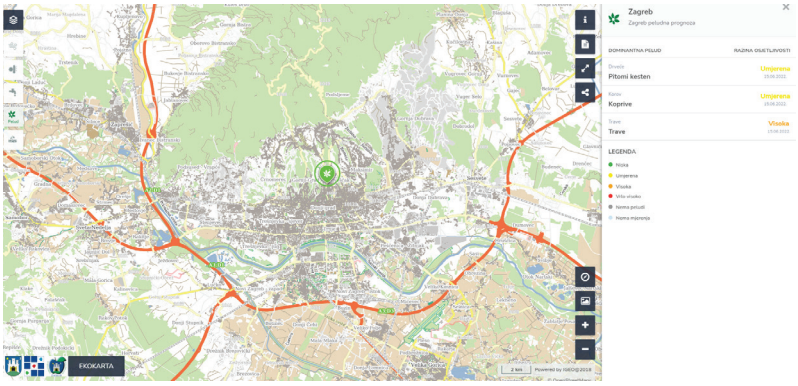

Figure 6: Pollen layer

3. CONCLUSION

The ecological map of the City of Zagreb is a unique example in the world of a unified representation of all components of the environment in real time

Since its presentation in 2018, the Ecological Map of the City of Zagreb has aroused great public interest, which shows that such a tool was needed by citizens to be timely and accurately informed about the current state of the environment in their city.

REFERENCES

[1] Marić, M.; Hrga I., Krivohlavek A.: *Ecological Map of the City of Zagreb*, 12th International Professional and Scientific Conference "Air Protection 2021"
Medulin, 2021

[2] https://ekokartazagreb.stampar.hr/ *Accessed:* 2022-07-08

[3] http://iszz.azo.hr/iskzl/help.htm *Accessed:* 2022-07-08

[4] https://airindex.eea.europa.eu/Map/AQI/Viewer/# *Accessed:* 2022-07-08

PROFESSIONAL EXPOSURE OF WORKERS TO INHALABLE DUST IN WOOD PROCESSING SECTOR

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Abstract: *Professional exposure of workers to inhalable dust of hard wood (oak and beech tree) is the most spread in wood processing industry of Bosnia and Herzegovina, and presents a major health issue. Long-term exposure of workers to dust particles of various size, concentrations and composition, produced by machine processing of hard wood is tied to series of health problems, including lung pathology and other health conditions cases.*

This paper shows results of gravimetric measuring of inhalable and respirable dust at work places in plants dealing with primary and final wood processing. The objective of the paper is to identify health risks of workers and to assess central dedusting system efficiency. Research proved that concentrations of inhalable and respirable dust at work places in plants for final processing exceed maximum allowed concentrations and limit values defined by EU Directive, thus indicating a high risk to workers health and inefficiency of central dedusting system

Keywords: *airborne dust , inhalable dust, hard wood, health effects*

1. INTRODUCTION

The economic sector of forestry and wood industry in BiH has the greatest potential, and currently has the largest turnover in country and provides a large number of jobs. Modern legal solutions that regulate safety and health at work oblige employers to assess risks and determine the level of danger, harm and efforts as well as how they affect workers and their health. Quality risk assessment of jobs in wood processing sector is essential for effective prevention given the fact that wood dust, especially hardwood, has carcinogenic properties.

Based on epidemiological evidences, the International Agency for Research on Cancer has classified wood dust as a group I carcinogen (IARC, 1995) [2]. EU Directive (2004/37 / EC) also classified hardwood dust as carcinogenic and set a limit value of 5 mg/m^3 [1]. of Inhalable wood dust concentration assessment in work environment in the FBiH is made on the basis of bylaws in field of occupational safety adopted in the SFRY (JUS standard Z.B0.001., 1992) [4], which does not define the limit exposure in relation to the type of wood as in the EU Directive.

The current threshold limit values (TLVs) are for inhalable dust[1] 10 mg/m^3 and respirable[2] 3 mg/m^3, where the concentration being determined by gravimetric method (mg/m^3) on a sample collected during eight working hours shift. In addition, legislation regulating occupational safety and health is partially in line with EU regulations. Although technical solutions and designs in a large number of technological processes of wood processing prevent or greatly reduce wood dust emissions into the immediate working environment, it is difficult to achieve an ideal solution for complete workers protection from harmful dust.

2. WOOD DUST

Wood processing technology, in all work phases, is characterized by lower or higher wood dust emissions into the working environment. The surface wood treatment, which is done by sanding and polishing, creates fine dust, and by cutting a larger fraction. Dust concentration and distribution in the workplace depends largely on dust emission from the machines into the working environment, particle size, humidity of wood being treated, and a number of other factors affecting dust transport and dispersion, such as: air turbulence in working environment, air humidity, etc.

Of total dust in the air around the worker, only one part will be inhaled and that part is called the inhalable fraction. One part of the inhaled dust is removed by sneezing and coughing because a large part of this fraction (particle size about 25 μm) is retained in the nasal cavity, and one part penetrates deeper to the upper and lower respiratory system. Small particles <5 μm in diameter, called respirable fraction, can penetrate the smallest parts of the lungs, alveoli and are therefore the most dangerous to human health [3] [7].

Exposure to softwood, hardwood and mixed wood dust is common among European workers, but the level of exposure to hardwood dust is usually below 5 mg/m^3. However, more than 0.5 million workers may be exposed to dust levels (of any type of wood dust) greater than 5 mg/m^3. High exposures occur especially in the construction sector and the furniture industry. Mixed exposure to several types of wood is very common, which complicates the assessment of exposure to different wood types. Due to the fact that workers in wood processing sector often work in poorly ventilated areas, the situation requires more attention and further study (T.Kauppienen et.al. 2006) [5].

Dust generated during wood processing is one of the most common occupational and carcinogenic agents identified to date, starting with dermatoses (skin diseases), eczema and allergic reactions. Diseases occur in lumberjacks and carpenters, most often when working with oak, beech, poplar, plane tree. Edematous and vesicular eczema can also occur, accompanied by irritations of the mucous membranes, which are manifested by inflammation of the conjunctiva (conjunctivitis), then the mucous membranes of the nose and respiratory tract. If wood parasites control agents are used in wood processing, then disorders of the digestive organs, liver, nervous system or kidneys can occur. Varnishes and polishes can lead to severe lung disorders if collective and / or personal protective measures are not taken. Statistics show that workers who work with wood have a 5-40 times higher

[1] mass fraction of total suspended wood dust particles that can be inhaled through the mouth and nose

[2] mass fraction of total suspended wood dust particles penetrating the pulmonary alveoli in the respiratory system

risk of developing nose and sinus cancer than the general population. The latent period for the cancer occurrence when working with oak and chestnut wood can range from 30-50 years.

3. MEASUREMENT METHODOLOGY

The measurement methodology is based on determining the dust concentration in working space around machine that creates and releases dust during operation. The height at which the sample of inhalable dust is taken corresponds to the worker's respiratory organs height.

Inhalable dust concentrations measurement was performed by gravimetric method. The CPM-3 is a stand-alone dust collector designed to measure workplace dust exposure during one work shift. The device is based on the selective separation of respirable dust from inhalable dust, by means of a ring effect in a rotating housing, which contains a filter made of polyurethane foam, the diameter of which corresponds to the diameter of the pulmonary alveoli.

Gravimetric processing of the collected dust sample based on the known flow of dust-air through the instrument determines the mass concentration of inhalable and respirable dust.

The aim of measuring the dust concentration in workplaces and plants in company that employs a large number of workers and manufactures furniture and semi-finished products: beech veneer and treated upholstery and varnishing is to identify risks to employee health and assess the effectiveness of central dust extraction system. Measurements were performed in a reference period of eight hours.

4. RESULTS AND DISCUSSION

The results of inhalable and respirable dust concentration measuring according to the work phases in the sawmill, furniture factory and carpentry workshop are shown in Table 1.

The ratio of inhalable and respirable dust in workplaces of primary and finishing wood processing is shown in the diagram, Figure 1. The share of respirable in inhalable dust is given in the diagram, Figure 2.

Table 1. Measurement results with limit values

MEASURING POINT / WORK PHASE	Dust concentration, (mg/m^3)			MDK (JUS Z.BO.001) Inhalable 10.0 mg/m^3; respirable 3,0 mg/ m^3	EU Directive 2004/37/EZ (and EU Directive 2022/431) Limit value (applies to all types of wood dust present in the mixture) 5,0 mg/m^3
	Inhalable	Respirable	Share of respirable in inhalable dust, %		
SAWMILL					
Band saw (1)	3,45	1,27	36,8		
Grinding and format saw (1)	3,86	1,37	35,5		
Press and plate construction (1)	2,36	0,87	36,9		
Peeling machine (1)	1,82	0,30	16,5		
Cutting station - cutting logs with a chainsaw (1)	3,86	1,23	31,9		
Grinding and format saw (2)	3,55	1,15	32,4		
Press and plate construction (2)	2,05	1,15	58,1		
Peeling machine (2)	1,32	0,45	34,1		
Cutting station - cutting logs with a chainsaw (2)	3,86	0,75	19,4		
Band saw (2)	1,63	0,41	25,1		
Rough cutter	2,70	0,62	23,0		
AC circular	1,47	0,58	39,4		
FURNITURE FACTORY					
Veneer factory - horizontal belt sander	13,28	7,53	56,7		
Table factory - table milling machine and column drill	7,60	4,80	63,1		
Table factory - grinder	19,33	16,00	82,8		
Table factory-edging machine	9,00	5,67	63,0		
Factory of elements - work on a circular saw	7,60	6,00	78,9		

Factory of elements - brush with grinder	10,22	7,35	71,9		
Factory chair - brush and belt sander	8,22	6,53	79,4		
CARPENTRY WORKSHOP					
Cutting	7,07	3,05	43,1		
Grinding	3,33	1,00	30,0		

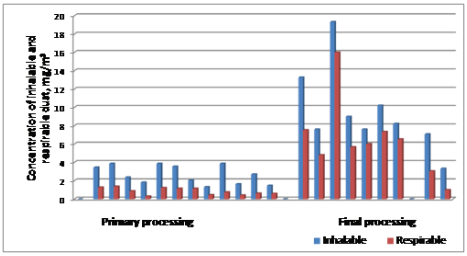

Figure 1: Inhalable dust concentrations

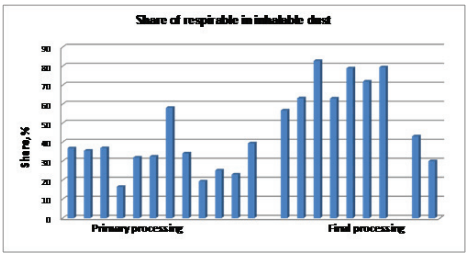

Figure 2: Share of respirable in inhalable dust

During the primary wood processing, which begins with peeling roundwood, and then cutting into different types of sawn timber (boards, slats, beams), dust emissions in relation to the normative values are not high. The total inhalable dust, most of which is retained in the upper respiratory system (nose, mouth, throat) in this part of the technological process, ranges from 1.32 to 3.86 mg/m^3, and respirable dust that penetrates deep into the lungs, from 0.30 to 1.37 mg/m^3. The share of respirable dust in total dust is about 32%. It can be concluded that the level of worker exposure to dust in primary wood processing plant is below the TLV and stricter limit values defined by the EU Directive. The reason for this lies in fact that delivered wood contains a natural amount of moisture, which has a positive effect on reduced dust emissions.

Since the smallest dust fractions have a large surface area from which a various organic aromatic compounds are released, some of them have proven carcinogenic properties, it is important to know that the technological phases that take place in primary wood processing plant do not pose an increased risk to employee health.

In plants where wood finishing is performed (furniture factory and carpentry workshop), where all work is performed exclusively on dry wood, with the mandatory use of other chemicals, concentrations of inhalable dust range from 3.33 to 19.33 mg/m^3, and respirable from 1.00 to 16.00 mg/m^3. At all measuring points (except in the carpentry workshop, during grinding) dust concentrations are significantly above the TLV, which represents a significantly increased risk to employee health.

The percentage of respirable dust in the total inhalable dust in the furniture factory is about 71%, and in the carpentry workshop 37%. The high proportion of the smallest fraction of dry wood dust, which has a high ability to stay in the air for a long time, in

inhalable dust is worrying primarily due to increased risk of respiratory diseases, due to the physical affect of wood particles, and additionally due to presence of a number of complex organic compounds that are released from the internal wood structure.

5. CONCLUSION

The testing results show that the exposure levels to inhalable dust at primary wood processing workplaces range from 1 to 5 mg/m^3, which poses a lower risk to employee health. During final wood processing, all technological operations are accompanied by significantly higher inhalable dust emissions. In the furniture factory, the exposure to inhalable dust at all workplaces is > 5 mg/m^3. In the carpentry workshop, the exposure to inhalable dust is > 5 mg/m^3 during the sanding phase. Of particular concern is the fact that 86% of work places in the furniture factory have an exposure to respirable dust > 5 mg/m^3, which significantly increases the risk of developing respiratory symptoms with long-term exposure. By using various chemicals whose application is necessary at this phase of wood processing, such as adhesives, paints, varnishes, solvents, etc., health risks associated with hardwood dust exposure are further increased. The results also show that the built-in central dust removal system does not have the expected effect and that the identified problems must be comprehensively considered and effective preventive and protective measures implemented.

Improvements in terms of design solutions for dust collector hoods would increase dedusting system efficiency and lead to a reduction in dust emissions into the working atmosphere. In order to protect workers working on woodworking machines, until improvements to the dedusting and ventilation system and closure (sealing) of the process are made, personal respiratory protection equipment should be allocated.

REFERENCES

[1] EU Directive 2004/37/EC-Carcinogens or mutagens at work, European Agency for Safety and Health at Work, 2004; Directive (EU) 2022/431 amending Directive 2004/37/EC
[2] IARC (1995): Wood dust and formaldehyde, IARC Monogr Eval Carcinog Risks Hum, 49: 1-648. PMID:2232124 IARC (1995): Wood dust and formaldehyde, IARC Monogr Eval Carcinog Risks Hum, 49: 1-648. PMID:2232124.
[3] ISO 7708:1995 Air quality: Particle size fraction definitions for health-related sampling International Standards Organisation.
[4] JUS Z.BO.001: Maximum permissible concentrations of harmful gases, vapors and aerosols in the atmosphere of workplaces and work sites, JUS Z.BO.001/VIII-1991.
[5] Kauppienen, T. et.al.: *Occupational Exposure to Inhalable Wood Dust in the Member States of the European Union, The Annals of Occupational Hygiene, Vol. (50) No.6, pp. 549-561, ISSN 2398-7316*
[6] Ordinance on the protection of workers from the risks related to exposure to carcinogens and / or mutagens *(NN br.91/2015)*
[7] Guidelines for good practice, Safe work in the sawmill, http://www.hzzz.hr uploads 11/2016.

OCCUPATIONAL KINESIOLOGY: LOW BACK PAIN IN ADMINISTRATIVE WORKERS

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Abstract:

Objective: The purpose of this study was to determine the prevalence of back pain and its relationship with the postural and movement habits in Croatian administrative workers. Methods: Back pain frequencies were assessed by using the online survey based on Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms. Postural and movement habits were assessed by using 10 self-designed photo questions. Results: The prevalence of back pain was 72.50 % and 69.40 % in females and males, respectively. The results showed that there is no statistically significant difference in prevalence of low back pain between men and women in the last 12 months (Chi-square 1.28, p<0.26, Phi 0.31). Odds ratio of logistic regression analysis were statistically significant between prevalence of low back pain and 9 of 10 posture and movement habits. Conclusions: The findings of this study showed that the occupational low back pain in administrative workers is significantly influenced by incorrect postural and movement habits, especially by static and dynamic spina flexion.

Keywords: *low back pain, prevalence, administrative workers, postural and movement habits, spina flexion.*

1. INTRODUCTION

Administrative workers endure statynamic efforts in their workplaces. These refer to static efforts caused by prolonged sitting and dynamic efforts caused by repetitive movements. One of the consequences of prolonged sitting can be the appearance of musculoskeletal disorders and pain in the low back. In his book, Pain in the low back and Sciatica [1], Dr. Popovič states that the most common causes of spinal pain are degenerative changes of *i.v.* discs and their consequences such as

osteochondrosis, disc herniation, sponiloarthrosis, spondylolysis, spondylolisthesis, stenosis, etc. Very often the causes of disc degeneration are a combination of inadequate quantity and quality of movement and work. The amount of movement and work has a direct impact on disc nutrition. Disc and cartilage belong to poorly perfused tissues, so as such they are prone to rapid aging and wear, and in adults there is no substance change in the *i.v.* discs through blood vessels but exclusively by diffusion [1]. The change of substance by diffusion is directly dependent on movement. For example, when sitting, the pressure on the disc is higher than when standing, which indicates the need to get up and walk more often during sedentary work. Dr. Stuart McGill in his book Low Back Disorder [2] states that some occupations require a reduction in the amount of work and some an increase in the amount of work in order to influence the prevention of low back injuries. This points to the importance of increasing the amount of movement and work in workplaces dominated by static loads and prolonged sitting, such as the workplace of administrative workers.

The study of biomechanical loads of the spine led to knowledge about the functioning of a healthy spine, as well as knowledge about the possible mechanisms of pathological changes on the spine and intervertebral discs [3]. Disc health and spinal stabilization function were found to be causally related. Degenerative processes of the intervertebral disc lead to increased mobility, and thus instability of the spine, which further results in various deformations that can cause acute or chronic pain due to compression of nerve structures [4]. Spinal instability begins with an imbalance in ligament tension, where some ligaments are overstretched and others loose. Sitting with pronounced flexion in the lumbar spine, can lead to stretching of lig. longitudinal posteriora, lig. flava, lig. interspinale and lig. supraspinale, and loosening of lig. longitudinal anterior. As the flexion angle of the lumbar spine increases, the passive structures of the lumbar spine stretch [5]. The results of the study [6] showed an increase in compression forces in the lower back (L5/S1) by 387 N during flexion of the lower back between 25° and 45°, and by 616 N when between 25° and 70°. Based on the above, it can be noted that it is wrong to observe the statodynamic efforts of administrative workers only quantitatively, but that they need to be observed qualitatively as well. This primarily refers to the correct ways of sitting down, sitting, getting up, reaching, turning, bending, body positions while using the keyboard, mouse, etc. since these are physiological positions and functional movements in which each skeletal and musculoskeletal system is located in the so-called neutral zone. Proper patterns of movement and work can significantly contribute to the effective prevention of pain and musculoskeletal disorders in the low back in administrative workers.

Numerous previous studies have found the presence of musculoskeletal disorder symptoms in the low back of administrative workers: 47 % [7], 52,7 % [8], 43 % [9], 36,6 % [10], 40,4 % [11], 81 % [12], 46,0%, 44,2% i 33,6% [13], 72,4 % [14], 75 % [15] etc.

Both men and women do administrative work. In the morphological space, a number of characteristics stand out that distinguish women from men. Compared to men, women have a torso longer than the extremities, significantly wider pelvis, greater angle between forearm and upper arm, higher Q-angle, lower percentage of

muscle mass, higher percentage of adipose tissue, in men 40% of body weight falls on muscles, and in women only 33% [9], women are on average 13 cm lower and 14-18 kg lighter than men [16]. Additionally, women are more flexible than men [17]. All of the above, in itself, do not represent risk factors for the occurrence and progression of musculoskeletal disorders in the low back.

The combination of natural physiological processes of aging, inadequate change of substance and disc nutrition, as well as irregular postural-movement habits is the ideal combination for the occurrence of degenerative changes in the discs and the appearance of pain. Learning and automation of proper movement patterns and ways of sitting in the workplace, both for men and women, is one of the most important measures of early intervention aimed at primary and secondary prevention of musculoskeletal disorders in the low back of administrative workers.

The aim of this study is to determine whether there is a difference in the prevalence of musculoskeletal disorder symptoms in the low back in the last 12 months in men and women administrative workers employed in the Republic of Croatia and whether this difference is significant. The goal is to determine the connection between the presence of musculoskeletal disorder symptoms in the low back and postural-movement habits of administrative workers.

2. METHODS

2.1. Sample of subjects

The sample of respondents consists of administrative workers who are employed and work in Croatia. The link to the anonymous online survey questionnaire created via the digital Google platform was sent to the official e-mail addresses of respondents employed in public administration bodies, employees in the banking system and some other companies. The survey was conducted in November 2021.

2.2. Sample of variables

A standardized Nordic questionnaire was used to determine the prevalence of musculoskeletal disorder symptoms by self-assessment [18]. To determine postural-movement habits, respondents answered 10 self-designed questions with photographs. Based on the questions with photographs, the respondents chose the body posture, i.e. the technique of work that is most similar to their body posture while working at their workplace. The original questionnaire can be found at: https://forms.gle/dnezaeLfda19dy6b9. Additionally, by scanning the QR code number 1, the original questionnaire can be obtained.

QR code 1. Online questionnaire on the prevalence of musculoskeletal disorder symptoms and postural-movement habits of administrative workers.

2.3. Data analysis

The results were processed by the software package STATISTICA 14.0.0.15. Descriptive statistics methods were used to determine the prevalence of musculoskeletal disorder symptoms in the low back and postural movement habits in administrative workers. To determine the significance of differences between men and women in the prevalence of musculoskeletal disorder symptoms in the low back in the last 12 months, a hi-square test was applied. The relationship between the effects of regular and irregular postural-movement habits on the prevalence of musculoskeletal disorder symptoms in the low back was determined using a series of logistic regression analyzes.

3. RESULTS AND DISCUSSION

A total of 1,620 respondents responded to the questionnaire. After the exclusion of non-administrative work respondents and respondents who had acute lifelong trauma, 1,307 respondents entered data processing, out of which 68.17% (N 891) were women and 31.82% (N 416) were men. The average age of female respondents was 41.99 years, and of male respondents 41.88 years. The average body weight of female respondents was 68.11 kg (SD 13.34) and of male respondents 83.25 kg (SD 10.99). The average body height of female respondents was 168.36 cm (SD 6.14) and of male respondents 181.75 cm (SD 7.08).

Out of the total number of female respondents (N 891), 72.50% (N 646) of them had low back problems in the last 12 months, and 27.50% (N 245) had no low back problems in the last 12 months. Out of the total number of male respondents (N 416), 69.47% (N 289) of them had low back problems in the last 12 months, and 30.53% (N 127) had no low back problems in the last 12 months.

Chi-square test results showed that there was no statistically significant difference between men and women in the prevalence of musculoskeletal disorder symptoms in the low back in the last 12 months (Chi-square 1.28, p <0.26, Phi 0.31).

Table 1: Chi-square test of the difference between men and women in the prevalence

of musculoskeletal disorder symptoms in the low back area in the last 12 months.

Chi-square 1.28, p<0.26, Phi 0.31 (Low back)			
	Women	Men	Σ N
Yes	N 646	N 289	N 935
	72,50%	69,47%	
No	N 245	N 127	N 372
	27,50%	30,53%	
Σ	891	N 416	1307

Since the results of the chi-square test showed that there is no statistically significant difference between men and women in the prevalence of musculoskeletal disorder symptoms in the low back in the last 12 months logistic regression analysis was calculated for men and women together.

OR logistic regression analyses suggest that the correlation of musculoskeletal disorder symptoms in the low back is statistically significant with:

- Emphasized spinal flexion while sitting – OR 1,64**, 95% confidence interval [CI] 1,27-2,11
- Unevenly distributed body weight while sitting – OR 1,90***, 95% CI, 1,47-2,45
- Tilting of the torso with spine flexion while sitting – OR 1,71***, 95% CI, 1,33-2,21
- Improper rotation of the body while sitting (axial rotation of the lumbar spine) – OR 1,44*, 95% CI, 1,13-1,84
- Flexion and axial rotation of the lumbar spine in lateral retrieval – OR 1,36*, 95% CI, 1,00-1,84
- Arms crossed over chest – OR 1,61**, 95% CI, 1,26-2,06
- Cervical and capital flexion while standing and using a mobile phone – OR 1,81**, 95% CI, 1,27-2,59
- Spine flexion when leaning the torso forward from a standing position – OR 1,44*, 95% CI, 1,11-1,86
- Improper handling of loads with spinal flexion – OR 1,31*, 95% CI, 1,01-1,69.

The correlation of musculoskeletal disorder symptoms in the low back is not statistically significant only with pronounced lateral flexion of the neck and head during improper telephoning since OR is 1.11 and 95% CI is 0.85-1.45.

Based on the above, it can be observed that the human body functions as a kinetic chain. The position of one part of the body inevitably affects the position of another part of the body. Due to non-usage of hips in their primary functions, which are flexion and extension of the torso in relation to the legs (and vice versa), compensatory movements occur, such as flexion of the lumbar, thoracic and cervical spine. The results of this study showed that automated irregular movement patterns in the form of daily application of spinal flexion when performing various movement structures in administrative workers result in a statistically significantly

higher probability of musculoskeletal symptoms compared to those employees who avoid irregular movement patterns. It can be concluded that static trunk bending is an occupational statistically significant risk factor for low back pain.

According to National Institute of Neurological Disorders and Stroke [19] about 80% of adults have experienced low back pain at some point in their lives. The results of this study are consistent with the abovementioned study since 82.63% of respondents who participated in this study answered that they had low back problems during their lifetime. According to an EU-OSHA report from 2020 [20], in the Netherlands, 5% of all sick leaves were due to back issues. The results of this study showed that 22% (N 288) of respondents had been examined by a doctor in the previous 12 months due to low back problems. Additionally, 50.26% (N 657) of the respondents had experienced sharp pain in the low back at some point in their lives when trying to lift or lower a load. 77.51% of respondents said that so far, they have not participated in educations on proper and safe ways to work and sit at the computer. All this indicates that administrative workers in Croatia are largely untrained to work safely, that they apply irregular movement patterns on a daily basis, that these irregular movement patterns significantly increase the risk of musculoskeletal disorder symptoms in the low back, and as stated, this results in a significant cost to the health system of the Republic of Croatia.

4. CONCLUSION

The results of the research showed that more than two thirds of respondents which are administrative workers in the Republic of Croatia have low back problems, both men and women. Irregular movement patterns were found to significantly increase the probability ratio, i.e. the risk of the prevalence of musculoskeletal disorder symptoms in the low back. Static lateral flexion, anteflexion, axial rotation of the lumbar spine and a combination of anteflexion and axial rotation have proven to be the main mechanisms of cumulative lower back trauma of administrative workers. By avoiding the mechanisms of cumulative trauma and automating proper movements, the worker would reduce the risk of lower back problems, ensure stable monthly income by avoiding sick leave, the employer would have a higher probability of workers staying healthy, of them maintaining or increasing productivity, not having to educate new workers due to sick leave of already employed workers, and the state would feel significant savings in the health care system due to fewer sick leaves, as well as due to health care savings.

The results of this research clearly indicate the importance of educating and training of administrative workers to work safely. Systematic organization of education in the field of occupational kinesiology is one of the most important measures of early intervention aimed at preventing musculoskeletal disorders in the low back of administrative workers.

REFERENCES

[1] Popovič, J.: *Bol u križima i ishijas*. Založba Mladinska knjiga, (1989).

[2] McGill, S.: Low Back Disorders (2nd ed. (Ed.)). Human Kinetics, (2002).

[3] Jeleč, V.: *Biodinamičke značajke križnoslabinskog dijela kralježnice čovjeka, kopnenih i morskih sisavaca kao osnova za nastanak patoloških promjena*. Doktorska disertacija, Veterinarski fakultet, Sveučilište u Zgrebu, (2013).

[4] Quint, U.; Wilke, H.J.; Löer, F. & Claes LE. Funktionelle Folgen operativer Dekompressionen am lumbalen Bewegungssegment--eine biomechanische Studie in vitro [Functional sequelae of surgical decompression of the lumbar spine--a biomechanical study in vitro]. *Z Orthop Ihre Grenzgeb*. Jul-Aug;136(4):350-7. German, (1998).

[5] Alessa, F. & Ning, X.: Changes of lumbar posture and tissue loading during static trunk bending. *Human Movement Science*, 57, 59–68, (2018).

[6] Das, B., & Sengupta, A. K.: Evaluation of low back pain risks in a beef skinning operation. *International Journal of Occupational Safety and Ergonomics*, 6(3), 347–361, (2000).

[7] Juul-Kristensen, B. & Jensen, C.: Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: The "BIT" follow up study on administrative workers. *Occupational and Environmental Medicine,* 62(3), 188–194, (2005).

[8] Žitnik, Z. (2006). *Anketno istraživanje zastupljenosti nekih muskulo-skeletalnih poremećaja kod korisnika računala* (diplomski rad). Filozofski fakultet, Odsjek za psihologiju, Zagreb, (2006).

[9] Shikdar, A. A. & Al-Kindi, M. A.: Administrative Ergonomics: Deficiencies in Computer Workstation Design. *International Journal of Occupational Safety and Ergonomics*, 13(2), 215–223, (2007).

[10] Giahi, O.; Khoubi, J.; Barkhordari, A.; Darvishi, E. & Ebrahemzadih, M.: Daily visual display terminal use and musculoskeletal disorders among Iranian bank tellers. Journal of Advances in Environmental *Health Research*, 2(1), 1–6, (2014).

[11] Kumar, R.; Pal, L. & Moom, N.: Prevalence of Musculoskeletal Disorder among Computer Bank Administrative Employees in Punjab: A Case Study. *6th International Conference on Applied Human Factors and Ergonomics*, 6624–6631, India, (2015).

[12] Quemelo, P. R. V.; Gasparato, F. D. S. & Vieira, E. R.: Prevalence, risks and severity of musculoskeletal disorder symptoms among administrative employees of a Brazilian company. *Work*, 52(3), 533–540, (2015).

[13] Campos-Fumero, A.; Delclos, G. L.; Douphrate, D. I.; Felknor, S. A.; Vargas-Prada, S.; Serra, C.; Coggon, D. & de Porras, D. G. R.: Low back pain among administrative workers in three Spanish-speaking countries: Findings from the CUPID study. *Injury Prevention*, 23(3), 158–164, (2017).

[14] Mohammadipour, F.; Pourranjbar, M.; Naderi, S. & Rafie, F.: Work-related Musculoskeletal Disorders in Iranian Administrative Workers: Prevalence and Risk Factors. *Journal of Medicine and Life*, 11(4), 328–333, (2018).

[15] Bontrup, C.; Taylor, W. R.; Fliesser, M.; Visscher, R.; Green, T.; Wippert, P. & Zemp, R.: Low back pain and its relationship with sitting behaviour among sedentary administrative workers. *Applied Ergonomics,* 81(June), 1–8, (2019).

[16] Šimek, S.; Čustonja, Z. & Nakić, J. Programiranje treninga s opterećenjem kod žena. *U Zbornik radova 11. ljetnoj školi kineziologa Republike Hrvatske*. 93 – 95, Rovinj, (2002).

[17] Alter, M.: *The Science of Flexibility*. Champaign IL: Human Kinetics, 2004.

[18] Kuorinka, I., Jonsson, B., Kilbom, A. & Vinterberg, H.: Standardised Nordic

questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics*, 18(3), 233–237, (1987).

[19] National Institute of Neurological Disorders and Stroke, National Institutes of Health Department of Health and Human Services: *Low back pain*. Bethesda, Maryland (2014).

[20] Isusi, I.: *Work-related musculoskeletal disorders – Facts and figures* (Syntesis od 10 national reports). In European Agency for Safety and Health at Work, (2020).

The data used in this research was obtained during the implementation of Educational and preventive activities aimed at preventing musculoskeletal disorder within the project of the Ministry of Labor, Pension System, Family and Social Policy - Directorate for Labor and Safety at Work entitled "Development of e-system learning, management and monitoring of safety at work". The project was co-financed by the European Union from the European Social Fund.

WHOLE-BODY VIBRATION ASSESSMENT IN FORKLIFT TRUCKS – CASE STUDIES

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Abstract: *This paper presents a case study of whole body vibration analysis in forklift drivers working in the same company. The analysis included three forklifts with exactly the same technical characteristics, work in the same space, and the difference is only in the year of production. Vibrations were measured in three orthogonal axes, (x, y and z), and then the calculated value of the weighted mean square acceleration was calculated - according to the ISO 2631-1: 1997 standard. The obtained results indicated that the age of the vehicle does not directly indicate the value of vibration exposure. In addition, ways to reduce the harmful effects of vibrations on the human body have been pointed out.*

Keywords: *whole body vibration, vibration disease, forklift, DORT*

1. INTRODUCTION

Vibrations represent the oscillatory movement of a body or particles around an equilibrium position and cover the area of infrasonic and partially sound frequencies. In addition to oscillations, vibrations can also be caused by high-intensity noise. The frequency interval that includes vibrations is very wide - from a few parts of Hz, up to 20,000 and more Hz [1-3].

Vibrations are manifested in the form of an earthquake in the construction of machines, buildings and their parts, or an earthquake of a solid body caused by a variable force. In the industry, vibration occurs as a result of incomplete centering of the device during installation or operation of an unbalanced machine, rhythmic movement, as well as the impact of pneumatic tools (pneumatic gun and hammer) [1-3].

Important characteristics of vibrations, on the basis of which diagnostics are performed, are: oscillation frequency, displacement amplitude, speed and acceleration. Measurement and analysis of these vibrations is an important method in the process of maintaining machines and devices. The described vibrations are called machine vibrations.

The resulting vibrations are also transmitted to the body of a person, who stands on a vibrating structure, holding a vibrating tool or an object that is processed with

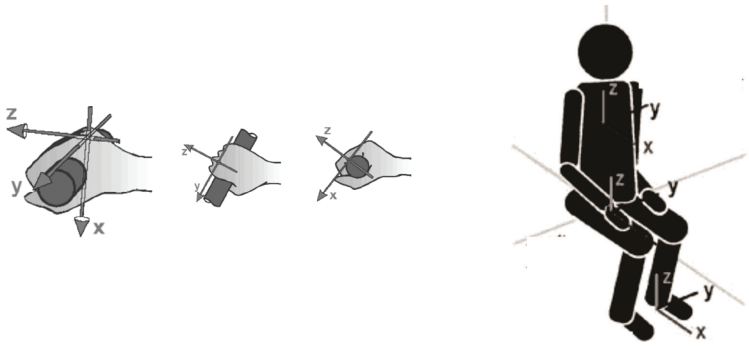
that tool [2]. As a result, the human body absorbs vibrations that can cause diseases known as vibration diseases. The measurement and analysis of vibrations to which the body, or parts of the human body, are exposed under these conditions, are called human vibrations. The human body perceives and absorbs vibrations in the frequency range of 1-1000 Hz [4] and therefore the biological effects of this area of vibrations are of great interest to modern medicine. Measurement, analysis and standardization of these vibrations is performed in the field of human vibrations.

1.1. Vibration diseases

Human vibrations are all harmonic oscillations and movements that are caused by the vibrating parts of machines, and which are in contact with the human body and lead to its movement. As each part of the human body vibrates with its own frequencies, external vibrations act as a forced force that can lead to the effect of resonance and a significant increase in the amplitude of its own oscillation frequency.

Depending on the area affected by the vibrations, they can be local and general [4,5].

- Local vibrations - are vibrations that act on certain parts of the human body when a person holds vibrating tools (eg hand vibrations). The direction of action of these vibrations is determined by a rectangular coordinate system consisting of three axes (X_h, Y_h, and Z_h) that intersect in the region of the third metacarpal bone of the hand. (Fig. 1.a).
- General vibrations - are vibrations that occur when a person is on a vibrating surface (eg tractor drivers, forklifts, …) and acts on the whole body. The direction of action of these vibrations is determined according to the three anatomical axes of man (X, Y and Z) that intersect in the region of the heart (Fig. 1.b).



a) b)

Fig. 1: Vibration range:
a) Local vibrations (hand vibrations) i b) General vibrations (whole body) [3]

The vibrations that are transmitted are mainly low frequency oscillations, usually in the range of 1-80 Hz, and most often from 1-20 Hz. In accordance with this, "driving disease" is also treated as a vibration disease of the whole body because they are in the frequency range from 0.1 to 0.63 Hz. All whose activities (work or life) are related to transport systems are exposed to these vibrations: all types of vehicles, platforms at sea, etc. [6].

Diseases caused by exposure of the body or parts of the body to vibrations are called vibration diseases. There is no single classification of vibration disease in the world. One of the divisions is into direct and indirect vibration diseases [4,5].

Direct vibration diseases occur at the site of vibration and manifest as traumatic phenomena.

Indirect vibration diseases occur as a result of the effect of vibrations on nerves and nerve endings, as well as muscles and tendons. Their action is transmitted by a complex mechanism to different parts of the nervous system, which also causes various disorders in:

- Blood vessels and heart
- Nervous system
- Bones, joints and muscles
- Senses of hearing, sight and balance
- Leather
- Stomach
- Endocrine system
- Metabolism, etc. [3,4].

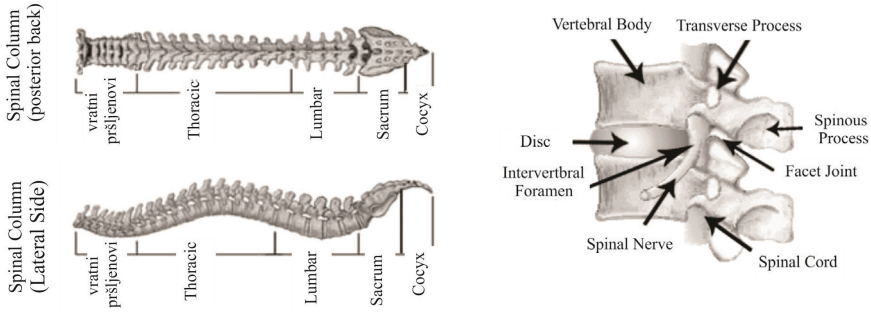
1.2. Whole body diseases caused by vibrations

In recent years, two diseases of employees have attracted the attention of the public because, according to official statistics, a significant increase has been noticed. These are: injury due to repetitive stress (LER-Lesão por esforço repetitivo) and disorder of the musculoskeletal system (DORT-disturbios osteomusculares relacionados ao trabalho) [7,8].

DORT is manifested by pain in the lower back and is the cause of a large number of short, but also long absences from work. It is estimated that this disorder affects 80% of employees. Some studies have shown an association between whole-body vibration exposure and DORT, as well as an association between poor posture and DORT [7,8]. Pointing out this dependence is very important when training employees for safe and healthy work when exposed to vibrations.

If this disease is not treated at the beginning, it can develop into a lumbar hernia in which the outer, fibrous ring (anulus fibrosus) of the intervertebral disc (discus intervertebralis) ruptures and allows the soft, central part (nucleus pulposus) to bulge. When there is a movement in such a system due to vibrations, there is a contraction in the muscles of the back (in an attempt to keep the body in its previous state), which causes a conflict between the nerve and the disc because they are in the same place. Thus, there may be a curvature in the disc which then presses on the

medulla thus causing pain. As time goes on, vertebral degeneration, worsening of the problem and more severe pain can occur. Figure 2 (a) and (b) show in detail the parts of the human spine that are responsible for pain [8].



a) b)

Fig. 2: The parts of the spine that are responsible for pain
a) spine i b) vertebral details [8]

2. VIBRATION MEASUREMENT ON FORKLIFT TRUCKS

Vibration measurement was performed on three forklifts of the same manufacturer and characteristics, but different years of production. All three forklifts perform the same work on the same coating during the day, so there is no need to analyze the speed and the surface on which they move. The characteristics of the observed forklifts are given in Table 1.

Table 1: Forklift characteristics

Forklift	The year of production	Load capacity (kg)	Power (kW)	Speed of rotation (o/min)
Forklift 1	2004	800	30	2200
Forklift 2	2004			
Forklift 3	2011			

Vibration measurement was performed by placing sensors on the vehicle seat, according to the standard for whole body vibrations ISO 2631-1: 1997 and the standard for sensors ISO 10326-1. During the measurement, employees performed normal work activities. The surface on which the vehicles were moving is completely the same for each vehicle, because it is a part of the company where forklifts are used for transport.

By measuring, the mean values of vibrations are obtained, along the x, y and z axes ($a_{rms,x}$, $a_{rms,y}$ i $a_{rms,z}$) expressed in units of acceleration - m/s^2. The value of

the vibration level to which the employee is exposed is calculated according to the equation:

$$a_{rms} = \sqrt{k_x a_{rms,x}^2 + k_y a_{rms,y}^2 + k_z a_{rms,z}^2} \quad \textbf{(1)}$$

Where is k_x, k_y and k_z weight factors that have the following values:

$$k_x = k_y = 1{,}4 \text{ i } k_z = 1 \quad \textbf{(2)}$$

By including the value from equation (2) in equation (1), the equation for calculating the vibration level is obtained:

$$a_{rms} = \sqrt{1{,}4 \cdot a_{rms,x}^2 + 1{,}4 \cdot a_{rms,y}^2 + a_{rms,z}^2} \quad \textbf{(3)}$$

The results of measuring the acceleration along the axis and the vibration value calculated according to equation (3) are shown in Table 2.

Table 2: Acceleration values and eight - hour daily exposure of tested forklifts

Forklift	$a_{rms,x}$ (m/s²)	$a_{rms,y}$ (m/s²)	$a_{rms,z}$ (m/s²)	a_{rms} (m/s²)	$A(8)$ (m/s²)
Forklift 1	0,3838	0,2390	0,3516	0,6402	0,620
Forklift 2	0,3171	0,2906	0,4446	0,6758	0,654
Forklift 3	0,3454	0,3911	0,5987	0,8600	0,833

The analysis of the values given in Table 2 shows that the values of acceleration along the x axis ($a_{rms,x}$) are approximately equal, while the values along the y and z axes differ and increase from forklift 1. As a result, there is an increase in the vibrations to which employees are exposed. It is interesting to note that the vibrations in the forklift 3 are the highest even if it is the newest vehicle. The cause of this can be very different, and since the visual inspection of the vehicle and tires did not give an answer, it is assumed that the main culprit is the operator of this vehicle and its behavior during operation.

If the action and limit value of whole body vibration exposure according to the Rulebook on preventive measures for safe and healthy work during vibration exposure ("Official Gazette of RS", No. 93/2011, 86/2019), which is in force in the Republic of Serbia, which are 0.5 m/s², or 1.15 m/s² respectively, it is noticed that the action value is exceeded but that all values are significantly below the limit value.

Since the action value of vibrations has been exceeded, the employer is obliged to implement protection measures. One of the protection measures is the implementation of organizational measures, or shifts of employees in order to reduce the exposure time and thus the eight-hour daily exposure. Therefore, the time for which individual forklifts reach the eight-hour action value was calculated, Table 3.

Table 3: Time for which the vibration action value is reached

Forklift	*t* (h)
Forklift 1	5,2
Forklift 2	4,67
Forklift 3	2,88

The obtained times indicate that during work on forklift 1, the driver will be exposed to the harmful effects of vibration after 5.2 h, while this will happen on forklift 3 after 2.88 h. A very similar result has been obtained by a large number of researchers [8-10], and solutions have been found that can reduce and / or mitigate the harmful effects of vibration. A large number of them are already well known, such as: smooth surface for movement, lower speed of movement, vehicle load, choice of seats, etc. However, a very interesting finding led to a connection between posture (good or bad) and DORT. Namely, in the case of employees who had proper posture during work, after the working day the DORT was smaller or completely absent.

3. CONCLUSION

A processed case study, exposure of whole body vibrations to which forklift drivers are exposed, confirmed that they are a category of drivers that are endangered by vibrations and in which the occurrence of DORT can be expected with a high probability. Therefore, it is a great challenge to reduce the consequences for employees to a minimum. This can be achieved in several ways.

Drivers should be informed of the health consequences of vibration exposure but also of the various methods used to mitigate them. During the training, attention should be paid to avoiding high speeds, impacts and other obstacles while driving, to take care of the condition of the tires, etc. It is especially important to point out the maintenance of the seats, because they can have a shorter service life compared to the vehicle. Poor posture is just one of the causes of lower back pain, so drivers should be trained to keep their body straight while sitting to minimize the risks of vibration transmission.

REFERENCES

[1] Ž. Adamović, Tehnička dijagnostika, Zavod za udžbenike i nastavna sredstva, Beograd, Beograd, 1998.
[2] D.J.Veličković, Fizičke štetnosti – buka i vibracije, Institut za dokumentaciju zaštite na radu, Niš, Niš, 1978.

[3] V.B. Petrović, Vibracije ruke-šake – procena izloženosti, konferencija Rizik I bezbednosni inženjering, Kopaonik, p.320-328, 2012.
[4] L.Burström, G.Neely, R.Lundrstöm, T.Nilsson, *Occupational exposure to vibration from hand - held tools -A teaching guide on health effects,risk assessment and prevention*, Protecting Workers' Health Series No.10,Umea Universitet.
[5] M. Aranđelović, J.Jovanović, *Medicina rada*, Medicinski fakultet, Univerzitet u Nišu, Niš, 2009.
[6] Vendrame, A. C., 2008, "Exposição ocupacional à vibrações" (in Portuguese), <http://www.vendrame.com.br/downloads/>, Accessed 2008.
[7] Ferreira Jr., M., *Saúde no trabalho: temas básicos para o profissional que cuida da saúde dos trabalhadore* (in Portuguese), 2000, São Paulo, Roca Ed., 357p.
[8] Zucco, C., Gomez, H.M., *Measurement and evaluation of vibration levels on forklift truck drivers*, 20th International Congress of Mechanical Engineering 2009 by ABCM November 15-20, 2009, Gramado, RS, Brazil.
[9] Salmonia, A.W., Cann, A.P, Gillin, E.K., Eger, T.R., *Case studies in whole-body vibration assessment in the transportation industry–Challenges in the field*, International Journal of Industrial Ergonomics 38 (2008) 783–791.
[10] Malchaire, J.,Piette, A., Mullier, I., *Vibration exposure on fork-lift trucks*, Ann. occup. Hyg., Vol. 40. No. 1, pp. 79-91, 1996

SMARTWATCH AS AN INSTRUMENT IN MONITORING BODY FUNCTIONS OF THE EMPLOYEES

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Abstract

Preserving the health of employees has a very important role in organizing occupational safety of human at workplace. Modern technologies today greatly enable employers to monitor employee's health. The idea of this paper is to present a smartwatch as a possible instrument for employers in monitoring the bodily functions of their employees. The smartwatch records data and sends it directly to the mobile application of a trained person who monitors the activities and health status of employees. The paper shows how digital modern technologies can help professional services as well as employers in monitoring employee health.

Keywords: *smartwatch, health, employees, smartphone, technology*

1. INTRODUCTION

Employees health protection has imposed itself as an imperative in the technological world. Usually, employees are exposed to a fast lifestyle which brings along various diseases such as stress, diabetes, arrhythmia, burn out and high blood pressure. Therefore, it was important to find a modern and simple solution for monitoring the bodily functions of employees. This can be achieved through smartwatch, which is ubiquitous in the modern world, and people use it to track physical activity, count steps, calories etc. Smartwatches as an instrument in monitoring the bodily functions of employees enable the general maintenance of the work of employees thus store data on monitoring the work of the heart and stress.

Today, activity trackers as smartwatches are one of the most popular wearable trackers which do have a numerous of benefits in tracking a lot of human health activities. This is because physical activity is beneficial both at home and the workplace as it enhances musculoskeletal strength, speed, stamina, accuracy, balance, sleep quality, and cardiovascular and respiratory endurance [1].

Organizations intending to implement wearable technology should focus its use on improving workplace safety, advance a positive safety climate, ensure sufficient

evidence to support employees' beliefs that the wearable will meet its objective, as well as involve and inform employees in the process of selecting and implementing wearable technology [2]. There are many advantages that smartwatches bring at workplace, especially in term of health monitoring.

2. THE USE OF SMARTWATCH AT WORKPLACE

Smartwatches are wearable devices which are equipped with a screen and sensors (e.g., accelerometers, IR sensors). A wireless connection to the internet on its own or through a smartphone allows to run proprietary as well as third-party apps [3]. The work-related risk factors for poor mental acuity are occupational stress, work shifts, irregular working hours, bright lights, odors, and noise. These risk factors can also stem from job insecurity, competition, low psychosocial support, low decision-making latitude, demanding job profile, and work-life imbalance [4].

Smartwatches continuously monitor physiological parameters and daily activities, thereby encouraging individuals to live a healthier lifestyle, which will ultimately result in reduced health care expenses. Thus, long-term smartwatch usage for personal fitness and health monitoring is highly desirable on the individual level for end-users as well as on the macro-level for government and health insurance funds [5].

The employers, particularly the corporate leadership and management staff, are ultimately responsible for implementing and adopting the risk-mitigating interventions to ensure a safe and healthy work climate. There are a number of challenges that arise from integrating wearables in the workplace. These challenges concern specific operational aspects related to the data that wearables collect, as well as more general aspects of the working environment related to both the immediate effects of wearables on employees and more long-term ramifications for organizations [6].

There are a lot of different smartwatches which are great to monitor human health. Table. 1. shows the most popular smartwatches used.

Table 1: Physical activity applications [1]

Company	Classification	Physical activity applications
Apple	Apple Watch Series 6	Tracking activity, running fitness performance, heart rate, sleep, stress, breathing, water intake, falls, and altitude acclimation
FitBit	Versa 2, Charge 4	
Fossil	Gen 4, Gen 5, Hybrid HR	
Garmin	Vivoactive, Vivofit, Vivosport	
Microsoft	Microsoft Band 2	
Mobvoi	TicWatch Pro, Sport, Express	
Philips	ActiWatch Spectrum	
Polar	Unite, Grit X, A370, M430	
SamsungGalaxy	Watch, Active2	

Hajj-Boutros, G. et.al. discovered that the Apple Watch 6 displays the highest level of accuracy for heart rate measurement with a coefficient of variation, whereas the Polar Vantage V and the Fitbit Sense presented various degrees of accuracy dependent on the activity. As for energy expenditure, all named devices displayed poor accuracy for physical activities [7].

3. CONCLUSION

Protecting and improving the safety, health, and productivity of workers is paramount for companies as they face post-pandemic challenges of acute shortage of skilled labor, strains on supply chain management, global inflation, and rising medical costs. In this regard, intelligent systems (deployable sensors and analytics) play a critical role to facilitate total worker health through continuous monitoring, management, and prediction of workplace risks and organizational assets [8].

Employees are increasingly wearing smart watches for their work duties. While these devices can support employees in their tasks, they can also collect sensitive information like health or location data about them, thus endangering their privacy [9].

Smart watches are one of the leading technological advances that certainly allow employers to monitor the health of employees at all times. In addition to the benefits, many authors cite a breach of privacy by the employer toward the employee about whom they store data. Smart watches are certainly important in enforcing quality safety at work and ensuring employee health protection.

REFERENCES

[1] Patel, V. et.al.: Trends in Workplace Wearable Technologies and Connected-Worker Solutions for Next-Generation Occupational Safety, Health, and Productivity, *Advanced Intelligent Systems,* Vol. 2022 No. 4, pp. 1-30
[2] Jacobs, J. et.al. Employee acceptance of wearable technology in the workplace
[3] Nascimento, B., Oliveira, T., & Tam, C. Wearable technology: what explains continuance intention in smartwatches? *Journal of Retailing and Consumer Services,* Vol. 43, 2018, pp. 157–169.
[4] Patel, V. et.al.: Trends in Workplace Wearable Technologies and Connected-Worker Solutions for Next-Generation Occupational Safety, Health, and Productivity, *Advanced Intelligent Systems*, Vol. 2022 No. 4, pp. 1-30
[5] Siepmann, C.; Kowalczuk, P. Understanding continued smartwatch usage: the role of emotional as well as health and fitness factors, *Electronic Markets,* Vol. 31, 2021, pp.795–809
[6] Maltseva, K. Wearables in the workplace: The brave new world of employee engagement, *Business Horizons*, Vol 63. 2020, pp. 493-505
[7] Hajj-Boutros, G. et.al. Wrist-worn devices for the measurement of heart rate and energy expenditure: A validation study for the Apple Watch 6, Polar Vantage V and Fitbit Sense, *European Journal of Sport Scienc*e, 2021, pp. 1-13
[8] Patel, V. et.al.: Trends in Workplace Wearable Technologies and Connected-Worker Solutions for Next-Generation Occupational Safety, Health, and Productivity, *Advanced Intelligent Systems*, Vol. 2022 No. 4, pp. 1-30
[9] Richter, A.; Kühtreiber, P.; Reinhardt, D. Enhanced Privacy in Smart Workplaces: Employees' Preferences for Transparency Indicators and Control Interactions in the Case of Data Collection with Smart Watches, *IFIP International Conference on ICT Systems Security and Privacy Protection*, 2021, pp. 34-50

TRAINING WORKERS TO WORK SAFELY
(e-learning)

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Abstract: In an era when computers have entered the lives of almost every one of us, it would be a shame not to use them to quickly and easily acquire the necessary knowledge, without wasting time. E-learning is a systematic acquisition of knowledge through the use of computers and the Internet according to prepared programs, customized to users' needs.

Keywords: training in the field of occupational health and safety, e-learning, e-course, the minutes

1. INTRODUCTION

Hrvatska elektroprivreda, the national power utility, has recognized the advantages of training and learning through e-learning and thus independently developed training programs in the field of occupational health and safety, in line with the prescribed legal obligations. Learning is conducted in such a manner that the expert in occupational health and safety or the e-course teacher sends an e-mail invitation to the employee for joining the e-course, containing the instructions how to use the program, the link to the training program and a knowledge test. Upon entering the e-course, the employee is obliged to pass the training within a previously defined deadline, and after successfully passing the e-course, the minutes are automatically created and sent to the teacher's e-mail.

2. SAFETY AT WORK AND FIRE PROTECTION UNIT

- unification and coordination of work safety and fire protection tasks;
- supervision of work performance, and the application of work safety and fire protection measures and rules;
- supervision of the implementation of internal acts, instructions and rules, professional assistance in organization and implementation, and the

development of plans and programs of work safety and fire protection improvement measures;
- preparation, determination and supervision of the strategy for educating workers and authorized personnel in occupational safety and fire protection;
- participation in the work of professional working groups and occupational safety committees in HEP Group companies [1]

2.1. Organization of HEP Academy

START CENTER - The Start Center faithfully preserves all important internal knowledge and organizes HEP Group-related education to provide employees with the opportunity to learn about business processes in a structured way and thus understand the functioning of the system more easily.
Education:

- Green business
- Protection of workers' dignity
- Production of energy in HEP's generation facilities
- Introduction to HEP
- Basic work safety program
- Information security
- Stress management
- GDPR
- Non-discrimination workshops
- Eathquake

LEADER CENTER - Lider is a center that organizes programs aimed at developing leadership skills and competencies and is primarily intended for leadership and managerial positions. Depending on the level of knowledge and experience, leaders will attend a program that will combine a number of important leadership topics within one cycle.
Education:

- Leadership skills
- Delegating
- Conducting meetings (in English)
- Strategic thinking and change management
- Defining company goals and key performance indicators

BIZ CENTER - Biz is a center that focuses on the development of business skills and competencies and is intended for all HEP Group employees. Depending on the needs, workers will attend training in soft and hard skills. E-learning will make education available to all workers.
Education:

- Business correspondence

- Microsoft Excel – basic and two advanced
- Communication skills and business etiquette
- Project management
- Conflict management
- Feedback

EXPERT CENTER - Expert is the HEP Academy center focused on the development of specialist technical knowledge, and intended for workers in all key segments of HEP Group's activities. This Center of Excellence and Innovation in the field of energy will organize expert meetings for gathering leading experts thus following global trends.
Education:

- Public procurement (Modules I and II)
- The state of electricity market
- Integrated quality management system (three ISO standards)
- Efficient customer communication
- Selection interview
- ESCO monitor
- NPP Krško
- Training program for the employer's authorized representative and the workers' representative for the implementation of safety measures at work

HEP BALANS (HEP BALANCE) - HEP BALANS is an initiative of the Human Resources Department of HEP d.d. for improving the quality of life of HEP workers by promoting health and a healthy lifestyle, with the aim of introducing workers to different information through various channels, which would lead to the adoption of new (healthier) habits and behaviour and increase the quality of their lives. Consequently, this results in greater employee engagement, greater productivity, less absenteeism and greater overall satisfaction with private and business life.
Education:

- Workplace exercises
- Personal financial management [3]

2.2. Online occupational safety courses

Content – created by Occupational Safety and Fire Protection Unit, Corporate Security Department, HEP d.d. [2]
Education - HEP Academy creates the interactive e-course based on the submitted content
E-learning system:

- the course is uploaded to Moodle
- the exam is created and additional material uploaded
- system testing

Attendees:

- in-house trainers invite the workers to access education
- completion tracking

WORK SAFETY application:

- Daty entry
- Keeping records
- Preparation of minutes of conducted training

Every e-course contains:

- Multimedia and interactive educational content (audio, video, gamification)
- E-course content and mode of operation
- Knowledge exercises through education
- Final exam and handbook
- Course evaluation

2.3. Basic occupational safety program

E-course data:
active since March 2021

- closed-type course (by invitation)
- successfully passed by 175 workers
- 72 workers filled the evaluation questionnaire

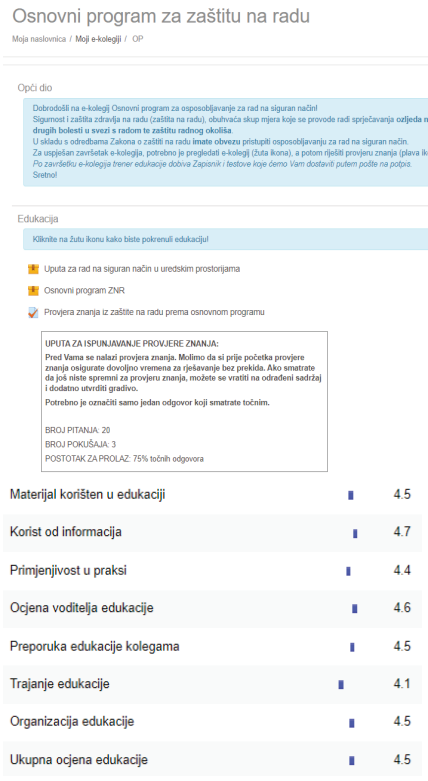


Figure 1: Program design and evaluation

2.4. STRESS MANAGEMENT - LINK

There is a link to the Stress Management e-course within the Basic Occupational Safety e-course.

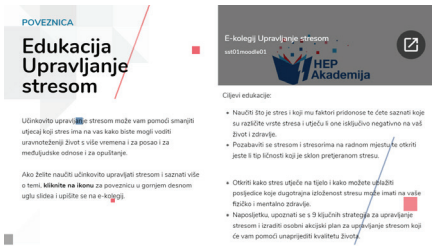


Figure 2: link within the course

2.5. Training program for the employer's authorized representative and the workers' representative for the implementation of safety measures at work

E-course data:

- active since February 2020
- closed-type course (by invitation)
- successfully passed by 162 workers
- 25 workers filled the evaluation questionnaire

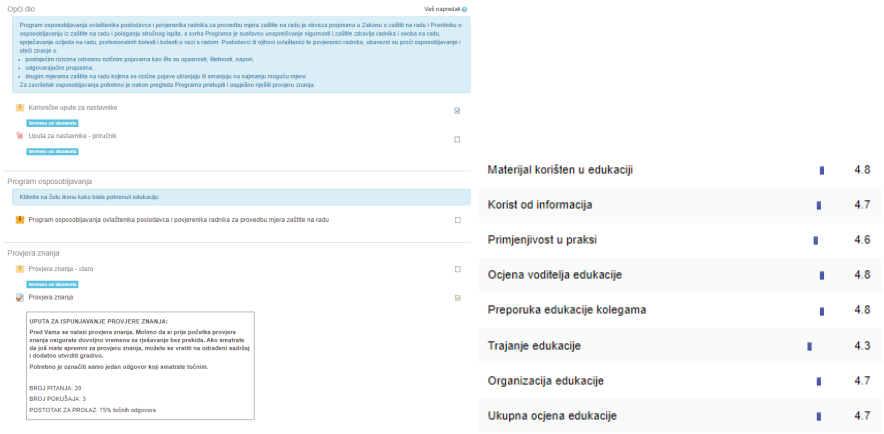


Figure 3: Program design and evaluation

2.6. Earthquake

E-course data:

- active since April 2021
- open-type education, autonomous entry
- successfully passed by 751 workers

- 378 workers filled the evaluation questionnaire

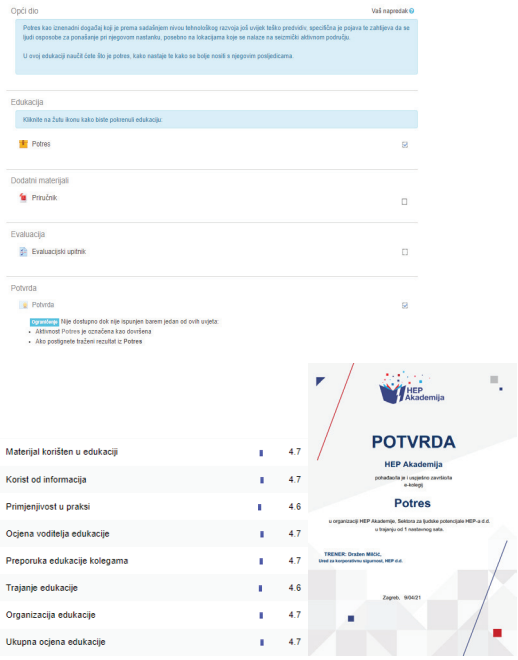


Figure 4: Program design and evaluation; the Certificate

2.7. Training workers to work safely

Training workers to work safely is a new course containing basic work instructions.

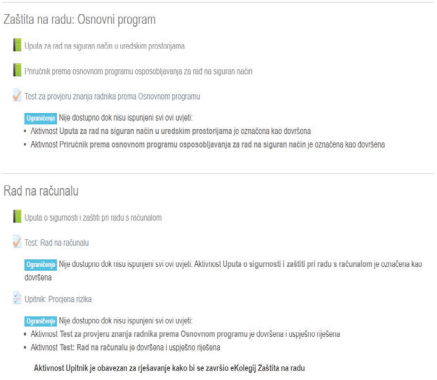
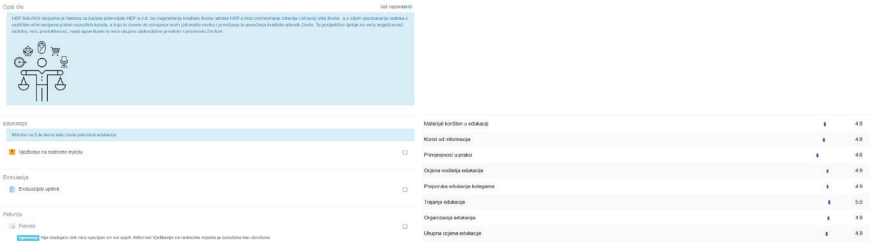


Figure 5: Program design - new

2.8. Workplace exercises

E-course data:

- active since January 2022
- open-type course (free entry)
- successfully passed by 108 workers
- 33 workers filled the evaluation questionnaire



Picture 6: Program design and evaluation

2.9. User guide for trainers

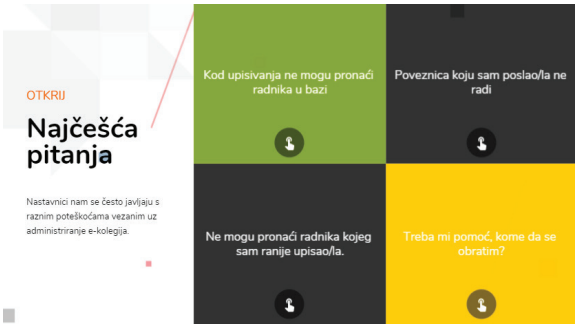


Figure 7. Program design

In addition to all the above-mentioned occupational safety courses, we have also prepared an e-course with instructions for trainers or work experts, for facilitating the use of or navigating Moodle.

3. CONCLUSION

The advantages of e-learning are as follows:

- Achieves significant financial and time savings for the company
- An ideal tool for companies with multiple locations
- Reaching a larger number of workers
- All workers receive identical information in a timely manner
- Attendees learn when it suits them, according to their scope of work
- Materials are always available, even after completing the course
- The worker's IT literacy is being developed
- Faster introduction of new workers to work
- More efficient monitoring of progress and results
- An excellent teaching method during a pandemic

REFERENCES

[1] Hrvatska elektroprivreda d.d.: Rulebook on organization and systematization of Hrvatska elektroprivreda d.d., Vjesnik HEP, Bilten number 339, 364, 445, 453, 493, Zagreb (2015- 2020)

[2] Health and Safety at work law in relation to the numbers N.N. 71/14. and 118/14. (2014)

[3] Hrvatska elektroprivreda d.d.: Report from HEP Moodle system of HEP grupe, HEP Academy, Zagreb (2022)

Comparison of tools for analyzing the degree of optimization of website search engines

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Abstract: *The aim of this paper is to compare tools for analyzing the degree of optimization of website search engines. Having in mind search engine optimization as one of the most important things to pay attention to when creating a website, an analysis of the meaning of the concept of search engine optimization will be conducted, an overview of methods for achieving the best possible level of optimization and two most popular tools for degree analysis search engine optimization Using three different tools, the same website will be tested and based on the results obtained, the similarities and differences between the tools, their features and characteristics and how relevant the results are for what is the ultimate goal of optimization, and this is the best possible position. on search engines.*

Keywords: *search engine optimization, google picture format, picture extensions, optimization, internet, marketing*

1. INTRODUCTION

Search engine optimization is the process of influencing search engine rankings for certain keywords. This type of optimization is key to quality organic traffic with minimal investment because visitors do not come to the site through paid ads.

It is especially important to invest in search engine optimization at the beginning of the business, because this way you reach visitors and potential customers faster and you can gain a better insight into the market position. Potential customers can also be reached through paid marketing, advertising on social networks and search engines, but it is more difficult to get an insight into the real potential of the site at an early stage and therefore many consider investing in this type of optimization to be the most profitable.

There are a number of factors that affect the position of a page on a search engine and it is important to keep these factors in mind. In order to achieve the best possible optimization results, various tools for analyzing the degree of search engine optimization are helpful, indicating omissions and shortcomings that need to be

eliminated in order for the search engine page to be better positioned. There are many free and paid tools that analyze the page taking into account search engine requirements and factors that affect positioning, and based on this give the user feedback on the quality of optimization.

2. SEARCH ENGINE OPTIMIZATION AND MARKETING

Search engine optimization (SEO) means a set of techniques for optimizing websites for search engines with the ultimate goal of raising organic, unpaid traffic to the site. The better and more thorough the SEO, the better the site will be positioned on a search engine for a particular keyword, so many consider investing in search engine optimization to be the most profitable investment in internet marketing for a very simple reason. Namely, due to quality optimization, the position of the website among the search results is improving, which directly affects the business.

Some experts specializing in SEO consider this type of optimization to be the basis of Internet marketing.

Quality search engine optimization is especially important for new entrants in the market who have not achieved revenue stability because a well-optimized site helps increase visibility and helps to find customers faster [3] without significant financial costs, so when creating a website it is worth paying special attention just on SEO.

"The basic goal of a human searcher is to obtain information relevant to an inquiry. However, searcher inquiries can take many different forms. One of the most important elements to building an online marketing strategy for a website around SEO and search rankings is developing a thorough understanding of the psychology of your target audience. Once you understand how the average searcher—and, more specifically, your target market—uses search engines, you can more effectively reach and keep those users." [4]

Link building strategies and link buying can greatly benefit both SEO companies in their bid to provide their clients websites with greater authority, as well as news media companies as they seek to grow their revenue. However, without adequate regulation, users stand to suffer, being presented with poor quality content and information that do not respond to criteria of journalistic or editorial feeds, but rather to those of advertising.[5]

3. WORKING PRINCIPLES AND TESTS

For the desired page URL, an analysis of fifty-two items divided into five different categories is performed. Each item is classified with an importance label

and each can be of exceptional, moderate or low importance for the final test result. The score is numerical in the range of 1 to 100.

The tests are focused almost exclusively on internal page optimization and the people who are in charge of page development and optimization when creating a page will benefit the most from the tests performed, while for site-based analytics SEO Site Checkup does not offer much in the free version.

The analysis takes, on average, less than one minute so the overall results are visible very quickly, at the very top of the page. Since registration is not required and the page can be analyzed once in 24 hours from a single device, it is possible to easily track the progress of creating a page.

In the first category "Common SEO issues", we analyze the things that are most important in SEO optimization and are focused primarily on the content of the page. The following is analyzed in this category: meta tags, use of keywords, title check, check files that help with indexing, Links on the page, Page code analysis, ALT mark on images, Favicon label, Integration with Google Analytics, Integration with social networks.

In the second category, the following optimization tests are performed in terms of page speed: Page size in, HTML file compression, Page load speed, Number of objects on the home page, cache the page, flash objects, content delivery network, minify files, avoid frames and nested tables, correct doctype declaration, URL redirection.

The third category examines server and website security, as follows: URL Canonicalization Test, Communication via HTTPS protocol, Website security, Use of e-mail addresses in text format, Server security.

Given that, according to research, more than two-thirds of website visits come from mobile devices [16], the fourth category examines the functionality and correct display of the site on smartphones and tablets. There is only one test in this category, the responsiveness test, which determines whether the content displayed on a website is specifically formatted, via a CSS file, for mobile devices using the media query technique.

In the last category, tests of implementation, as the site states, of advanced SEO techniques are conducted: Data structuring, Personalized error page 404, Avoid noindex tags.

4. PLATFORM FOR CONTENT ANALYZING

4.1. Service Diib.com

Diib has a different approach compared to other services with the same characteristics. There is no universal numerical rating of the degree of page optimization, the results are divided into several categories, more emphasis is placed

on external optimization and it can be said that Diib is primarily intended for other types of users.

SEO Site Checkup is primarily intended for developers because it clearly tells what mistakes are made when creating a page and gives instructions on how to fix them, while Diib observes the page for a long time, which is why registration is needed and offers more analytical data and more competition data. Diib is more focused on people in charge of marketing and analytics.

Testing of the site is conducted continuously, and test results and opportunities for improvement are presented in the interface.

In the section related to the health of the site, information related to the degree of optimization of the site for search engines is presented as: SSL validity, Domain authority, Sitemap, Keywords for which Google has ranked the page, Domain status related to e-mail, Links to other websites.

The site is analyzed on a daily basis and evaluated according to forecasts based on analyzes conducted by the system. If the result is less than 100% it means that the traffic on the page is below expectations, and if it is higher than 100% it means that it is above expectations.

In the next section, the analyzed page is compared with other similar pages that Diib selects automatically. Evaluation is carried out in four categories: Traffic on the site, Connection with social networks, Adaptability to mobile devices, User experience.

4.2. Advantages and disadvantages of service Diib.com

Diib.com provides a detailed insight into the items that need to be optimized in order to achieve the best search positions for certain keywords, but although a very detailed tool has advantages and disadvantages for the average user.

Advantages

- Extensive and detailed analysis of various aspects of page optimization
- The free version provides very high quality and useful information
- The billing version offers an automatic page optimization service
- Pages are monitored continuously and upward or downward trends are shown
- Easy integration with Google Analytics, Facebook and Google Ads
- Test results accurately indicate the position of the page on search engines
- In the free version it is possible to monitor the degree of optimization of multiple pages

Disadvantages

- It takes more time to understand the recommendations than with some other tools

- Difference in data display in Google Analytics and Diib interface after integration
- Occasionally there are errors in suggestions for improvement

4.3. Service Semrush.com

Semrush is a platform that, in addition to analyzing the degree of search engine optimization, also offers the creation of quality content according to brand needs in order to achieve better results, market research and analysis of competing websites, optimize online advertising and develop social networking strategies. With this platform, there is no universal assessment of the degree of page optimization, but tests for one page are conducted in a total of eleven separate categories.

Search engine optimization tests are divided into several categories.

- Site health - technical aspects of site optimization
- Search engine position - tracking search engine position for specific keywords and position change trends
- Internal search engine optimization - check the application of the best SEO methods for page optimization
- Review links to other sites
- Analysis of content on the page

The validity of the SSL certificate, the ability to index pages, the code structure and internal links are checked. Each of these items is assigned a percentage score of 0 to 100 percent.

The most important errors that, according to the system, need to be corrected in order for the site to start achieving the best results, then errors that are not so important, classified in the system as warnings, and information related to problems detected by the system, not necessarily problems, but it is recommended to eliminate them. All this affects the formation of the final grade expressed as a percentage.

4.4. Advantages and disadvantages of service Semrush.com

Semrush offers very similar features as Diib, so they are similar in terms of advantages and disadvantages, with some differences.

Advantages

- Extensive and detailed analysis of various aspects of page optimization
- Pages are monitored continuously and upward or downward trends are shown
- Test results accurately indicate the position of the page on search engines
- Easy integration with on-site traffic monitoring and analysis systems

Disadvantages

- There is no free version, only a trial period of seven days
- Outdated and somewhat less clear main project interface
- It takes a lot of time to get acquainted with the work
- Filling the email inbox with very frequent messages

5. ANALYSIS OF THE CONDUCTED COMPARISON

Each of the three analyzed tools has its advantages and disadvantages and some peculiarities that need to be noted. SEO Site Checkup is a tool that provides easy and quick insight into the technical aspects of page optimization and performance with the ability to analyze only one page in 24 hours as the biggest drawback. The test is conducted once and does not analyze changes to the page in time intervals nor does it track search engine positions so this tool can be characterized as ideal for developers who possess technical knowledge but do not go into marketing as much. Although a good optimization rating does not necessarily mean a good position on search engines, feedback is an excellent foundation for further optimization.

Semrush and Diib provide a deeper insight into various aspects of optimization, not just technical ones, and they can be used to continuously monitor search engine rankings for specific keywords. Diib in its free version allows multi-page analysis and there is no 24-hour limit, while Semrush offers only a one-week trial period for free. The results of the analyzes coincide with the position on the search engine because they take into account very important factors that the previously mentioned tool does not take into account and as such represent a great upgrade to the technical aspects of optimization. The user should choose between these tools as they provide very similar results, with Diib having the advantage due to its free version.

Combining SEO Site Checkup and Diib tools in their free versions can lead to good results even for those who do not have technical knowledge of search engine optimization because the information obtained from analysis is very useful and understandable, so it can be started or in self-optimization or in search of someone who can do optimization with certain savings because the requirements can be defined very clearly.

Diib and Semrush offer automatic optimizations in their billing versions, which can also be a quality solution for raising search engine rankings and better optimization. The book, which describes 99 ways to drive traffic to a website, describes SEO as a "strategy that can be written as a separate book" and points out that SEO is changeable, that trends need to be continuously monitored and optimization is always maintained. and this is where the greatest strength and benefit of the optimization degree analysis tool lies.

6. CONCLUSION

Given all the above, it can be concluded that the tools for SEO analysis are extremely useful for achieving the best level of optimization and ultimately achieving the best possible position on search engines. There are many such tools and each of them puts a special focus on a certain part of optimization, so it is recommended to analyze the site with several different tools, especially because such tools are widely available and provide extremely useful feedback in their free versions.

SEO is an area that is constantly changing, so it is important to continuously work on optimizing the site so that the results are continuously satisfactory and so that there is no drop in traffic through the website. It is important, therefore, to continuously study this area and apply new insights and knowledge to the page that needs to be optimized.

In large systems with many employees this is not a problem because in most such cases there is one or more people whose task is exclusively to analyze website traffic, rank pages by keywords and invest in marketing, but in smaller systems with one employee or only a few employees find it much harder to keep up with the pace of the Internet.

This clearly shows how useful search engine optimization tools can be because they give users important and useful feedback without the need to educate the user and follow the latest trends, but the team behind these tools does it for them. Based on monthly reports, the user can easily decide whether it is worth using services that are described in article.

REFERENCES

[1] M. R. Baye, B. De Los Santos, M. R. Wildenbeest; Search Engine Optimization: What Drives OrganicTraffic to Retail Sites?, *Journal of Economics & Managment Strategy,* p. 25, 2016.; https://doi.org/10.1111/jems.12141

[2] E. Enge, S. Spencer i J. C. Stricchiola, The Art of SEO, O'Reilly Media, Inc., 2015., p. 43, ISBN-10: 1491948965

[3] E. Enge, "Perficient"; 23. 3. 2021.. [Web]. Available: https://www.perficient.com/insights/research-hub/mobile-vs-desktop-usage#:~:text=Globally%2C%2068.1%25%20of%20all%20website,of%20visitors%20came%20from%20tablets. *Accessed* 2021-05-18.

[4] Fishkin R., Enge E., Spencer S., Stricchiola J.; The Art of SEO, 2nd Edition; O'Reiley Media Inc.; 2012; ISBN: 9781449304218

[5] C. Lopezosa, L. Codina, C. Gonzalo-Penela, Off-page SEO and link building: General, *International Journal on information and communication,* pp. 157-158, 2019. eISSN: 1699-2407.

[6] A. Jain, D. Meenu, The Role of Backlinks in Search Engine Ranking, *International Journal of Advanced Research in Computer Science and Software Engineering,* p. 597, 4. 2013., ISSN: 2277 128X

Difference in stability scores of lateral parts of dental archs

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Abstract: *Dental implants are used as a substitute for dental trauma. In order to eliminate the human factor during the manual placement of the implant a system of dental guides was developed. Dental guides are positioned on the patient anatomy to provide assistance in drilling and cutting operations of a surgeon. While in use guides can be unstable on the anatomy, so to preoperatively analyze stability of these guides a mathematical model is used to asses stability while designing the guide. Main hypothesis in this study is that there is no significant difference in stability scores between lateral parts of the dental arch. In total, ten 3D scanned dental castings were prepared and used to calculate stability scores between "left" and "right" part of the dental arch. Stability scores for left part (M_T=1,46 ± 0,07; M_R= 3,6 ± 0,31) and right part (M_T=1,47 ± 0,09; M_R= 3,7 ± 0,37) are very similar in stability scores. M_T is a parameter of translational stability, and M_R of rotational stability. Hypothesis was tested using two tailed t-test (α=0.01) which confirmed the main hypothesis, that there is no significant difference in stability scores between lateral sides of dental arch.*

Keywords: *dental guides, stability, dental arch*

1. INTRODUCTION

Recently, implant prosthetics as a dental activity has been developing very rapidly. The joint action of oral surgery and prosthetics as well as the radiological treatment of patients are important for a successful implant placement procedure. The implant procedure replaces one or more natural teeth with an implant. Tooth loss is a common occurrence on a daily basis. This is evidenced by data according to which 80% of people record the loss of at least one tooth. Thanks to extremely fast

technological progress, the type and algorithm of radiological diagnostics of patients in the pre- and post-implant procedure are changing. Prior to the advent of implantology, some types of edentulousness could not be treated properly.

Today, intraosseous implants that look like screws are mostly used in implantology. Intraosal implants, on which prosthetics are attached, enable morphological, functional, aesthetic, phonetic as well as oral hygienic rehabilitation of patients. There is no age limit for implant placement, but mostly middle-aged or elderly people opt for this procedure, where jaw changes are more frequent. Recently, dentists have used ergonomically designed dental guides produced by additive technology during the implant procedure.

Although ergonomic dental guides have a positive effect on precision compared to the classic procedure, there is still the possibility of deviation from the plan [1-5]. According to research studies, deviations of all technical parameters in the construction of dental guides are still unknown. According to the results, the total deviation is up to ± 2 mm, which applies to all types of dental guides.

One of the influential parameters is the stability of the guides on the patient's anatomy. In order to improve the stability during the design of the guides on the computer, the calculation (simulation) of stability is performed according to the proposed mathematical model [6].

2. HYPOTHESIS

In practice, the entire dental arch is most often used to make dental guides that rest on the teeth. This approach results in guides that are often too large for their purpose, i.e. sometimes it is enough for the guide to rest on only half of the dental arch because the implant is placed only on one side of the jaw. Consequently, the main hypothesis was formulated to test whether there are differences in stability between the left and right halves of the dental arch.

Hypothesis: There is no significant difference in stability scores between lateral parts of the dental arch.

3. MATERIALS AND METHODS

Ten castings of full dentition were made of dental plaster class IV by standard procedure (Table 1). Dental castings were digitized with an industrial 3D scanner ATOS CORE(GOM). Digitization was performed in the measuring laboratory under controlled conditions of temperature 22 ± 1 ° C and relative humidity 55% ± 10%. 3D models of castings on a computer were arranged for the design of dental guides (Figure 1).

Table 1: *Characteristics of Interstone Type IV dental plaster.*

Mixing recipe:	23 ml water / 100 g gypsum
Mixing time (manual):	15 sec
Mixing time (in vacuum):	60 sec
Bonding time:	Cca. 5 min
Work time:	Cca. 10 min
Binding elasticity:	after 2h; 0,10 %
Compressive strength:	after 1h; 49 MPa
Hardness:	after 24 h; 150 MPa

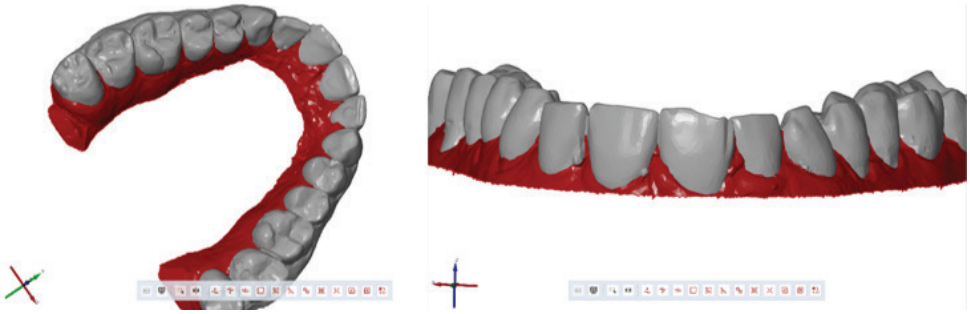

Figure 1: 3D scanned dental surface.

3D models of castings were divided by a plane into two equal (symmetrical) halves which were later compared (Figure 2). Stability calculation was performed using a mathematical model [6] implemented in the Matlab(MathWorks) software package.

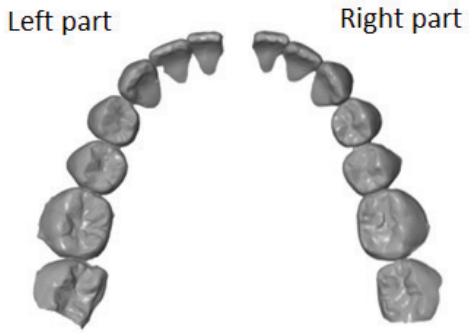

Figure 2: Model of dental casting separated in “left” and “right” side.

4. RESULTS

By calculating the stability scores for all ten models (surfaces) in Matlab without selecting the drilling reference point, the results for the translation stability parameter (M_T) and the rotational stability parameter (M_R) were obtained. The simulation results are shown in Table 2.

A statistical t-test was performed for each left and right halves to see if there was a statistically significant difference between the left and right halves of the dental arch. The assumption is that there should be no difference. The T-test was conducted in the Matlab (Mathworks) software package.

Table 2: Stability scores for lateral parts of dental archs.

“Left”				“Right”		
No.	M_T	M_R		M_T	M_R	No.
1	1.3970	3.5605		1.4039	3.5770	1
2	1.4576	3.4591		1.4123	3.6293	2
3	1.4478	3.2887		1.4767	3.4903	3
4	1.5647	3.9486		1.5242	3.7977	4
5	1.3913	3.1637		1.3877	3.2747	5
6	1.4351	3.6264		1.4413	3.6151	6
7	1.4923	3.5660		1.5001	3.4800	7
8	1.6003	4.0869		1.7120	4.6451	8
9	1.3856	3.3727		1.4526	3.6307	9
10	1.4169	3.9817		1.4083	3.8267	10
$\bar{x}$	1.46	3.6		1.47	3.7	$\bar{x}$
SD	0.07	0.31		0.09	0.37	SD

t-test	0	0	0	0	t-test

The hypothesis that the calculated coefficients of stability (M_T and M_R) for the left and right halves of the dental arch were independent random samples from normal distributions with equal mean values and equal variances was tested. If the test result is H = 1, it means that the null hypothesis is rejected, and if the result is H = 0, the null hypothesis is accepted with the selected level of significance ($\alpha = 0.01$).

The results of both t-tests show that for the calculated stability parameters (M_T and M_R) there is no statistically significant difference between the left and right halves of the dental arch (Table 2). Also, in previous studies [6] it was shown that the numerical difference between the stability parameters should be greater than 0.5 points for the difference in stability to be noticeable. As the differences in the results are less than 0.5, we come to the same conclusion that there is no significant difference in stability between the left and right halves of the dental arch.

5. CONCLUSION

Due to the growing demand for dental implants, newer and more modern techniques for making ergonomic dental guides are being developed. The use of devices such as CT devices and additive technologies that, in combination with a computer, enable safer, easier and more accurate placement of dental implants. These new technologies also allow easy customization and patient specific ergonomic guides and implants manufacturing.

In the stability analysis for the left and right halves of the dental arches, the conclusion is that there is no major difference between the left and right halves of the dental arch. This confirms and adopts the initial hypothesis. This was also expected since the geometry differs very little, i.e. the dental arch is in normal anatomy almost perfectly symmetrical, so the results for the stability parameters must be the same or very similar.

REFERENCES

[1] Gjelvold, B.; Mahmood D.J.H.; Wennerberg, A.: Accuracy of surgical guides from 2 different desktop 3D printers for computed tomography-guided surgery. The Journal of prosthetic dentistry. (2019), pp. 498-503. doi: 10.1016/j.prosdent.2018.08.009

[2] Schneider, D.; Sax, C.; Sancho-Puchades, S.; Hammerle, C.H.F,; Jung, R.E.: Accuracy of computer-assisted, template-guide implant placement compared with conventional implant placement by hand—An in vitro study. Clinical Oral Implants Research.
(2021), pp. 1052-60. doi: 10.1111/clr.13799
[3] Cristache, CM.; Gurbanescu, S.: Accuracy Evaluation of a Stereolithographic Surgical Template for Dental Implant Insertion Using 3D Superimposition Protocol. International Journal of Dentistry. (2017), doi: 10.1155/2017/4292081.
[4] Neumeister, A.; Schulz, L.; Glodecki, C.: Investigations on the accuracy of 3D-printed drill guides for dental implantology. International Journal of Computerized Dentistry. (2017), pp.35-51.
[5] Verstraete, MA.; et al.: 3D printed guides for controlled alignment in biomechanics tests. Journal of Biomechanics. (2016), doi: 10.1016/j.jbiomech.2015.12.036.
[6] Van den Broeck J, Wirix-Speetjens R, Vander Sloten J. Preoperative analysis of the stability of fit of a patient-specific surgical guide. Computer Methods in Biomechanics and Biomedical Engineering. 2015; 18(1): 38-47. doi. 10.1080/10255842.2013.774383.

RISK ASSESSMENT METHODOLOGY FOR HEIGHT WHEN PERFORMING ASSEMBLY WORKS

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Abstract: Falls from a height are one of the most common causes of serious injuries and deaths at work. Therefore, it's necessary to take measures to protect workers at every stage of work involving work at height. Measures to eliminate or reduce risk are taken on the basis of a risk assessment. Where work at height cannot be avoided, falls should be prevented by implementing technical measures and selecting the appropriate type of equipment and education. It's vital that anyone working at height has the appropriate training and skills.
Through a practical example of work on the assembly of a storage hall, the paper presents a method of risk assessment that includes a plan of measures related to the elimination of residual risk.
Key words: safety and health, work at height, adult training, risk assessment

1. INTRODUCTION

Risk assessment is a systematic process of analyzing the hazards, harms and efforts to which a worker is exposed at the workplace. If irregularities in the work process are identified, the assessment determines the level of walking consequences and the measures that need to be taken. The identified risks need to be eliminated or other protection measures proposed.
When tasks are performed at height, risk management refers to the proactive control and assessment of threats and risks to prevent accidents, uncertainties and errors. Working at height is one of the most dangerous types of work. The International Labor Organization (ILO) recognizes it as one of the leading causes of injuries and deaths in the workplace. It's therefore necessary to take measures to protect workers at every stage of work involving work at height. Based on the risk assessment, measures are taken to eliminate or reduce the risk. Where work at height cannot be avoided, falls should be prevented by implementing technical measures and selecting the appropriate type of equipment and education. It's vital anyone working at height has the appropriate training and skills.

Implementing safety regulations must be taken into account when assessing risk. In Croatia, this refers to the Ordinance on the preparation of risk assessments (NN, no. 112/14 and 129/19) and regulations relating to work equipment and personal protective equipment. For the purposes of writing this paper and risk assessment for work at height, the Fine-Kinney method for residual risk assessment was used.
The assessment of the risk of falling from a height does not include the risks of actions performed from an elevated position. Therefore, the overall level of risk is determined on the basis of the synergistic effect of the assessed risks to which the worker is exposed while working at height (such as the risk assessment for the safety and health of workers when handling loads manually).
Risk assessment is performed by a team of experts from various fields (employer, architect, occupational safety expert). Workers - direct executors of work activities must be involved in the preparation of risk assessment and implementation of acceptable protection measures.
Good knowledge of the technological process and the work to be performed at height is a requirement for starting a risk assessment. As the risk of falls increases with the height from which the works are carried out. Accordingly, it will be necessary to harmonize the implementing protection measures accordingly.
After the implementation of measures to eliminate or reduce the risk, the assessment of the level of remaining risk is approached. If the remaining risk is not acceptable, additional protection measures need to be implemented.

2. DESCRIPTION OF TECHNOLOGICAL PROCESSES

Prefabricated storage halls are designed exclusively for storage of materials, semi-finished products and/or finished products. Longer retention of workers in the hall is unneeded except in the process of loading or unloading goods.
The construction of the hall is made of galvanized steel profiles. The finished construction is covered with sandwich panels for fronts and sandwich panels for roofs. Roof panels are laid at a height of 10 meters.

2.1 Stages of work

Bearing in mind the way of performing the works, we distinguish three phases: making a steel structure, assembling a metal structure and installing insulating panels.
Finished steel profiles and columns are delivered to the construction site already prepared for installation. The main pillars are placed at the places of lifting and assembled to lie down. Vertical columns are connected by roof girders (horns). The finished structure is lifted by a car crane. In this phase of works, the workers connect the parts of the roof structure with connecting elements. The works are performed from a mobile, prefabricated scaffolding or hydraulic platform. These works require the implementation of special measures to protect against falls and the installation of anchorages for securing the workers. Workers are required to use a protective belt for the whole body. Anchors must be installed on all parts of the structure where the

roof fasteners are installed so that work can be performed in motion, without downtime. The worker should be tied with a position rope to the upper bar of the scaffolding or platform, and with an elastic rope and retarder to the anchorage. Despite the above, complete fall, protection cannot be provided. As all the proposed measures have been taken, the residual risk is acceptable.
Insulation panels are installed after the locksmith installation work is completed. When installing roof panels, the anchors are attached to the steel structure and connected by cable. The workers are connected to the cable with a sliding element, via a fall damper, with a dynamic rope. In the event of a fall, the fall damper will prevent lurching, and the worker will remain hanging on the rope.
The side panels are mounted from a lifting platform. In this way, fall protection is implemented by the basic rules of safety at work. Workers' falls can only occur when reaching equipment to be mounted and tilting beyond the dimensions of the platform. For this reason, fall protection is provided by connecting the seat belt to the platform fence. A rope with a built-in shock absorber is used for connection.

3. FALL RISK ASSESSMENT

The fall risk assessment indicates the dangerous situations in which a fall may occur, the damage that may occur during a fall and the likelihood of a fall. Risk assessment for works at height is carried out in three steps, as follows: Identification of hazards; Fall risk assessment; Selection of risk reduction measures.

3.1 Identification of fall hazards

The danger of falls is present in all phases of work. They refer to the unloading and assembly of steel elements. This is followed by raising the pillars and fixing the roof rafters. Final work includes the installation of insulation panels.
Hazard identification and risk assessment should be performed for all phases of works, according to the types of hazards of: falling at the same level (passage width, unevenness, excavations, slopes, obstacles, liquids, slippery substances, vehicles, objects, materials, machinery, excavations, unprotected openings, etc.) and falls from a height above 1 meter. The risk of falls is also affected by other elements such as microclimatic conditions, statodynamic efforts, unprotected roof surfaces, erection of the structure, etc. The danger is increased by malfunction or incorrect choice of work equipment and inadequate training of workers.
Based on the assumed hazards, a checklist is prepared, and an assessment of the residual risk is performed for each work activity (Table 1).

3.2. Fall risk assessment

Evaluation of risk (R) is performed by the formula:

$$R = P \times C \times F \qquad (1)$$

where is:
R – Risk level

P – Probability of injury
F - Frequency and timing of exposure to hazards/efforts
C - Consequences or severity of possible injury or illness

Table 1: Checklist for identifying fall hazards

Danger	Performed activity Dangerous operation	Risk assessment			
		Probability (P)	Frequency (F)	Consequences (C)	**Risk level** P x C x F
Fall in level	Walking on surfaces	10	10	1	**100**
	Access to the workplace and obstacles	10	10	1	**100**
Fall from height	Height works on roofs, platforms, scaffolding, bridges and columns	3	10	6	**180**
Work activities	Performing business-related work tasks at height	10	6	3	**180**
	Statodynamic efforts	10	6	3	**180**

Criterion - probability (P) is ranked ranging from 0.1 - virtually impossible, to 10 - predictable (Table 2).

Table 2: Description of the criteria for assessing the probability

Probability (P)	Criteria for assessing the probability
0,1	Virtually impossible
0,2	Practically impossible
0,5	Plausible, but unlikely
1	Improbable, but possible at boundary conditions
3	Unusual, but possible
6	Possible
10	Predictable

Criterion - consequences (C) (possible damage) is ranked ranging from 1 to 10 and that is considered catastrophic. The criterion - the frequency of occurrence of danger and harm (F) it is determined by the duration of the activity of a particular job, which can consequently cause a decline in workers (in a given period). Table 3 indicates the rank of the criteria for assessing consequences and frequency.

Table 3: Description of the criteria for assessing the consequences

Level	Description of the criteria	
	Consequences (C)	Frequency (F)
1	Disease, injury which requires first aid and any other treatment	Rare (yearly)
2	Medical treatment by a doctor	Monthly
3	Disability, mandatory hospitalization	Occasional (weekly)
6	Accidents with lethal outcome	Regular (daily)
10	Catastrophic - with multiple lethal outcomes	Permanent

The level of risk (R) is ranking from acceptable, negligible levels R1, to the extreme, impermissible, which requires interruption of work activities and the instantaneous preventive actions defined as the risk level R5 (Table 4).
Based on the risk assessment matrix, the characterization of the risk assessment is defined.

Table 4: Risk classification

Ranking	**Total rating R = P x C x F**	**Classification level of risk** (description)
1.	**0,1 – 20**	**Negligible risk** No action is required
2.	**21 – 70**	**Low risk** No need for additional activities, monitoring of work activities is needed
3.	**71 – 200**	**Medium risk** Constantly monitor working conditions and implementation of fall measures; reduce exposure
4.	**201 – 400**	**High risk** Take urgent action to reduce the level of risk, reduce exposure to fall risks
5.	**Over 400**	**Extreme risk** The operation cannot be started nor continued until the risk is reduced

3.3. Choice of risk mitigation measures

Where and when this is possible, scaffolding and guardrails are installed to protect against falls from heights. Nevertheless, the danger cannot be completely eliminated. The fundamental principles of fall protection prescribe that technical achievements should be used primarily to prevent risks at the source. The order in which possible solutions must be found must follow the following order of measures:

1. Prevention of risks from fall at the source (conduct preparation and assembly works of the structure on the ground level)
2. Application of technical protection measures (use mobile platforms instead of mobile scaffolding)
3. Undertaking organizational protection measures (continuous education of workers working at height, giving priority to younger workers, shortening the working hours of exposure)
4. Use of personal protective equipment for protection against falls from heights (use only certified equipment, conduct regular inspections of equipment, conduct training in the use of equipment)

4. CONCLUSION

By analyzing the assessed risks, it can be concluded that the risk of falling arises from working at the same level, working from an elevated position and working at height. Especially dangerous are construction and installation works that are performed at high altitudes. The implementation of protection measures depends on the height from which the works are performed. For falls at the same level, it is necessary to ensure the basic rules of safety at work (daily maintenance of surfaces for movement, access to the workplace and the necessary obstacles). In the case of works at height, in addition to the already listed protection measures, it is necessary to comply with special rules relating to:

- The construction project envisages the installation of anchorages (in the phase of works);
- Make a risk assessment before starting work. In accordance with the obtained results, implement protection measures;
- Educate employers and their representatives and acquaint them with fall protection measures, equipment used for this purpose and the possible consequences of poor protection;
- Train workers to work at height and correct use protective equipment;
- Train a rescue team;
- Where possible, use collective fall protection measures (scaffolding, platforms);
- Carry out regular control of the work equipment.

LITERATURE

[1] Model Code of Practice: Managing the risk of falls at workplaces, Available on *https://www.safeworkaustralia.gov.au/doc/model-codes-practice/model-code-practice-managing-risk-falls-workplaces*, Accessed: 2022-05-16
[2] Norme: EN ISO 14121-1: 2007 (*Safety of machinery - Risk Assessment, Part 1: Principles*) and EN ISO 12 100-1,2: 2004 (*Safety of machinery - Basic concepts, general princples for design*)

[3] Oturakci M.: *A New Approach to Fine Kinney Method and an Implementation Study*, Available on *https://www.researchgate.net/publication/288888151_A_New_Approach_to_Fine_Kinney_Method_and_an_Implementation_Study,* Accessed: 2022-05-16
[4] The Work At Height Safety Association: REFERENCE INFORMATION FOR WORK AT HEIGHT - HSE RESOURCES, Available on *http://www.wahsa.org.uk/*, Accessed: 2022-05-1

6

ECOLOGY

ENVIRONMENTAL PRODUCT DECLARATION AS PROOF OF PRODUCER AWARENESS OF THE PRODUCT IMPACT ON THE ENVIRONMENT

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Abstract: *Increasing environmental awareness places demands on many producers to offer products that meet high environmental standards, as well as the responsibility to pass on information about the environmental quality of their products. One of the more current ways to achieve and prove the environmental awareness of producers about the impact of products on the environment is the environmental product declaration. Producers motivated by their interest, using environmental product declaration as a communication tool, can certainly improve production efficiency and expand their market. This paper present guidelines and methodological approach for company managers who want to understand the conditions under which the environmental product declaration can be a useful tool for company competitiveness. Each product has a more or less adverse impact on the environment, which is manifested in all stages of the product life cycle. The process of conducting product life cycle assessment analysis is necessary because environmental friendliness has certainly become an additional quality of the product.*

Keywords: *Ecological awareness, environment, product, ecological product declaration.*

1. INTRODUCTION

The protection of the environment and the space in which we live is of increasing importance due to the fact that under the great pressure of the modern age the development of industry is increasing and thus the increasing pollution of water, air and land, as well as all other natural resources. Recently, people are also more concerned about the environment, so there has been a change in the decision to buy products, so consumers often prefer "green" products made from recycled material, which can be recycled or whose packaging after product consumption can be reused. This is also noticed by many companies that turn to organic production. Eco-labels are the best way to communicate with environmentally conscious consumers. [1]

The main purpose of eco-labels is to provide information to consumers in order to build their trust in organic products. Eco-labeling primarily means the transparency of product data. It can be understood as an obstacle in international trade, but on the

other hand it can be a stimulus in the development of trade because people's awareness of ecology is changing.

Eco-labels for producers can be mandatory and voluntary. Those imposed by law, such as warnings of flammability, dangers of poisoning, etc., are mandatory. Voluntary eco-labels are divided into three groups; type I, type II and type III, as determined by the International Organization for Standardization (ISO). For each type, there are standards that determine the properties of the product they can label, and they are: ISO 14024, ISO 14021, and ISO 14025. There are currently 464 labels in 25 industrial sectors worldwide. [2]

Emphasizing the type III product declaration, this paper will present guidelines and methodological approach as well as the importance of the Environmental Product Declaration (EPD) so that company managers can understand the conditions under which the EPD can be a useful tool for company competitiveness.

2. LIFE CYCLE ASSESSMENT

In order to meet the requirements for obtaining an EPD, it is necessary to apply and conduct a life cycle assessment of products and processes. Life Cycle Assessment (LCA) is a systematic approach to product reviews and its entire life cycle. The cycle assessment covers the entire life cycle of the product, process or activity, and includes the exploitation and processing of raw materials, production, transport and distribution, use, recycling and finally final disposal [3].

The LCA offers a "Cradle to Grave" approach to a product or process, taking into account the environmental aspect and potential environmental effects (Figure 1).

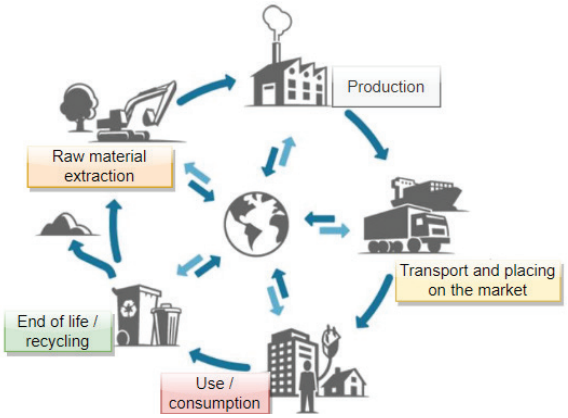

Figure 1: Process of LCA analysis ("Cradle to Grave" approach)

LCA analysis of products and processes began in the 1960s in the United States due to growing environmental concerns, ie. due to the mainly negative effects of various industries and other activities on the balance of the Earth and the Earth's atmosphere. Given the knowledge that natural sources of raw materials are limited, it was necessary to find a way to monitor and analyze consumption in order to gain insight into the expected situation in the future.

This sequence of events led (1993) to the development of official guidelines for the proper conduct of life cycle assessment entitled "Guidelines for Life - Cycle Assessment: A Code of Practice", and later (1997) to the development of LCA standards by the International Organization for Standardization (ISO) 14000 series. With this standard, the product and process life cycle assessment method has only been confirmed to be a very good tool for environmental impact testing.

The methodology, with the application of appropriate tools (computer programs with appropriate databases), conducts systematic evaluation of environmental aspects of products and/or services through all phases of its life cycle on the principle of interdependence. Due to the detailed specification in the LCA modeled product system, caused by the requirements for accurate data on the tools for assessing the lifetime impact of different types of products, Product Category Rules (PCR) have been developed. These rules have been developed for different product groups. [4]

3. ENVIRONMENTAL PRODUCT DECLARATION

3.1. The procedure for obtaining an EPD

Environmental Product Declaration (EPD) is an international label based on the international standard ISO 14025, belongs to the Type III group and is one of the most famous eco-labels [5]. The seat of the institution where the label was created is in Sweden, and the declared products can be found in 40 countries around the world.

The Environmental Product Declaration is a verified and registered document that offers transparent and comparable information on the product life cycle.

Obtaining the EPD declaration lately is often the main purpose of conducting LCA product analysis. It is important to emphasize that for a particular product, environmental impacts must be measured by one expert and these measurements must be confirmed by another qualified, impartial person. Because it requires data and impact to be taken into account throughout the product life cycle, the process is very complex and time consuming, so this type of declaration is intended for use in industry and is not recommended for consumers [6].

ISO 14025 provides guidelines for the development of EPDs, but they are not sufficiently specified. So a link is created between EPD and PCR because the rules of product categorization fill that gap in the definition. Without these additional rules, it would not be possible to implement the EPD [5].

Figure 2: Environmental Product Declaration

The Environmental Product Declaration generally consists of a series of results showing the factors of environmental impact categories and serving to compare products of the same category assessed through the Product Categorization Rules (PCRs) [4].

The process of making EPD takes place through five steps shown in Figure 3 [6]:

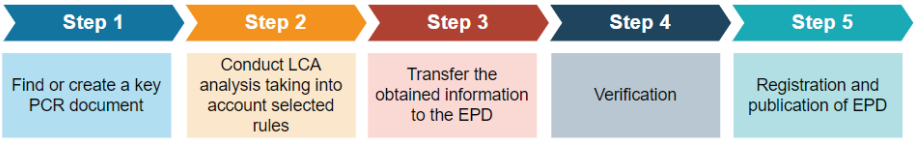

Figure 3: The process of making EPD

1. step: Find or create a key PCR document

- Finding the PCR document

Product Categorization Rules (PCR) documents already exist for many product groups and are constantly being developed and updated. In the PCR database of the International EPD® system, ready-made PCR documents are available as well as those in preparation.

- If any PCR does not exist (or has expired)

If PCR does not exist for the desired product category, it must be developed and verified and approved. PCR documents are prepared and produced in an open, transparent and participatory process involving multiple companies and professional organizations to ensure the provision and input of relevant and expert knowledge about a particular product.

If the validity period for PCR has expired, the document can be reactivated and updated, making it valid again for a certain period of time.

2. step: Conduct LCA analysis taking into account selected rules

LCA analysis should be performed in accordance with ISO 14040 and 14044, and according to the described steps, with additional conditions set by the selection of PCR documents.

3. step: Interpret the obtained information in the EPD

The output format of the EPD declaration is a PDF document that contains the required information prescribed in the General Program Instructions and the

corresponding PCR, and must therefore contain: Information, Reports and Summary.

4. step: Verification

The created EPD document must be verified and certified by the International EPD® system. All types of information must be verified separately, which means that the evaluator of the document must not be involved in any way in conducting the LCA analysis, ie the evaluator must be completely impartial.

5. step: Registration and publication

After verification, the EPD declaration goes through the registration process and is stored in the EPD database. The applicant receives an official confirmation of this and the EPD is published.

3.2. Importance of eco-labels for producers

Eco-labels are voluntary instruments for environmental protection by which producers show respect for high standards of environmental protection.

In the context of achieving and implementing the concept of sustainable development, certification of industries together with eco-labels are important and the only solutions to climate change caused by excessive pollution. Sustainable development enables the entire product life cycle to be as environmentally friendly as possible, which the eco-label confirms to the consumer.

The main reasons for companies to introduce eco-labels are [6]:

- promotion of sustainable development, ecological production, advertising of products that do not endanger the environment;
- encouraging production methods that optimally save natural resources - desirable consumption of materials that are prone to the recycling process;
- providing consumers with a credible message about the impact of a particular product on the environment.

3.3. Eco-labels

An eco-label helps identify products or services that are more environmentally friendly. Today, in addition to consumers making purchasing decisions based on price, quality, design, country of origin, they emphasize that environmental protection is of great importance to them. Most consumers prefer products with the eco-label because they are a true indicator of the environmental quality of the product. [7]

The eco-label uses its way of communicating with consumers by "explaining" which material the product is made of and which eco-labels it contains. This is most often presented in the form of an image or text that provides information on the ecological system impact. [8]

Table 1: Examples of EPD in Europe and the world

Eco-label	Name (Country)	Eco-label	Name (Country)
	EPD Italy (Italy)		EPD India (India)
	EPD Ireland, The Environmental Product Declaration Project (Ireland)		EPD-norge, The Norwegian EPD Foundation (Norway)
	EPD Australasia (Australia and New Zeland)		Epddanmark (Danmark)
	Third-party Verified EPD, Institut Bauen und Umwelt e.V. (Germany)		EPD Latin America (Chile, Mexico, Brazil)

4. CONCLUSION

The general goal of eco-labeling is the protection of the environment as the primary goal which seeks to orient customers towards products and services that pollute the environment less.

In the case of buying an organic product, consumers give specific feedback to the producer confirming that they buy the products only because they have eco-labels on them. Therefore, EPD as a communication tool certainly gives companies a competitive advantage.

Competitive advantage certainly brings higher profits to companies on the one hand, and on the other hand, producers encourage consumers to participate in improving the protection of the environment and the entire ecological system. Company managers should raise the level of awareness and reliability among consumers through various educational activities and marketing of environmental development. In this way, they would increase the efficiency of eco-labels on the market and strengthen their competitive advantage in existing and new markets.

REFERENCES

[1] Bajramović, E. & Islamović, F.: Društvena odgovornost za zaštitu okoliša, Conference: Fifth Scientific Conference with International Participation, June 5 - World Environment Day, Bihać, Bosnia and Herzegovina (2017).
[2] Strazza, C.; Borghi, DA.; Magrassi, F. & Gallo, M.: Using Environmental Product Declaration as source of data for Life Cycle Assessment: a case study,

Journal of Cleaner Production, **Vol. 112** (2015), DOI:10.1016/j.jclepro.2015.07.058.

[3] Steubing, B. & Koning D.: Making the use of scenarios in LCA easier: the superstructure approach, *The International Journal of Life Cycle Assessment,* **Vol. 26** (2021) pp. 2248–2262, https://doi.org/10.1007/s11367-021-01974-2.

[4] Minkov, N.; Schneider, L.; Lehmann, A. & Finkbeiner, M: Type III Environmental Declaration Programmes and Harmonization of Product Category Rules: Status Quo and Practical Challenges, *Journal of Cleaner Production,* **Vol. 234** (2015), DOI:10.1016/j.jclepro.2015.02.012.

[5] ISO 14025: Environmental labels and declarations - Type III environmental declarations - Principles and procedures.

[6] Service for Technical Assessment and Approvals. *Available from* http://www.zag.si/en/certifikati-soglasja/service-for-technical-assessment-and-approvals *Accessed:* 2022-06-10.

[7] Welling, S. & Ryding, SO.: Distribution of environmental performance in life cycle assessments - implications for environmental benchmarking, *The International Journal of Life Cycle Assessment,* **Vol. 26** (2021) pp .275-289, https://doi.org/10.1007/s11367-020-01852-3.

[8] Manzini, R.; Noci, G.; Ostinelli, M. & Pizzurno, E.: Assessing environmental product declaration opportunities: A reference framework, *Business Strategy and the Environment,* **Vol. 15**, (2006), pp. 118-134, https://doi.org/10.1002/bse.453.

ENGLISH-CROATIAN TERMINOLOGY IN CHEMICAL-BIOLOGICAL HAZARDS

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Abstract: *The analysis of English-Croatian terminology analysis in chemical-biological hazards is shown through separate display of chemical hazards and biological hazards. As an introduction to the main purpose of the paper which is the systematisation of glossary of the most common terms from the profession. The terms are strictly related to chemical-biological hazards and the table is provided for the purpose of highlighting the importance of understanding and using the terms correctly. As a conclusion it has been noticed almost 50 % of terms in English have their own translation in Croatian and they are used equally, but there are also English terms that have been adopted in the Croatian language and they are used more often than the Croatian version.*

Keywords*: chemical hazards, biological hazards, safety at work, terminology*

1. INTRODUCTION

Hazardous substances in industry are those substances which may jeopardise health, our well-being and cause material damage. Will a substance have a negative effect, this depends mainly on its quantity and physical, chemical and toxic properties. The main goal of the paper is to highlight the need for terminological systematisation in English and Croatian and ultimately create a glossary in the field of chemical-biological hazards. Internet sources, *i.e.* online dictionaries, were used as the main source of the glossary. The first part of the paper deals with theoretical part of chemical-biological hazards and the second part will present the method behind compiling a specialised glossary, selection and systematisation of the terms and specificities of this terminology in the field of chemical-biological hazards. The glossary is presented in the theoretical part in addition to providing an account on

the methodology behind the glossary as well as how the terms were selected and used.

2. CHEMICAL HAZARDS

Chemical hazards is the common term for hazardous substances which can harm the health of employees in contact with them in the process of production, handling, transport, transfer, storage and use. In practice, chemical substances come in the form of dust, gas, vapour, mist and fibres [1]. Various physical, chemical and toxic properties determine the level of hazard of the substances, but the main determinant is the quantity of substance which penetrated the employee's organism. In view of this maximum allowable concentration (MAC) is prescribed for each chemical substance for a hazard-free 8-hour working day. In case the exposure lasted up to 15 minutes and happened not more than four times during a working day minimum allowable concentration is prescribed for these substances. A minimum of 60 minutes has to pass between the two exposures and the value is expressed in ml/m^3 (ppm) or mg/m^3 [2]. The hazards may leave short-term consequences; they may be acute or chronic, appearing in a period from several months and/or years and resulting in professional illness [3]. There are several ways of how hazardous substances enter the organism: inhalation (breathing), absorption (skin or eyes) and ingestion (swallowing). For all of the mentioned reasons, it is very important to use the prescribed protective equipment. Which type of equipment will be used, depends on the type of chemical (concentration), physical and chemical properties (aggressiveness, reactivity, aggregate form) as well as manner, speed and scope of absorption into the organism [4]. The main principle of protection against chemical hazards is to substitute dangerous substances with those that are less dangerous and protective equipment must correspond to the level of exposure to chemical hazards. It is vital the employees are familiarised with the hazards of substances they handle and work with, and the related workplace have to display written instructions for safe work in addition to warning signs [5].

3. BIOLOGICAL HAZARDS

Biological substances include viruses, bacteria, parasites, fungi, insects and organic matter, all of which workers comes into contact during work and all of which may cause difference illnesses, mainly professional. Sources of biological hazards are: working with people who suffer from contagious diseases, working with infected animals and working in open (contact with animals who transfer poisons and viruses through biting [2]. Biological agents are microorganisms, cultures of cells and human endoparasites which could cause infections, allergies or poisoned state. According to the AUVA methodology, biological agents are grouped into four groups of hazards considering their level of risk from contagion [7]. Group 1 refers to biological agents which will unlikely cause diseases in humans.

Group 2 includes biological agents which may cause diseases in humans and may be dangerous in the workplace, but they will probably not spread in the environment and medical treatment is available. Biological agents which may cause serious illness in humans and may present great risk of spreading, but efficient medical, but treatment is usually available fall into Group 3. Group 4 includes biological agents which cause serious illnesses in humans and present serious threat to the workplace; there is a high risk of spreading into the environment and medical treatment is usually unavailable.

4. TERMINOLOGY

After the theoretical part which presented chemical and biological hazards in general and briefly touched upon the related regulations, this part focuses on the main purpose of this paper: highlighting the need for terminological systematisation between English and Croatian language. In todays global word foreign professional literature has become more available and since English remains at the top of the list of world languages, no one can avoid it regardless of their profession. It is vital to know and understand the terminology both in Croatian and English to be able to study foreign professional literature. Terminology refers to the system of terms used in scientific, artistic, technical, business or some other area. It also refers to the science on terms and their use, studying the formation and relation between terms, their properties and descriptions, creation of terminological systems, definitions, harmonisation of name and term, methods of terminological lexicography and the problem of compiling terminological databases. Since it studies terms of all professions, terminology is considered multidisciplinary science which relies partly on linguistics and partly on the related profession. This paper obviously focuses on Safety and Protection at Work, that is, chemical-biological hazards. Since terminology is part of the standard language, it has to be in compliance with linguistic norms of both Croatian and English language. Terminological principles also have to be taken into consideration and names and terms have to be harmonised. In this sense, the names should be harmonised with linguistic norms of English and Croatian as well as terms of the related profession [9]. New names in certain professions may be formed by taking them over from another foreign language and/or using local words with a new meaning through a process called terminologisation. Therefore, terminologisation is a process in which a common word is transfer into a technical term, and the meaning of the word from the general, standard language of given professions is determined precisely, it is narrowed down and it is determined by a certain definition. This would mean that a common word always means what is determined by its definition [9].
Certain principles should be followed in the process of creating terms. There are two institutions in Croatia which are in charge of the Croatian language. The first one is Infoterm (International information centre for terminology) which provides support and coordinates international cooperation in the area of terminology [10]. The second institution is the institute for Croatian language and linguistics (Institut za

hrvatski jezik i jezikoslovlje) which initiated the Struna project – terminological data base of the Croatian professional terminology which systematically collects, creates, processes and interprets terms from various professions with a purpose of forming and harmonising terminology in Croatian [11]. Terminological glossary is an alphabetical list of specialised or technical words, terms or abbreviations and their definitions usually related to a certain discipline or field of knowledge [12]. To create specialised glossaries, there are certain steps which follow. Firstly, selection of users the glossary is intended for. Secondly, the volume of the glossary has to be determined (i.e. discipline and languages). Thirdly, the structure of the glossary has to be determined. This process includes deciding on the arrangement of words, terms or abbreviations; whether the order will be alphabetical or based on themes of a certain area or some other criteria. Furthermore, the components which will be included in the glossary will be determined *(i.e.* term in source language, term in target language, term definition and example in use). The next step is determining where the glossary will be inserted. They are usually inserted at the end of a book or scientific paper, but it is not so uncommon to find them at the end of each chapter. Moreover, glossaries on various themes are available on the internet [12]. The last two steps include selecting a team which will compose the glossary, bearing in mind that in the case of specialised glossary the team should be interdisciplinary and include professionals of the selected area as well as a lexicographer [13]. Finally, a plan for glossary maintenance should be developed. Even though, specialised glossaries are less prone to revisions, it is advisable to secure a mechanism for submitting mistakes, proposing additional translations or explanations, proposals for adding new terms (via e-mail or online form). This paper includes terms in English as a source language with definitions and their translation into Croatian as a target language.

5. GLOSSARY OF CHEMICAL-BIOLOGICAL HAZARDS

This part of the paper focuses on presenting the glossary of the area of chemical-biological hazards with practical use. Before presenting the glossary itself, it will be explained which corpus was used and how the terms were selected. Corpus is a compilation of linguistic material selected and collected based on linguistic criterial to form a linguistic pattern [14]. The following literature was used for forming this glossary: *Kemijske i biološke opasnosti* (Zlatko Jurac), *Environmental Chemistry* (Gary W. VanLoon, Stephen J. Duffy) and *Ekotoksikologija* (Tahir Sofilić). *Glossary of Chemical Hazard Terms (WHO)* [15] was used for the majority of terms and definition in the English language in addition to the *Glossary of Terms on Chemical Safety* (ILO) [16]. The terms included in the following glossary (Table 1) and which relate to chemical-biological hazards are manly terms which are commonly used in the courses of Safety and Protection in addition to mandatory and additional literature and the related laws and regulations. The glossary contains three components: the terms are listed alphabetically in English as the source language, following by a definition in English and their Croatian translation. The goal of this

paper is to systematise basic terminology used in the area of chemical-biological hazards and in the courses of Safety and Protection, and it is intended for students of the related studies or anyone interested in studying literature in English or Croatian.

Table 1: Glossary

English	Definition	Translation
action level	OSHA concentration calculated as an 8-your time-weighted average	razina otpornosti
acute health effect	a severe effect which occurs rapidly after a brief intense exposure to a substance	akutni zdravstveni štetni učinak
acute effects	effects that occur rapidly following exposure and are of short duration (WHO, 1979).	akutna toksičnost
asphyxiant	a chemical (gas or vapour) that can cause death or unconsciousness by suffocation.	asfiksijant
bioconcentration	a process leading to a higher concentration of a chemical in the organism relative to its environment (WHO, 1979).	biokoncentracija
carcinogen	a substance that causes cancer in humans or, because it has produced cancer in animals, is considered capable of causing cancer in humans.	kancerogen
chemical reactivity	a chemical's ability to react with other materials.	kemijska reaktivnost
chronic health effect	an adverse effect with symptoms that develop or recur very slowly, or over long periods of time as a result of continued or periodic exposure to the offending agent.	kronični zdravstveni štetni učinci
concentration	the amount of a substance present per unit of media.	koncentracija
corrosive	a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action	korozivno djelovanje
cytotoxin	a substance toxic to cells in culture or to cells in an organism.	citotoksini

death rate	an estimate of the proportion of a population that dies during a specified period.	stopa smrtnosti
explosive	a chemical that causes a sudden release of pressure, gas, and heat	eksplozija
eye irritant	a chemical which irritates the eye.	iritacija očiju
hazardous chemical	any substance or chemical which is a health hazard or physical hazard	kemijske opasnosti
hazard warning	any words, pictures, symbols appearing on a label that convey the hazards of the chemical(s) in the container.	upozorenje o opasnosti
health hazard	a harmful effect on health if an overexposure occurs.	opasnost po zdravlje
hepatotoxins	chemicals that cause liver damage.	hepatotoksini
highly toxic chemicals	a material which produces a lethal dose or lethal concentration	kemikalije visoke toksičnosti
inhalation	the breathing in of an airborne substance.	inhalacija
irritants	chemicals which cause reddening, swelling and pain when it contacts skin, eyes, nose	iritacija
label	any written, printed, or graphic material displayed on or affixed to containers of hazardous chemicals.	oznaka
mutagen	capable of changing (mutating) genetic material	mutagen
occupational exposure limits	maximum allowable concentration of hazardous substances in workroom.	granična vrijednost profesionalne izloženosti
permissible exposure limit (pel)	exposure limit established by OSHA	granica dopuštene izloženosti
reactivity	the ability of a substance to undergo a chemical change alone or with other substances	reaktivnost
respiratory hazard	a particular concentration of an airborne contaminant	respiratorne opasnosti
safety data sheet (SDS)	written or printed material concerning a hazardous chemical	sigurnosno tehnički list (SDS)
short term exposure limit (STEL)	a term used by the ACGIH to express the maximum concentration most workers can tolerate for a 15-minute exposure period	granična vrijednost za kratkotrajnu izloženost (STEL)
toxic	poisonous.	toksično

threshold limit value (TLV)	airborne concentration of a material to which most workers can be exposed during a normal daily and weekly work schedule	dopuštena granična vrijednost
time weighted average (TWA)	a technique for averaging individual variant measurements over an 8-hour workday.	vremenski ponderirana prosječna vrijednost
work area	a room or defined space in a workplace where hazardous chemicals are used	radno okruženje

6. CONCLUSION

One of the goals of monitoring efficiency of working conditions is to preserve health and safety. To ensure this is possible there are regulations applicable to the working environment. Each worker has to be provided with quality safety protective equipment to minimise any hazards related to workplace. The Safety and Protection Act regulates all issues related to safe work, employers' duties towards employees and vice versa. The glossary in this paper was made for the purpose of systemising terminology for the field of chemical-biological hazards. Naturally, it is important to spot the importance of the context which might shed more light on certain terms. Actually, in most cases without the context, it is impossible to understand the term in its full meaning. Furthermore, to fully understand a certain profession, a worker or a translator has to be completely familiarised with the terminology of a certain field, owing mainly to globalism and the fact that most of the literature is available in English, therefore, the terms have to be adequately translated from source to target language. However, it should also be noted that for some terms there is a Croatian translation, but also an international version used as often as a Croatian one. This glossary was made for the purpose of presenting at least some English terms from the field of chemical-biological hazards as well as their definition and the Croatian translation.

REFERENCES

[1] Preventa, *Available from*: https://preventa.hr/zastita-na-radu-upit/kemijske-stetnosti, A*ccessed:* 2022-05-26.
[2] Šaravanja, B. et al.: Istraživanje uvjeta radne okoline u tehnološkim procesima proizvodnje odjeće*, Tekstil*, **Vol.** (2018) 67 (5-6), pp. 146-154, *Available from:* https://hrcak.srce.hr/229012, *Accessed*: YYYY-MM-DD.
[3] Štajner B.: *Priručnik za usavršavanje specijalista zaštite na radu,* 2015

[4] Jurac, Z.: *Kemijske i biološke opasnosti,* Veleučilište u Karlovcu, ISBN 978-953-7343-39-2, Karlovac, (2010)
[5] Sofilić, T.: *Ekotoksikologija* Sisak. metalurški fakultet, 2014.
[6] Jurković, M., Tufekčić, Dž.: *Tehnološki procesi – Projektiranje i modeliranje,* JU Univerzitet u Tuzli, ISBN 9958-609-03-7, Tuzla, (2000)
[7] Begović,V.: *Unapređivanje zaštite na radu i zaštite zdravlja radnika u javnom sektoru,* Matica hrvatskih sindikata, (2019)
[8] Sombol, S., *Rukovanje opasnim kemikalijama,* 2016, *Available from*: https://uznr.mrms.hr *Accessed*: 2022-05-27.
[9] Hrvatska enciklopedija, online edition. Leksikografski zavod Miroslav Krleža, *Available from* http://www.enciklopedija.hr, *Accessed*: 2022-05-27
[10] International Information Centre for Terminology, *Available from* http://www.infoterm.info/, *Accessed*: 2022-05-24.
[11] Struna – Hrvatsko strukovno nazivlje. *Available from* http://struna.ihjj.hr/page/o-struni/, *Accessed*: 2022-05-29.
[12] Teaching Tip: Glossaries? What Glossaries? Why Glossaries? Where Glossaries?. Pedagogical Development Office, Vanier College, 2012 , *Available from:* https://www.vaniercollege.qc.ca, *Accessed*: 2022-05-29.
[13] Martínez Motos, R.: The Role of Interdisciplinarity in Lexicography and Lexicology. In Balteiro, I. (Ed.), New Approaches to Specialized English Lexicology and Lexicography. Cambridge Scholars Publishing, 2011, *Available from*: https://www.cambridgescholars.com/resources/pdfs/978-1-4438-2577-1-sample.pdf, *Accessed*: YYYY-MM-DD.
[14] Tadić, M.: Raspon, opseg i sastav korpusa hrvatskoga suvremenog jezika, *Filologija*, **Vol.** (1998) 30. – 31., pp. 337 – 347
[15] International Labour Organization: Glossary of Terms on Chemical Safety, *Available from:* https://www.ilo.org *Accessed*: 2022-05-29.
[16] WHO: Glossary of Chemical Hazard Terms, *Available from*: https://ehs.uccs.edu *Accessed*: 2022-06-07

Analysis of the confined spaces atmospheres in a wastewater drainage network

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Abstract: *There is an underground technical infrastructure for the disposal of wastewater in most of urban areas, which is periodically targeted for maintenance and rehabilitation by specialized workers, or even used more specifically by authorities or emergency forces. Each entry point can be considered a separate confined space, where there are hazardous atmospheres to the physical integrity of the workers.*

To understand the hazards to which all subjects are exposed, a systematic and exhaustive analysis was carried out in the interior atmosphere of the manholes in the wastewater drainage network, in the entire eastern zone of the city of Beja, the gases produced and at those facilities.

The collection of the data was performed when the network was its normal state of exploration, had minimum flows. The flow rates were classified as minimum, after analyzing the readings of recording of the flow meters installed in the zones of measurement and control of the water distribution network, in two very distinct periods.

Keywords: *Safety in confined spaces, Dangerous atmospheres, Drainage network, Combustion and fermentation gases*

1. INTRODUCTION

The research in question is regulated by specific legislation that obliges companies to comply with all requirements issued, thus safeguarding the health and physical integrity of their workers by introducing prevention procedures based on the legislation described.

Portuguese law, Portaria 762/2002 of July 1 aims to establish a set of requirements to ensure the safety, hygiene, and health of workers in the operation of public water distribution systems and public drainage systems for domestic, industrial, and rainwater [3].

It states that specific risk factors inherent to the operation activities of water supply systems and wastewater systems are those that result, namely, from the following situations: - Insufficient atmospheric oxygen and the existence of dangerous gases or vapors in the network in question, more specifically in the manholes of the wastewater drainage network.

The circular manholes are composed of prefabricated rings and eccentric cone obeying, respectively, the Portuguese standards NP 881 and NP 882. These manholes have, as a rule, body in prefabricated concrete rings of 1.00 m diameter for heights up to 2.50 m and 1.25 m diameter for greater heights.

According Portuguese Law, Decreto Regulamentar 23/95, 23th of August, they are composed of:

- Threshold, formed in general by a concrete slab that serves as a foundation for the walls;
- Body, formed by the walls, with layout in plan usually rectangular or circular;
- Roof, flat or asymmetrical truncated cone-shaped, with a vertical generator in the continuation of the body to facilitate access;
- Access device, formed by recessed steps or a fixed or removable ladder, the latter to be used only for depths of 1.7 m or less;
- Strong locking device.

2. TECHNICAL REQUIREMENTS

The collection method is based on quantitative data, taken in a real context from the interior atmospheres of the manholes of the wastewater drainage network in the urban East zone of the city of Beja., Portugal

A 5% sample of each interval of the level quotas that compose the same drainage network was considered, being that for the East zone, readings were collected in about 61 cases during two distinct periods of the day, one in the morning between 10 am and 12 pm and the other in the afternoon between 3 pm and 5 pm [1].

The method used for the collection was based on the comparison of readings of the flow meters that record the daily consumption of water distributed to the network, where by its analysis, it can be verified in the normal operating regime the time intervals in which the water network is with reduced values in its daily distribution which, in turn, gives the indicator of minimum flow in the network of wastewater drainage due to consumption being reduced in the distributed water [2].

Parameters analyzed:

- Hydrogen Sulfide (H_2S)
- Methane (CH_4)
- Carbon Monoxide (CO)
- Oxygen ($O_{2)}$
- Depth
- Temperature

Methodology:

- Collection of outdoor temperature reading near the manhole cover
- Calibration of the multi-gas detector with reference to the outside atmosphere
- Opening the manhole cover
- Simultaneous introduction of the probes into the manhole, collection of readings and depth measurement
- Closing of the manhole cover

3. RESULTS

The data were collected at all elevations in the eastern part of the city of Beja, Portugal, between elevations 156 and 290 m above the sea line.

In the morning period, eight hydrogen sulfide readings are collected in eight manholes throughout the analysis area. In the afternoon period the number of manholes with Hydrogen Sulphide records increases by 4 more, increasing the record values to the amount of 12 manholes in the urban network that present Hydrogen Sulphide values. The results taken in the morning period are higher at higher elevations than at lower elevations (fig 1).

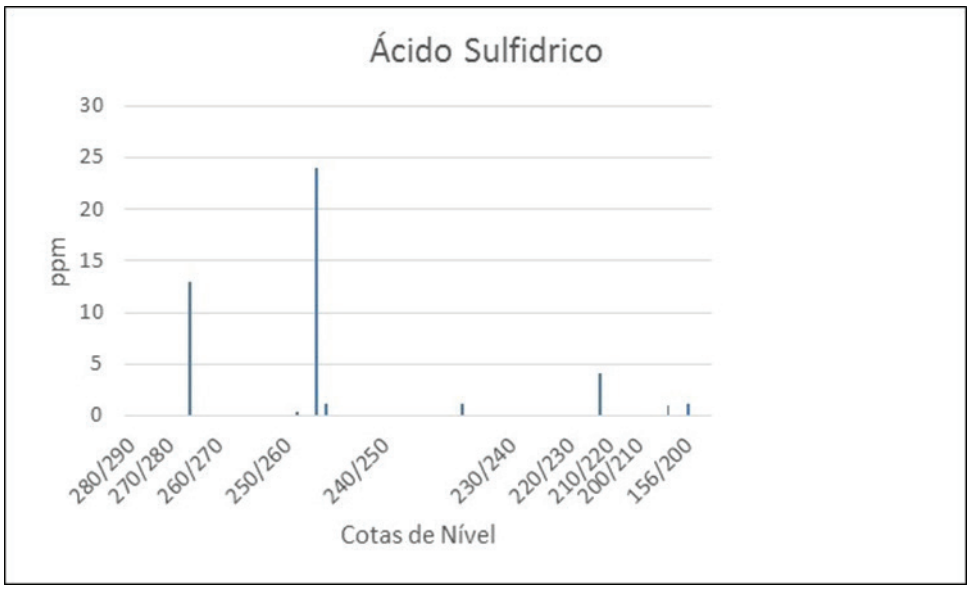


Figure 1 - Hydrogen Sulfide concentrations in the morning reading periods

In the afternoon period there is an inverse behavior, with higher values at lower levels while at higher levels the records made show lower values (fig. 2).

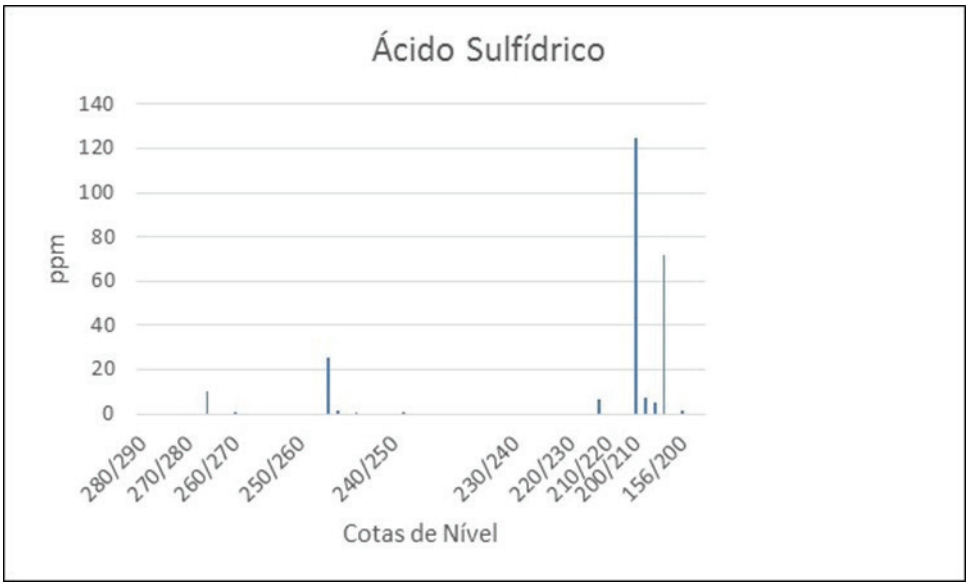


Figure 2 - Hydrogen Sulfide concentrations in the afternoon reading periods

Methane is recorded at elevation level in the morning in 1 manhole, in the afternoon, it is also recorded in 1 manhole at elevation level, throughout the entire analysis area in the other elevations there are no recorded values for methane, with a reading of 0 % LEL (fig. 3 and fig. 4).

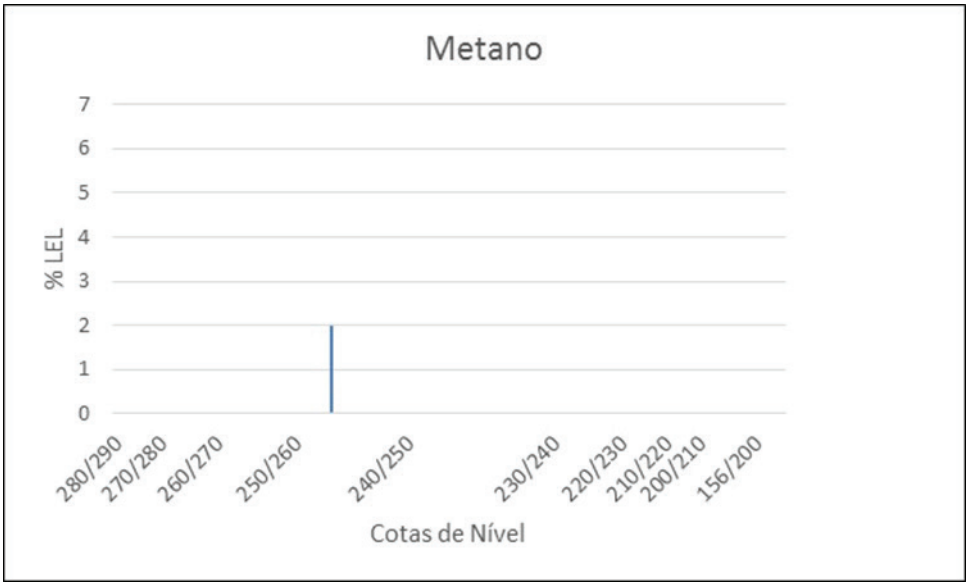


Figure 3 - Methane concentrations in the morning reading periods

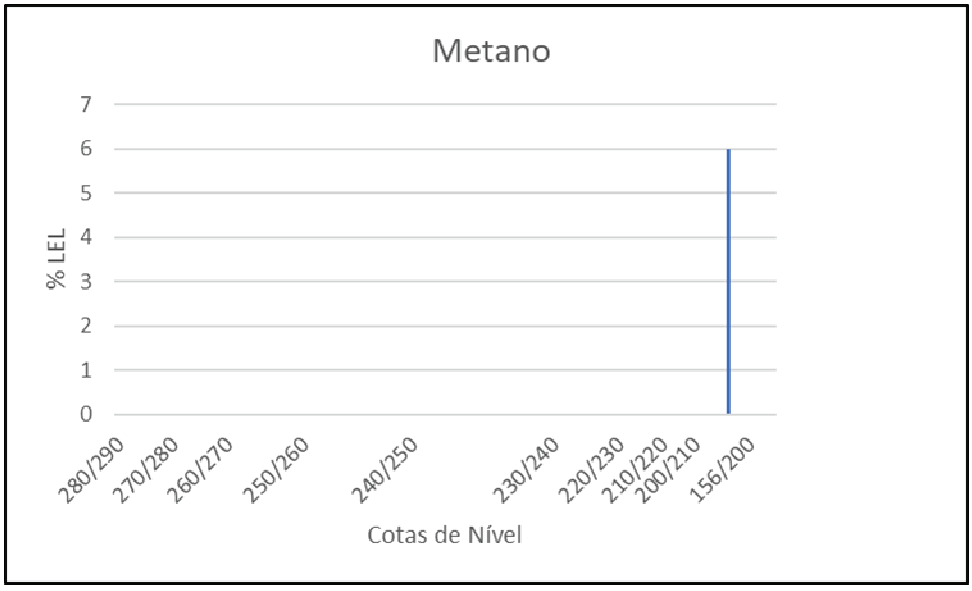


Figure 4 Methane concentrations in the afternoon reading periods

The Carbon Monoxide is observed during the morning. In the afternoon period besides the registers being maintained in the same elevations of the morning, this, is

also witnessed in 2 more manholes in the middle elevations, in the other elevations of the analysis area no register values are obtained for the gas, this presents a reading of 0 ppm (fig. 5 and fig. 6).

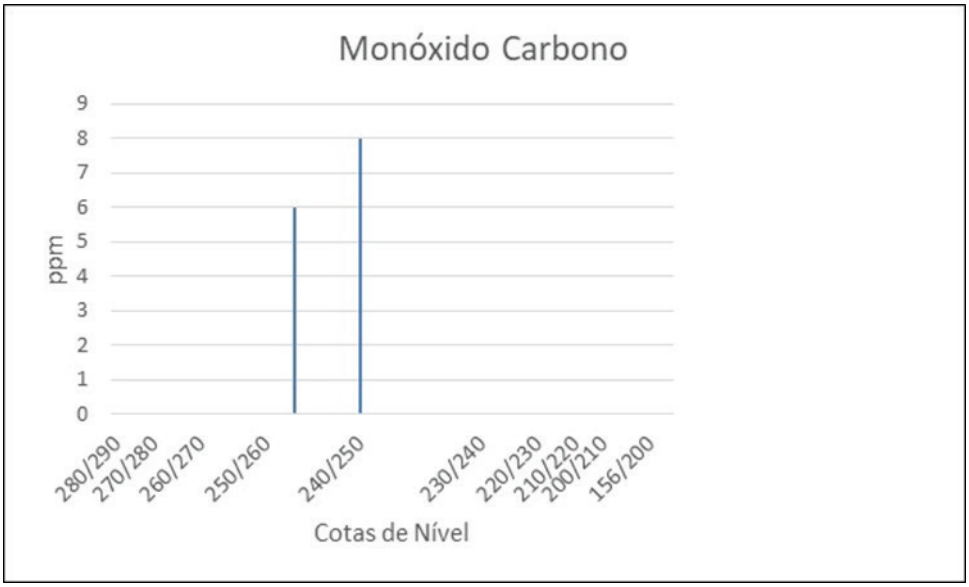
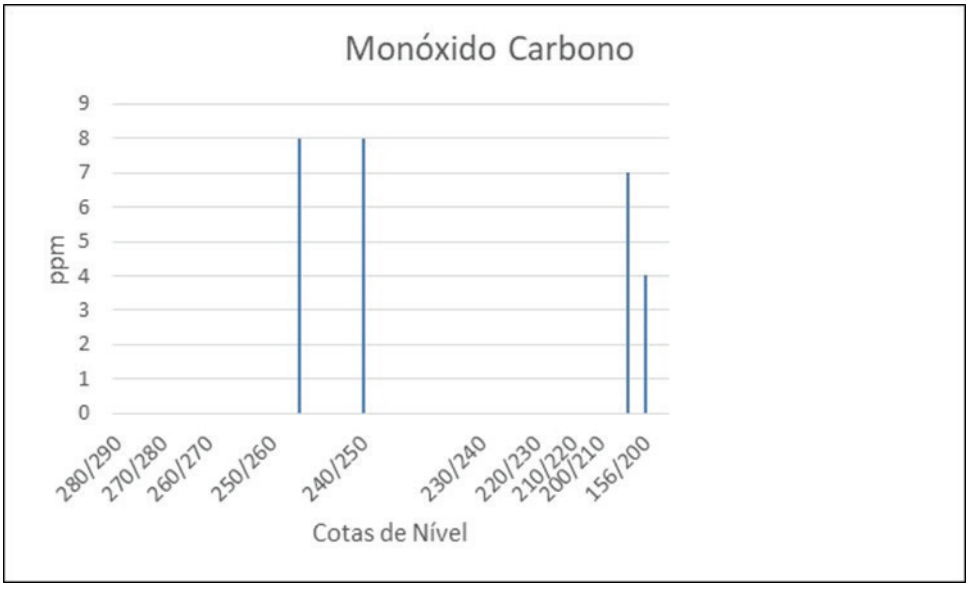


Figure 5 - Carbon monoxide concentrations in the morning reading periods



The values of Oxygen, these, present themselves reduced with some expression in two distinct cases. In the other the values within the permissible parameters for the presence of workers (fig. 7 and fig. 8).

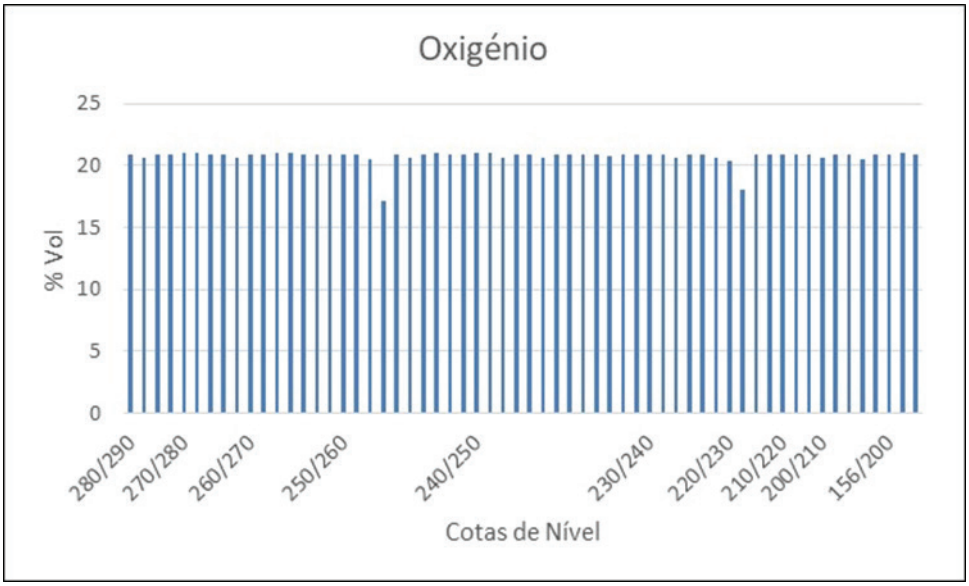


Figure 7 - Oxygen concentrations in the morning reading periods

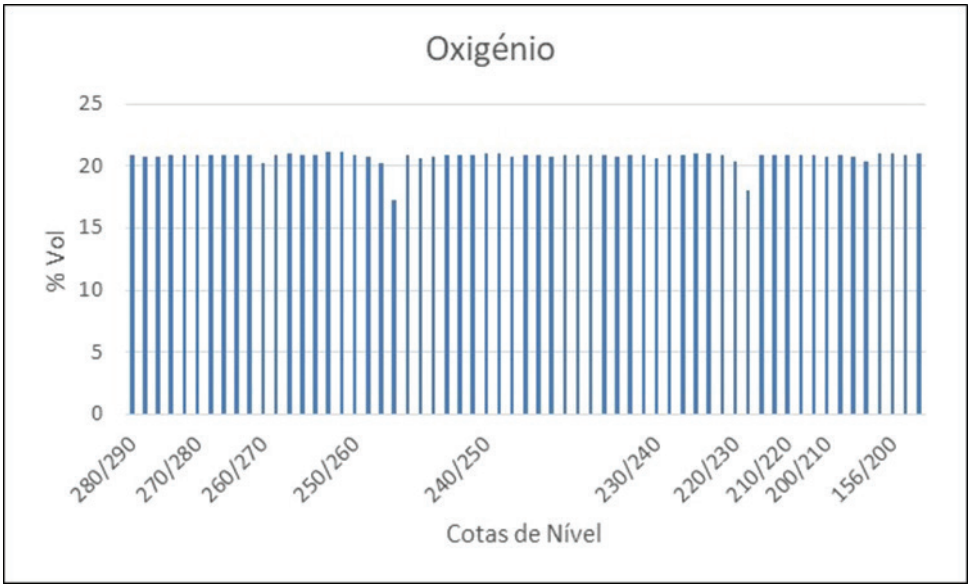


Figure 8 - Oxygen concentrations in the afternoon reading periods

The manholes studied vary in depth between 0.73 m and 5.48 m.

In the morning period the outside temperatures were always higher than the inside temperature, with the range of 24ºC - 34ºC for the inside temperatures and the range of 24.4ºC - 39.5ºC for the outside temperatures.

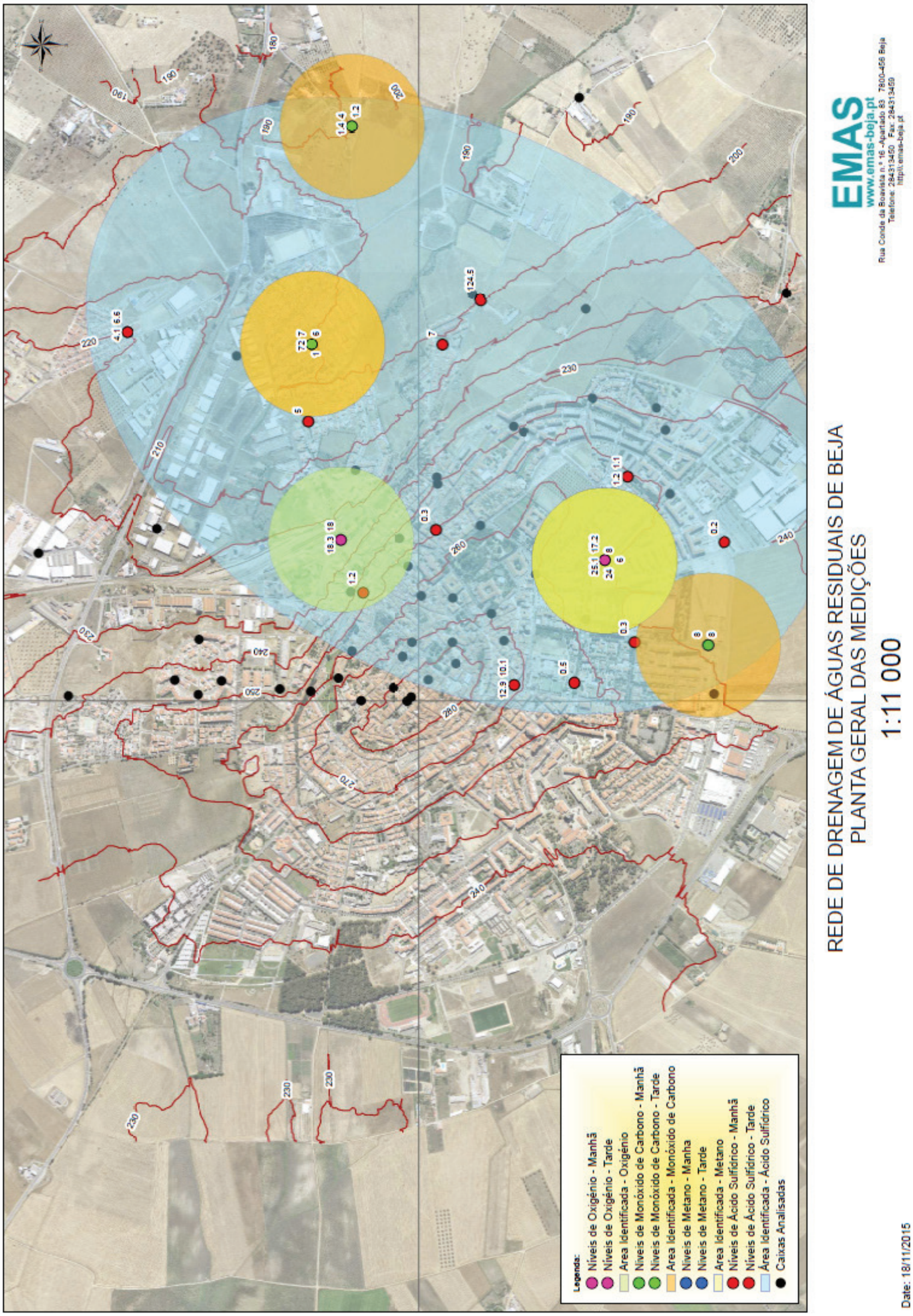
As for the analysis made in the afternoon, the outside temperatures were always higher than the inside temperatures, with the range of 30ºC - 40.9ºC for the inside temperatures and the range of 31.3ºC - 43ºC for the outside temperatures.

4. CONCLUSION

By the values obtained, it is verified the existence of the most problematic areas for the integration of workers in future works in the manholes of the urban wastewater network.

It was then elaborated the risk map relative to the manholes of the city of Beja, obtained through the collection and analysis of the collected data (fig. 9).

These maps will be very important to safeguard the integrity of the company's workers, as well as other entities that may have to resort to this infrastructure, such as paramedics, firefighters, subcontractors, among others.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Legenda:
Níveis de Oxigénio - Manhã
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Área Identificada - Monóxido de Carbono
Níveis de Metano - Manha
Níveis de Metano - Tarde
Área Identificada - Metano
Níveis de Ácido Sulfídrico - Manhã
Níveis de Ácido Sulfídrico - Tarde
Área Identificada - Ácido Sulfídrico
Caixas Analisadas
Date: 18/11/2015

REFERENCES

[1] Sousa, Vera Mónica Almeida, *Estudo das emissões gasosas por processos de Desodorização*, Master Thesis, Faculdade de Engenharia da Universidade do Porto (2009)
[2] Dias, Teresa Maria Madeira, A Directiva ATEX 137 em Saneamento Básico, Master Thesis, Faculdade de Engenharia da Universidade do Porto (2008)
[3] EMAS, Regulamento dos Sistemas Públicos e Prediais de Drenagem de Águas Residuais do Município de Beja, Regulamento nº 283/2013, Diário da República nº 138/2013, Série I de 2013-07-19 (2013).

SURFACE MODIFICATION OF POLYESTER FABRIC AT LOWER TEMPERATURE

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Abstract: *Polyester hydrolysis is conventionally carried out using alkali at a temperature higher than 100 °C. For the purpose of economy and energy savings, the possibility of polyester hydrolysis at reduced temperature was investigated. For this purpose, standard polyester fabrics (PES) were treated in 1.5 M NaOH with addition of the cationic surfactant hexadecyltrimethyl ammonium chloride (HDTMAC) as an accelerator at temperature range from 70 to 90 °C in the time 5-60 min. The change in mass per unit area and breaking force, whiteness, and ability to manage moisture were tested according to standardized methods. The results were compared with the start PES fabric and the reference sample, alkaline hydrolyzed at 100 °C. For selected treatments Scanning Electron Microscopy analysis was performed using FE-SEM, Mira II, LMU, Tescan. It has been shown that it is possible to carry out alkaline hydrolysis at a lower temperature with the addition of an accelerator. Treatment at 80 °C with the addition of HDTMAC in 30 minutes gives the best results, and such a process is energetically and economically sustainable.*

Keywords: polyester, alkaline hydrolysis, accelerator, moisture management, SEM.

1. INTRODUCTION

Polyester fibers (PES) are the most common man-made fibers on the market due to its strength, resistance to chemicals, light and microorganisms, dimensional stability and fast drying. However, due to its high degree of crystallinity (65-85%), the lack of polar groups in the polymer chain makes PES fibers hydrophobic with a low moisture absorption, the ability to accumulate electrostatic charges and soiling, and the tendency to create peeling [1-7]. To eliminate these disadvantages, the surface of polyester fibers can be modified. Polyester hydrolysis is conventionally carried out using alkali (NaOH or KOH of concentration 4-20%) at a temperature higher than 100 °C what is not environmentally or energetically friendly. Such treatment increases fineness, hydrophilicity, absorbency, softness and easy care [3-

7]. Under alkaline conditions the hydroxyl ion reacts with oxygen in the carbonyl group of the ester to give the carboxyl and hydroxyl groups. Since highly ionized inorganic compounds cannot diffuse into nonpolar PES fiber, and the reaction takes place on the surface and while the fiber decreases in diameter and fabric in weight [4]. High temperatures and strong alkalis cause irreversible damage, so the treatment conditions should be controlled. The optimal weight loss is 10-20%, and in the strength (mechanical damage calculated from the breaking force) is up to 35-45% [5-7]. Regarding the alkali hydrolysis of poly(ethylene-terepthalate), it is well known that some cationic surfactants can accelerate the reaction [5-7]. Therefore, the possibility of hydrolysis of standard polyester with an accelerator at lower temperature was investigated in this paper.

2. MATERIAL AND METHODS

A standard polyester fabric by WFK (30A, code 30000) of 170 g/m^2 mass per unit area was used. It was modified by alkaline hydrolysis without and with addition of 4 g/l cationic surfactant hexadecyltrimethyl ammonium chloride (HDTMAC, 25% solution in water, Sigma-Aldrich) as an accelerator. It was carried out in 1.5 mol/l NaOH by exhaustion method in Linitest (Original Hanau) with a liquor ratio of LR 1:50 at 70, 80, and 90 °C. Treatment time was 30 and 60 min without addition, and 5, 10, 15, 30, 45 and 60 min with addition of accelerator. Conventional alkaline hydrolysis was performed for 5, 10 and 15 min at 100 °C as reference. After treatment, rinsing was carried out in hot, warm and cold distilled water; neutralization with 1% HCl, then rinsing to neutral and air dried.

The mass per unit area (m) [g/m^2] was determined according to ISO 3801:1977 using weighing on a KERN digital scale, model ALJ 220-5DNM of accuracy 0.0001 g, and the weight loss (Δm) was calculated. The breaking force (F) [N] was measured according to ISO 13934-1:2013 using the Tensolab, MESDAN-LAB dynamometer, and the loss in strength (ΔF) was calculated. Spectral remission was measured on a Spectraflash SF 300 remission spectrophotometer, Datacolor. Degree of whiteness, W_{CIE}, in accordance to ISO 105-J02:1997 and Yellowness Index, YI, to DIN 6167:1980-01 were automatically calculated. Liquid Moisture Management Properties were determined according to AATCC 195-2017 using SDL Atlas Moisture Management Tester (MMT M290). The morphology of fibers in selected polyester fabrics was analyzed on micrographs taken on a scanning electron microscope (SEM) FE-SEM, Mira II, LMU (Tescan) with a magnification of 3000×. The fabrics were coated with a thin layer of chromium for 120 s.

3. RESULTS AND DISCUSSION

The results of the weight loss and the loss in strength calculated from breaking force after alkaline hydrolysis of the standard polyester fabric at different temperatures without and with addition of an accelerator are shown in Figures 1 and 2. It can be observed that alkaline hydrolysis of standard polyester fabric (STD) at 100 °C for 60 min results in slightly higher loss than desired, 22.21%, while the weight loss for 30 min is less than 10%. With the weight loss, the loss in strength occurs due to decreasing of fiber diameter. The loss in strength after 30 min of alkali treatment is 25.39% and after 60 min slightly higher than the tolerance limit, 46%.

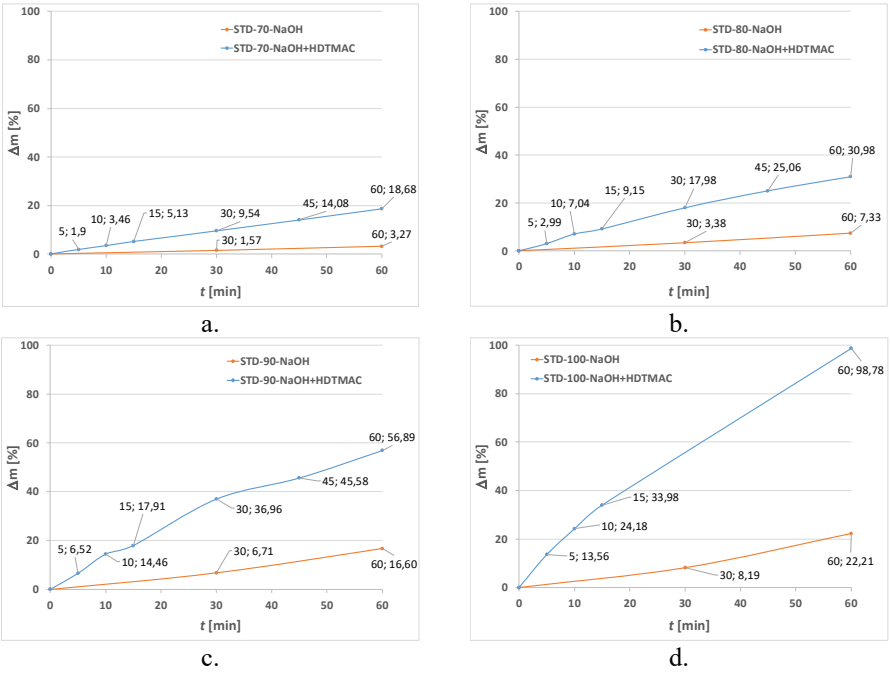
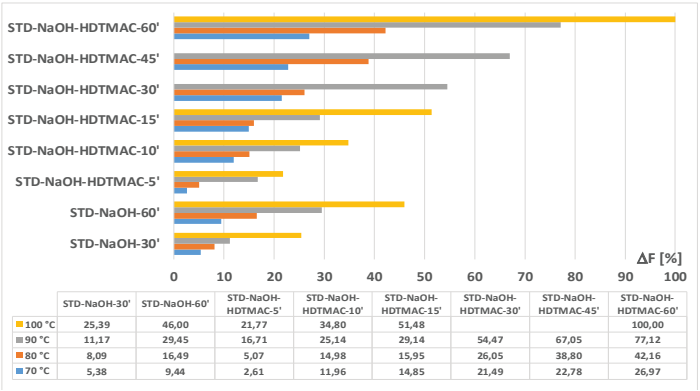


Figure 1: Weight loss (*Δm*) of standard polyester fabric after alkaline hydrolysis at a. 70 °C; b. 80 °C; c. 90 °C and d. 100 °C

The results clearly indicate that HDTMAC is an excellent accelerator of this reaction. The desired weight loss is achieved in 5 min (weight loss 13.56%, loss in strength 21.77%). After 10 min there is a weight loss of 24.18%, and 34.80% loss in strength. Further processing leads to higher weight loss and complete degradation after 60 min. For the purpose of energy efficiency, the alkaline hydrolysis with the addition of HDTMAC was further researched at lower temperature of 70, 80 and 90 °C. From the results of weight loss and the loss in strength it can be seen that alkaline hydrolysis at 90 °C without addition of accelerator for 60 min leads to weight loss of 16.6% with loss in strength of 29.45% and this is the optimal reaction

time. The addition of HDTMAC shows a weight loss of 14.46% for 10 and 17.91% for 15 min with loss in strength of 25.14% and 29.14% respectively. Increasing the treatment time leads to a significant increase in weight loss and fabric damage. The fabric treated for 60 min has a weight loss of 56.89% and loses 77% of its strength and is not acceptable for usage. By reducing the temperature to 80 °C, the alkali-treated fabric without the addition of an accelerator for 60 min of treatment has a weight loss of 7.33%, which is low, and the treatment time should be extended. With the addition of the accelerator, almost the same weight loss of 7.04% is achieved in 10 min, and the optimal weight loss of 17.98% is achieved after 30 min with loss in strength of 26%. These results show that it is possible to carry out hydrolysis in a more energy-efficient way. Alkaline hydrolysis at 70 °C without the addition of an accelerator does not achieve the desired result even after 60 min; weight loss is only 3.27%. Adding the HDTMAC the desired result can be achieved after 45 min of treatment, with a weight loss of 14.1% and the loss in strength of 22.78%. After 60 min the weight loss is 18.68% which is also within the tolerance limits.



	STD-NaOH-30'	STD-NaOH-60'	STD-NaOH-HDTMAC-5'	STD-NaOH-HDTMAC-10'	STD-NaOH-HDTMAC-15'	STD-NaOH-HDTMAC-30'	STD-NaOH-HDTMAC-45'	STD-NaOH-HDTMAC-60'
100 °C	25,39	46,00	21,77	34,80	51,48			100,00
90 °C	11,17	29,45	16,71	25,14	29,14	54,47	67,05	77,12
80 °C	8,09	16,49	5,07	14,98	15,95	26,05	38,80	42,16
70 °C	5,38	9,44	2,61	11,96	14,85	21,49	22,78	26,97

Figure 2: The loss in strength (ΔF) of standard polyester fabric after alkaline hydrolysis at temperatures of 70, 80, 90 and 100 °C

The degree of whiteness (W_{CIE}) and the Yellowness Index (YI) were determined after alkaline hydrolysis. From the results presented in Table 1, it can be seen that the treatment did not significantly change the whiteness or resulted in fabric yellowing.

Table 1: CIE whiteness (W_{CIE}) and Yellowness Index (YI) of standard polyester fabric before and after alkaline hydrolysis

	t	70 °C		80 °C		90 °C		100 °C	
Sample	[min]	W_{CIE}	YI	W_{CIE}	YI	W_{CIE}	YI	W_{CIE}	YI
STD	0	79.5	2.04	79.5	2.04	79.5	2.04	79.5	2.04
STD-	30	78.9	2.00	79.4	1.83	79.3	1.87	78.6	1.69
NaOH	60	80.0	1.75	79.6	1.72	78.7	1.78	78.3	1.83
STD-	5	78.0	2.37	78.9	2.09	79.5	1.58	80.5	1.46

NaOH+ HDTMAC	10	79.1	2.02	78.6	1.94	78.7	1.99	78.4	1.86
	15	78.7	2.17	79.3	1.85	79.5	1.74	78.5	1.78
	30	78.9	1.95	79.6	1.65	79.2	1.45	-	-
	45	79.1	1.76	78.3	1.82	78.7	1.47	-	-
	60	78.4	1.86	78.4	1.61	77.3	1.60	-	-

For selected fabrics the results of Liquid Moisture Management properties determined according to AATCC 195-2017 are shown in Table 2 and morphology on SEM micrographs in Figure 3. OMMC indicates the overall capability of the fabric to manage the transport of liquid moisture, and based on the results, MMT classifies fabrics. The results of the moisture management of untreated standard fabric indicate a short wetting time and a small wetting radius indicating a hydrophobic surface. Therefore, OMMC suggests "Water Penetration Fabric", which means "it breaths". In the case of hydrolyzed standard fabrics, the type of fabric is similar, but there is a change in the moisture management properties. The reason for this is the change in surface area and better absorption, so that a small amount of water binds to new surface groups of fibers. It can be seen that MWR is higher, as well as SS.

Table 2: Moisture management properties of selected standard polyester fabrics

		STD	NaOH-100 °C-60'	NaOH+ HDTMAC-100 °C-10'	NaOH+ HDTMAC-90 °C-10'	NaOH+ HDTMAC-80 °C-30'	NaOH+ HDTMAC-70 °C-60'
WT [s]	T	4.82	80.02	6.58	3.09	6.28	8.29
	B	4.94	7.28	2.06	3.72	6.04	7.94
AR [%/s]	T	7.50	7.82	9.23	16.08	6.83	7.53
	B	51.60	67.76	23.62	41.11	47.36	63.37
MWR [mm]	T	6.25	5	12.5	11.25	7.5	6.25
	B	5	5	15	15	8.75	8.75
SS [mm/s]	T	5.056	0.063	13.632	7.638	0.951	0.714
	B	5.012	0.671	10.109	7.837	1.008	0.81
R [%]		667.27	893.29	483.84	374.22	588.08	681.75
OMMC		0.64	0.66	0.70	0.67	0.61	0.65
Type of fabric		Water Penetration Fabric	Water Penetration Fabric	Water Penetration Fabric	Moisture Management Fabric	Water Penetration Fabric	Water Penetration Fabric

*Top (T) and Bottom (B) surface; Wetting Time (WT), Absorption rate (AR), Maximum wetted radius (MWR), Spreading speed (SS), Accumulative One-way Transport Capability (R) and Overall (liquid) Moisture Management Capability (OMMC).

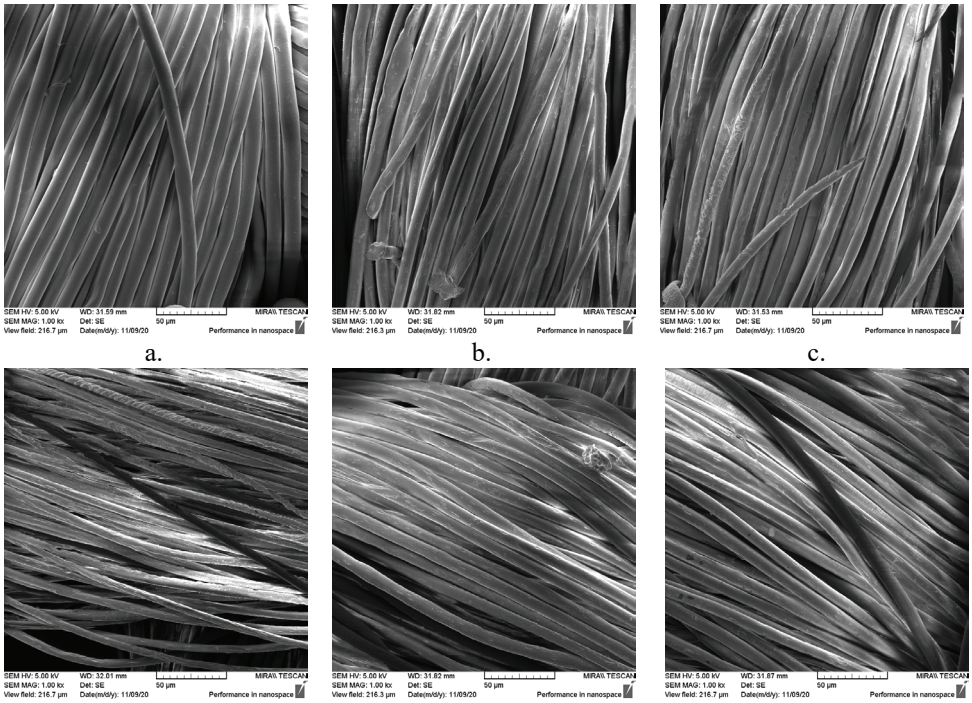


Figure 3: SEM micrographs of polyester fibers in fabrics at magnification 1000×: a. untreated; b. NaOH-100 °C-60'; c. NaOH+HDTMAC-100 °C-10′; d. NaOH+HDTMAC-90 °C-45′; e. NaOH+HDTMAC-80 °C-30′; f. NaOH+HDTMAC-70 °C-60′

In the case of hydrolyzed fabrics, it is similar, but in the case of alkali hydrolysis with the addition of accelerator at 90 °C for 10 min, even better transport and "Moisture Management Fabric" were achieved.

The fibers in the untreated fabric have a smooth surface (Figure 3a). Due to alkali action on surface hydrolyzed fibers shallow craters are clearly visible on the surface, confirm that the modification was carried out under optimal conditions (Figure 3b, c, e, f). As example in Figure 3d highly damaged fiber can be seen. It has deeper craters and holes which correlate with a high weight loss and loss of strength.

4. CONCLUSION

In this paper the hydrolysis of standard polyester fabric at lower temperature (70-90 °C) without and with addition of the cationic surfactant HDTMAC as an accelerator was researched for the purpose of economy and energy savings. HDTMAC has proven to be very efficient accelerator. At 100 °C the optimal results can be achieved in 5 min instead 60 min. At lower temperatures, taking into account all tested parameters, optimal effect can be achieved in 10 min at 90 °C, 30 min at

80 °C and 60 min at 70 °C. It is to point out treatment at 80 °C for 30 min with the addition of HDTMAC as economic and energy friendly due to lower temperature and shorter treatment time.

REFERENCES

[1] Čunko, R.; Andrassy, M.: *Vlakna*, Zrinski d.d., ISBN 953-155-089-1, Čakovec, (2005.)
[2] Grishanov, S.: 2 - Structure and properties of textile materials, In *Handbook of Textile and Industrial Dyeing: Principles, Processes and Types of Dyes*, Volume 1, Woodhead Publishing Series in Textiles (Ed. M. Clark), Sawston, Cambridge, ISBN 9780857094919, (2011), pp. 28-63
[3] Grancarić, A.M.; Soljačić, I.; Rukavina, I. & Čavar, T.: Utjecaj obrade na efekte alkalne hidrolize poliestera, *Tekstil,* **37** (1988.) 12, pp. 689-694, ISSN 0492-5882
[4] Grancarić, A.M. & Kallay, N.: Kinetics of polyester fiber alkaline hydrolysis: Effect of temperature and cationic surfactants, *Journal of Applied Polymer Science,* **49** (1993) 1, pp. 175-181, ISSN 1097-4628
[5] Gawish, S.M.; Bourgeois, M. & Ambroise, G.: Effect of Cationic Surfactants on the Alkaline Hydrolysis of Polyester Fabrics, *Am. Dyest. Report.*, **75** (1986), pp. 19–24, ISSN 0002-8266
[6] Čorak, I.; Tarbuk, A.; Đorđević, D.; Višić, K. & Botteri, L.: Sustainable Alkaline Hydrolysis of Polyester Fabric at Low Temperature, *Materials*, **15** (2022) 4, ISSN 1996-1944

The work of Ivana Čorak has been supported in part by the "Young researchers' career development project–training of doctoral students" of the Croatian Science Foundation. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Croatian Science Foundation. This work has been supported in part by Croatian Science Foundation under the project UIP-2017-05-8780 HPROTEX. This work is a result of Croatia-Serbia cooperation in science and technology, 2019–2022 entitled "Bio-innovative polyesters".

OPTIMIZATION OF THE WASHING PROCESS FOR HOSPITAL TEXTILES

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Abstract: *In this paper, the lowering of the washing temperature in the standardized washing process ISO 15797:2017 and the new, environmentally friendly agent for chemical bleaching and disinfection were researched. The main objective was to maintain the quality of textiles after the washing process according to the requirements for textiles washed in a hospital environment. Standard pigment/sebum stains and blood stains on cotton and cotton/polyester blends were selected to monitor the primary effect over 10 wash cycles. The effect of the standardized and optimised washing process was additionally monitored by the so-called secondary effects, with the 3rd and 25th wash cycles serving as control points. It was found that the optimised process achieves the rationalization idea, resulting in a satisfactory washing effect, even at lower temperature.*

Keywords: *hospital environment, stains, cotton based textiles, washing process, optimization*

1. INTRODUCTION

Washing is a complex process carried out in an aqueous medium. According to the concept of Sinners' cycle, the washing result is a combination of four parameters: mechanical action, chemistry, temperature and time. These parameters affect the washing performance [1]. Sinner's cycle describes the principles of the washing process and explains that the reduction of one of these parameters, i.e. water or energy, should be compensated by another parameter, needs an increment of other parameter, i.e. a longer time or an increase in chemistry, to achieve a certain performance [1-3]. Although the main purpose of the washing process is to remove soiling from textiles, the requirements in a hospital environment are somewhat more stricter. In addition to removing microorganisms from soiled and contaminated textiles, a satisfactory hygienic aspect, i.e. disinfection, must also be ensured [4,5].

In the Republic of Croatia, until 2018, there were no standards or guidelines for the washing and care of linen in health facilities. One of the tasks of the Ministry of Health at that time was to prepare Croatian national standards for the washing and care of linen in clinical and inpatient healthcare facilities. Since microbiological limits for textiles and water are not clearly defined, it was necessary to research laundry standards and good practise guidelines from EU countries [6].

In EU laundries, the quality and hygiene of the laundry is based on criteria assessed by standard methods defined by RAL GZ-992 (RAL - Reichs-Ausschuss für Lieferbedingungen, a German institute for quality assurance and certification). Quality is controlled by testing secondary effects on a standard control fabric after 25 or 50 washing cycles. These effects are analysed by examining the degree of damage and redeposition after repeated washing cycles. On the basis of the values determined and their comparison with the prescribed values, it is determined whether the conditions prescribed by the RAL have been fulfilled. Tolerance limits for individual parameters have been prescribed and developed, on the basis of which certain influences in the washing process can be controlled [7,8].

It is well known that hospital textiles are washed at a temperature of 75°C and higher, with peracetic acid (PAA) as a bleach, which has a significant impact on energy consumption [3]. Therefore, the aim of this research was to optimise the standardised washing process at 75°C by lowering the washing temperature and to introduce a new, ecologically favourable ε-phthalimido-peroxy-hexanoic acid agent (PAP).

2. MATERIALS AND METHODS

The standardised washing process according to ISO 15797:2017 for cotton (CO) and polyester/cotton (PES/CO) is performed at 75°C with peracetic acid (PAA) as a bleach. For the purpose of this research, the washing process was modified by the reduction of temperature (to 50°C) and by introducing a new bleaching additive, ε-phthalimido-peroxy-hexanoic acid (PAP), which can act as bleach and disinfection agent. The parameters of standard and optimised washing process is presented in Tab 1.

Table 1: Parameters of standard and optimised washing process

	Washing process				
	Standard (W75) with PAA		Optimised (W50) with PAP		
Washing program	CO	PES/CO	CO	PES/CO	Process
Load ratio	1:12	1:17	1:12	1:17	
Liquor ratio	1:4	1:4	1:4	1:4	Washing
Detergent [g/L]	4	4	4	4	
Bleach additive [g/L]	2	2	2	2	
Temperature [°C]	75±2	75±2	50±2	50±2	

Time [min]	20	20	20	20	
Cool down [min]	no	yes	no	yes	
Drain [min]	1	1	1	1	
Interspin [min]	1	1	1	1	
Liquor ratio	1:5	1:5	1:5	1:5	Rinsing, 3 times
Time [min]	3	3	3	3	
Drain [min]	1	1	1	1	
Interspin [min]	1	1	1	1	
Residual moisture [%]	50-55	35-40	50-55	35-40	

Secondary effects of washing performance were evaluated on a reference 100% cotton fabric according ISO 2267:1986. Standard CO and PES/CO fabrics, stained with the pigment/sebum (P-S) and temperature treated blood (B) by Wfk Testgewebe, Germany, were chosen for this research. Fabric were in plain weave, mass per unit area of 170 g/m^2, yarn density of 25±2 number of threads in warp and weft. Primary effect was evaluated by monitoring stain removal. For that purpose, 10 fabric samples of each soiling were washed for one washing cycle separately, and the average was evaluated.

Fabrics were subjected to washing cycles in Wascator FOM71 CLS (Electrolux) within 10 single washing cycles (for primary effects) and 25 repeated washing cycles (for secondary effects) using a standard detergent with optical brightener, of known and defined composition as defined in ISO 15797:2017.

The spectral characteristics of washed fabrics was measured on a remission spectrophotometer Spectraflash SF 300 (Datacolor). The whiteness degree and the tint deviation (TV, TD) were calculated automatically according to Ganz/Griesser, and CIE degree of whiteness according to ISO 105 J02:1997.

The breaking force and elongation of the cotton fabrics was measured by the strip method in the warp direction according to EN ISO 13934-1:2013, using a Tensolab 3000 dynamometer, Mesdan s.p.A. Mechanical damage (U_m) was calculated from the results of breaking force according to ISO 4312:1989. Ash content of cotton fabrics was determined according to ISO 4312:1989.

3. RESULTS AND DISCUSSION

In this paper, the standard procedure for washing hospital laundry was modified. Detergency properties, known as primary effects, were monitored on standard stains. The stained standard CO and PES/CO test fabrics were subjected to 10 single washing cycles according to the standard and the optimised procedure. The results of the primary effects are based on four individual measurements per sample (R_W) and are expressed as the difference between the mean values and the standard (R_0) at a wavelength of 460 nm (ΔR_{460}) (Fig. 1).

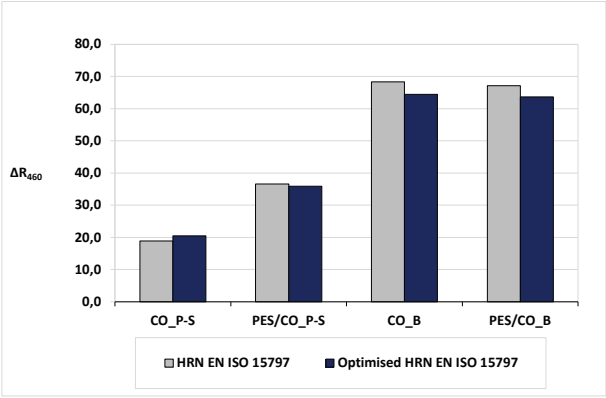


Figure 1: The primary effects on standard stained fabrics

The obtained values show satisfactory primary washing effects, even though the standard detergent does not contain enzymes which are necessary for specific stains, i.e. pigment/sebum and blood. For primary effects of pigment/sebum stained fabrics it can be seen that both fabrics have similar effect as in standard washing process at 75°C, while for CO the effect is even better. For blood, slightly weaker effect can be seen. In summary, the primary washing effect is almost identical for both standard stained fabrics since the remission differs by less than 4 units. By comparing the standard washing program at 75°C in relation to the modified washing program at 50°C, there is no significant difference in the ability to remove the tested types of stains. This modified washing program at a lower temperature provides not only economy, but also a satisfactory effect of washing and removing stains.

The impact of the optimisation of the standard washing process was determined on a reference cotton fabric after the 3rd (3W) and 25th (25W) washing cycle by secondary effects through the changes in strength, ash content and whiteness degree, Tab. 2 and Figs 2-3. Since RAL-GZ 992 prescribes the parameters of washing quality control only for cotton fabric, the PES/CO fabric was not investigated.

Table 2: The mechanical damage (U_m) and the changes in breaking force and elongation during washing CO fabrics at 75 and 50°C

Fabric	F_B [N]		ε [%]		U_m [%]
	σ [N]	CV [%]	σ [N]	CV [%]	
0W	66.47	6.12	13.80	2.66	-
75_3W	74.98	8.10	17.45	3.43	14.78
75_25W	60.57	6.67	22.06	3.73	16.36
50_3W	51.59	5.38	18.24	2.94	11.59
50_25W	75.51	8.17	20.82	1.29	14.87

*σ-std. dev., CV-variation coeff.

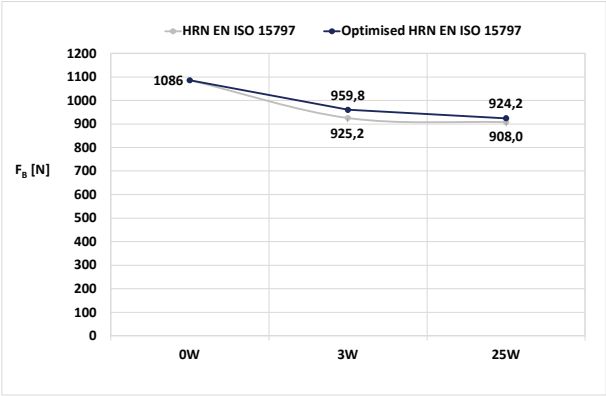
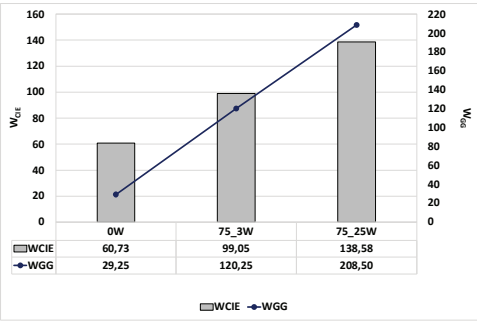


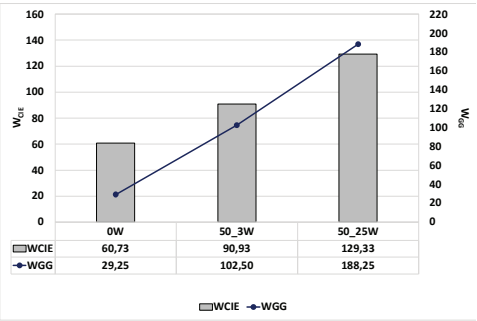
Figure 2: Breaking force (F_B) of washed CO fabrics at 75 and 50°C after 3rd and 25th washing cycle

The results obtained indicate that the washing causes changes in mechanical properties of the washed fabrics, Tab. 2 and Fig. 2. Breaking force decreases in comparison to the unwashed fabric, indicating fabric damage. The most prominent changes happen in the beginning washing process, i.e. up to 3rd washing cycle (14.78% at 75°C and 11.59% at 50°C after 3rd washing cycle). By increasing the number of washing cycles it can be observed that the loss in breaking force is lower, only additional 2.5% (16.36% for CO fabric washed at 75°C and 14.88% for CO fabric washed at 50°C). It can be noticed that with an increasing number of washing cycles the differences of mechanical damage (U_m) between CO fabrics washed at 75 and 50°C is similar, but at 50°C is still lower.

The whiteness degree of CO fabric washed with standardized and optimised washing process is presented in Fig. 3. The lowest whiteness degree shows the unwashed fabric, 0W (W_{CIE} 60.73, W_{GG} 29.25). During washing, the whiteness degree increases in both cases, and by standardized and optimised washing process. As a control points were taken 3rd and 25th washing cycle. From the results at these control points it can be seen that after three washing cycles a high whiteness is obtained (W_{CIE} 99.05 for the standardized program and 90.93 for the optimised). The increased number of washing cycles increases the whiteness. It can be explained by the presence of optical brightener from the standard detergent and their accumulation on a fabric surface. However, slightly lower values are accomplished by optimised washing procedure. The most likely reason is the type of optical brightener in standard detergent, which is probably intended for higher temperatures.



a.)



b.)

Figure 3: Whiteness degree of washed CO after 3rd and 25th washing cycle at: a.) 75°C and b.) 50°C

Monitoring of achieved effects from standard and optimised process is performed in accordance with the RAL-GZ 992 criteria. Results are collected in Tab 3.

Table 3: Washing quality criteria according to RAL-GZ 992 and obtained results

Quality parameter		RAL limit value after 25th cycles	CO_75	CO_50
Decrease in tensile strength		< 15 %	16.36	14.87
Whiteness quality	Whiteness (WG)	≥ 170	208.50	188.25
	Tint deviation (TV, TD)	R 1.5 – G 2.49	-1.1./R1	-1.1/R1
	Basic whiteness (Y)	> 85	84.8	90.6
Ash content		≤ 0.7 %	0.12	0.05

The results have confirmed that optimised washing process comply to all washing quality criteria related to RAL-GZ 992. Whiteness degree, tint deviation, basic whiteness, decrease in tensile strength and ash content are within the tolerance limits. It is to point out that standard washing process at 75°C, for decrease in tensile strength is above tolerance.

4. CONCLUSION

The evaluation of effectiveness of standard and optimised washing process was monitored by primary and secondary effects. The obtained results showed that optimised process fulfilled all the requirements defined in RAL-GZ 992. As hygiene is an important parameter for hospital environment, one of the future tasks will be to investigate the hygiene effectiveness of such optimised washing process.

REFERENCES

[1] Sinner, H.: Ueber das Waschen mit Haushaltwaschmaschinen: In *Welchem Umfange Erleichtern Haushaltwaschmachinen und—Geraete das Waeschewaschen im Haushalt?* Haus und Heim: Hamburg, Germany, 1960.
[2] Stamminger, R.; Bues, A.; Alfieri, F & Cordella, M: Durability of washing machines under real life conditions: Definition and application of a testing procedure, *Journal of Cleaner Production* **261** (2020) 121222, ISSN 0959-6526
[3] Soljačić, I. & Pušić, T.: *Njega Tekstila, Dio 1: Čišćenje u vodenim medijima*, Zagreb, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, ISBN 953-7105-08-3, Zagreb, Croatia (2005)
[4] Neral, B.; Šostar-Turk, S. & Fijan, S.: The soil removal and disinfection efficiency of chemo-thermal and LCO2 treatment for hospital textiles, *Industria Textila* **63** (2012) 5, 246-251, ISSN 1222–5347
[5] Zoller U.: Part A: Properties, Disinfection and Preservation In *Detegrents in Handbook of Detergents*, Marcel Dekker, Inc, ISBN 0-8247-1417-2, Basel (1999), 743-755
[6] Ministarstvo Zdravstva Republike Hrvatske: Hrvatski nacionalni standardi pranja i održavanja rublja u kliničkim i bolničkim zdravstvenim ustanovama, Zagreb, 2018., Available from https://zdravlje.gov.hr/UserDocsImages/2018%20Vijesti/Standard%20za%20pranje%20i%20odr%C5%BEavanja%20rublja%20.pdf, *Accessed: 2022-6-15*
[7] Pušić, T. & Soljačić, I.: Kontrola kvalitete pranja prema RAL-GZ 992, *Tekstil* **57** (2008) 6, 296-302, ISSN 0492-5882
[8] Fijan, S. & Šostar-Turk, S.: Microbiological evaluation of hospital textiles and textiles from the food-processing industry, *International Journal of Sanitary Engineering Research* **2** (2008) 2, 20-30, ISSN 1855-0452

Acknowledgment

This work has been supported in part by Croatian Science Foundation under the project UIP-2017-05-8780 HPROTEX.

INVESTIGATION OF MOISTURE MANAGEMENT ABILITY OF COTTON FABRIC TREATED WITH β-CYCLODEXTRIN AND INCLUSIVE COMPLEXES β-CD-ESSENTIAL OIL

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Abstract: *In this paper, the wettability, liquid penetration and absorbtion of cotton fabrics previously treated with cationized beta-cyclodextrin (β-CD) and the inclusion complex β-CD-essential oil of black cumin were tested before and after maintenance cycles to define their use in a hospital environment. Tests were performed by the standard test methods for the determination of the water absorbency and liquid transport: AATCC TM 79-2014, AATCC TM 197-2018, AATCC TM 198-2018 and moisture management properties to according AATCC TM 195-2017 on the Moisture Management Tester (MMT M290, SDL Atlas). It has been shown that cotton samples treated with the inclusion complex β-cyclodextrin-black cumin have a shorter wetting time than standard cotton fabric, which did not change significantly with the washing cycles. In the case of the cotton sample treated with cationized β-CD, the wetting time is faster compared to the standard cotton fabric. For samples subjected to maintenance cycles, the wetting time is visibly extended.*

Keywords: *Cotton, liquid absorption and transport properties, inclusion complex β-CD-essential oil*

1. INTRODUCTION

Knowledge of fabric properties with regard to liquid absorption and substance transport are key to achieving stable processes such as dyeing, printing and finishing, and also affect the functional properties of products for sportswear, protective clothing, disposable clothing, hygiene material and medical textiles [1, 2]. Thus, in the finishing, dyeing and printing processes, an important role in achieving durability properties on functional textile material is played by the wetting process, it is a process when the fibre-air interface is replaced with a fiber-liquid interface, and often takes place with the application of pressure force or heating of the bath and material. When the fabric is wet, the wicking process (wicking; capillarity;

penetration; wetting) should be ensured, which starts when the liquid enters into the capillary formed between two fibers or yarns by the capillary forces [3]. In this way, a process for successfully binding the active substance with the functional groups of textile fibers is ensured, but also for stimulating the targeted release of medicinal substances from the structure of functionalized textiles. Considering the purpose of textiles, especially those that are in contact with human skin, a high level of comfort is sought to be achieved, which is characterized by excellent properties of absorption, transfer of water and water vapor, which reduces the feeling of moisture on the skin, facilitates the evaporation of the moisture (water vapor) generated by the exudation of perspiration from the skin thus ensuring comfort during daily use and during physical activity [4].

In this work, the wetting, liquid penetration, and absorption properties of standard cotton fabric treated with cationized β-CD and inclusion complexes of β-CD-black cumin essential oil were researched.

2. MATERIAL AND METHODS

The paper investigated the adsorptivity and moisture transfer properties of the standard 100% cotton fabric WFK 10A DIN 53919/ISO2267 and the same after treatment with cationized β-cyclodextrin and inclusion complex β-cyclodextrin-black cumin essential oil before and after 3 washing cycles. Cationization of β-CD (CycloLab R&D Ltd., Budapest, Hungary) was performed by adding 50% Rewin OS (CHT-Bezema, Montlingen, Switzerland) to the mass of β-CD. The preparation of the inclusion complex of β-cyclodextrin and black cumin essential oil (Sigma Aldrich, St. Louies, MO, USA) was carried out by mixing β-cyclodextrin with 30% black cumin essential oil based on the mass of β-cyclodextrin. Both previously described samples were prepared using a high-energy vibrating mill RETSCH®-MM 400 by a mechanical reaction process at a frequency of 25 Hz for 10 minutes. Deionized water in which 25% of cationized ß-cyclodextrin on material weight was dissolved, was used to treat the standard cotton fabric. The finishing was carried out using an impregnation system with approximately 100% drainage effect. The samples thus prepared were returned to the bath for aging for 72 hours. And then they were 15 minutes exposed to microwave energy at a power of 80%. The samples were drained and dried at 110 °C for 2 min and thermocondensed at 150 °C for 5 min.

For the treatment of standard cotton fabric with the β-CD inclusion complex of black cumin, a bath with the following composition was prepared: 35 g/l maleic acid (Scharlau), 32.5 g/l Na-hypophosphite hydrate (Sigma-Aldrich), 25% of the inclusion complex β-cyclodextrin-black cumin by weight of material, 1 g/L Felosan RG-N (nonionic wetting agent) (Bezema) and deionized water.

The fabric samples were immersed in a bath and subjected to the influence of microwaves at a power of 50% for 15 minutes. The samples were aged for 48 hours in the bath. Then, they were dried at a temperature of 110 °C for 5 minutes and

thermocondensed at a temperature of 150 °C for 5 minutes. Part of the samples was subjected to three cycles of washing in accordance with ISO 6330:2012. Untreated, treated and treated washed samples of the labels shown in Table 1 were subjected to different test methods to evaluate absorbency and moisture management ability. The following methods were used to test the properties listed: drop test AATCC TM 79-2014 Absorbency of Textiles, AATCC TM 197-2018 Vertical Wicking of Textiles, AATCC 198-2018 Horizontal Wicking of Textiles and testing of moisture transfer through specimens according to AATCC TM 195-2017 on instrument that measures moisture management AATCC TM 195-2017 Liquid Moisture Management Properties of Textile Fabrics (MMT, SDL Atlas).

Table 1. Description of the samples with the corresponding labels

Samples	Finishing description
CO	standard 100% cotton fabric WFK 10A DIN 53919/ISO2267
CO_β_CD_ROS	Sample of standard cotton fabric treated in a bath with the addition of 25% of the cationized beta-cyclodextrin by weight of material
CO_β_CD_ROS_3W	Sample of standard cotton fabric treated in a bath with the addition of 25% of the cationized beta-cyclodextrin by weight of material and washed three time
CO-β-CD-CK	Sample of standard cotton fabric treated in a bath with the addition of 25% of the inclusion complex β-cyclodextrin-black cumin by weight of material
CO-β-CD-CK- 3W	Sample of standard cotton fabric treated in a bath with the addition of 25% of the inclusion complex β-cyclodextrin-black cumin by weight of material, and washed three time

3. RESULTS AND DISCUSSION

The results of the Drop test according to AATCC TM 79-2014 are shown in Table 2. It can be seen that all the samples are hydrophilic, i.e. they immediately absorbed the drops, slightly lower hydrophilicity is shown by the CO_β_CD_ROS_3W, where the drop penetrated in the material 9.7 seconds.

Table 2. Drop test expressed as penetration time t [s] into the fabrics

Samples	t, s
CO	0
CO_β_CD_ROS_50	0
CO_β_CD_ROS_3W	9.7
CO-β-CD-CK	0
CO-β-CD-CK_3W	0

In Table 3 the results of ability of vertically aligned fabric specimens to transport liquid along and/or through them according to AATCC TM 197-2018 are shown. The results are expressed as the speed of water penetration (Wicking rate, W mms^{-1}), for a short and a long period, by warp and weft. From the obtained results, it is evident that all treated fabrics have better wicking rate than the untreated standard fabric. Differences in the wicking rate are visible in CO_β_CD_ROS_3W during a short monitoring period, which points to possible structural or physicochemical changes in the sample after the wash cycles that will be investigated.

Table 4 shows the results of measuring the horizontal wicking of samples according to AATCC TM 198-2018. The results show the time required for the water to reach a radius of 100 mm of horizontally aligned samples, and from these data, the mean wicking rate, (W, mm^2/s) was calculated.

Table 3. The results of vertical wicking of samples according to AATCC TM 197-2018

Samples		Short period			Long period		
		d, mm	t, s	W, mms^{-1}	d, mm	t, s	W, mms^{-1}
CO	warp	20.0	93.41	0.21	55.0	1800	0.03
	weft	20.0	105.82	0.19	42.0	1800	0.02
CO_β_CD_ROS	warp	20.0	28.0	0.71	91.0	1800	0.05
	weft	20.0	40.0	0.50	89.0	1800	0.05
CO_β_CD_ROS_3W	warp	20.0	52.27	0.38	94.0	1800	0.05
	weft	20.0	50.96	0.39	78.0	1800	0.04
CO-β-CD-CK	warp	20.0	27.9	0.72	89.0	1800	0.05
	weft	20.0	28.5	0.70	83.0	1800	0.05
CO-β-CD-CK_3W	warp	20.0	22.78	0.88	97.0	1800	0.05
	weft	20.0	30.47	0.66	91.0	1800	0.05

Table 4. Results of mean wicking rate of water of horizontally aligned samples according to AATCC 198 - 2018

Samples	$\bar{d}$, *mm*	$\bar{t}$, *s*	$\overline{W}$, mm^2s^{-1}
CO	100	59.3	132.38
CO_β_CD_ROS_50	50	74.06	26.50
CO_β_CD_ROS_50_3W	78	300	15.92
CO-β-CD-CK	100	88.47	88.74
CO-β-CD-CK-3W	100	55.80	140.69

The results in Table 4 show a slower wetting of the samples treated with cationized β-cyclodextrin (CO_β_CD_ROS_50), which further slows down after 3 washing cycles. The reason for this may be the shrinkage of the fabric during washing and the slow entry of water molecules into the interior of the cavities of cationized β-CD. In the CO-β-CD-CK sample, the horizontal wicking rate is slower

compared to the wicking rate of water into the untreated standard fabric, while in the CO-β-CD-CK-3W sample, the wicking rate of water increases, which may indicate an increase in the active hydrophilic surface caused by the presence β_CD on and in the fabric structure.

By testing of liquid moisture management properties according to AATCC TM 195–2017, objective results were obtained. The results of four samples of the tested fabric are shown in Table 5. by the mean value (mean) and the coefficient of variation (CV) for each property.

Table 5. *Prikaz rezultata dobivenih mjerenjem uzoraka na MMT za uzorak* CO_β_CD_CK

		CO		CO_β_CD_ROS_50		CO_β_CD_ROS_50_3w		CO_β_CD_CK		CO_β_CD_CK_3w	
		Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
WT*, s	T	4.96	0.57	2.41	0.41	6.65	0.06	2.78	0.03	2.69	0.02
	B	3.62	0.12	2.64	0.29	6.51	0.13	2.90	0.03	2.83	0.02
AR*, %/s	T	19.75	0.14	62.50	0.04	78.21	0.11	73.71	0.07	66.35	0.05
	B	22.52	0.49	58.05	0.03	69.80	0.08	88.62	0.27	61.78	0.05
MWR * mm	T	23.33	0.12	25	0	23.75	0.20	25	0	25	0
	B	23.33	0.12	25	0	25	0	25	0	25	0
SS, mm/s	T	2.90	0.45	5.33	0.24	4.03	0.14	4.46	0.01	4.73	0.02
	B	2.75	0.22	4.81	0.12	4.30	0.1	4.32	0.01	4.59	0.02
AOWTI*, %		419.3	0.05	40.45	0.23	55.41	0.34	-53.45	0.05	-36.42	0.11
OMMC*		0.68	0.12	0.48	0.03	0.53	0.03	0.45	0.08	0.41	0.03
Type of fabric		Moisture Management Fabric		Fast Absorbing and Quick Drying Fabric		Fast Absorbing and Quick Drying Fabric		Fast Absorbing and Quick Drying Fabric		Fast Absorbing and Quick Drying Fabric	

*T - top surface, B - bottom surface, CV – coefficient of variation, WT - Wetting Time, AR – Absorption Rate; MWT – Maximum Wetted Radius, SS – Spreading Speed, AOWTI – Accumulative One-way Transport Capability, OMMC – Overall (liquid) Moisture Management Capability (OMMC).

The wetting time (WT) is the time required for the upper and lower surfaces to start wetting and corresponds to the absorption time of the drop in the Drop test. For CO_β_CD_ROS, CO_β_CD_CK and CO_β_CD_CK_3w, the wetting time of the upper and lower surface is faster compared to the standard cotton fabric. In the case of CO_β_CD_ROS_3W samples, the wetting time is visibly extended and amounts to 6.65 s for the upper surface and 6.51 s for the lower surface. The reason for the

fast wetting time of the samples before washing is probably the deposited molecules of cationized β-CD and inclusion complex β-CD-CK on the surface of the material. The longer wetting time of CO_β_CD_ROS_3W indicates the presence of bound particles of cationized β-CD and reduced absorbency of treated washed samples compared to standard fabric (CO). The maximum wetting radius of the upper and lower surfaces of all treated samples is greater than the untreated CO sample. The spreading speed, which represents the accumulative wetting rate from the center to the maximum wetting diameter for all treated samples before and after three maintenance cycles shows almost double the value compared to CO. The accumulative ane-way transport capability (AOWTI) represents the difference between the areas of the upper and lower surface moisture curves of the material with respect to time. For a standard cotton fabric, the AOWTI is 419.3%, which means that the moisture content on the upper surface is higher than on the lower surface. For the CO_β_CD_ROS sample, the AOWTI decreases compared to the standard fabric (CO), which may be the result of shrinkage during washing and indicates a lower degree of absorptivity compared to CO. AOWTI in the samples CO_β_CD_CK and CO_β_CD_CK_3w took a negative value, which indicates that the water content on the upper surface is lower than the water content on the lower surface of the fabric and that the liquid introduced on the lower surface is slowly transferred to the upper surface. The results of the overall (liquid) moisture management capability (OMMC), which represents the index of the overall ability of the fabric to transfer drop moisture, are lower for all fabrics treated with cationized β-CD and the β-CD inclusion complex of black cumin essential oil compared to the standard cotton fabric and have the rating "fast absorbing and quick drying fabric. CO fabric shows a high ability to absorb water due to the polar groups to which water molecules bind, in addition, it shows a high fast spreading, has excellent one-way transport, and it is rated as a "moisture management fabric"[4].

4. CONCLUSIONS

From the obtained values the wetting, liquid penetration, and absorption properties, of standard cotton fabric treated with cationized β-CD and inclusion complexes of β-CD-black cumin essential oil we can conclude that the fabrics prepared in this way could be used in the hospital environment primarily as wound dressings. For these purposes, further physico-chemical, toxicological and dermatological research will be carried out.

Acknowledgments: This work has been supported in part by Croatian Science Foundation under the project UIP-2017-05-8780, Hospital protective textiles HPROTEX and in part by the University of Zagreb (TP4/21).

REFERENCES

[1] Tang, K.-P., Kan, C.-W., Fan, J.: Evaluation of water absorption and transport property of fabrics, Textile Progress, 46 (2014) 1, pp. 1-132, ISSN 17542278, 00405167

[2] Wijesena, R. N.: Moisture management fabric; *Available from*: https://www.researchgate.net/publication/284578937_Moisture_management_fabric, *Accessed:*: 2022-06-14.

[3] Dekanić, T., Tarbuk, A. i Flinčec Grgac, S.: The liquid moisture management properties of low-temperature cured water-repellent cotton fabrics. *Tekstil*, **67** (2018) 7-8, pp. 189-200, ISSN: 0492 - 5882

[4] M290 Moisture Management Tester, Instruction Manual, Rev. 1.4 (06/18) www.sdlatlas.com

THE EFFECTS OF CHEMICAL WARFARE AGENTS ON THE ENVIRONMENT

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Abstract: The use of chemical warfare agents (CWAs) in wars and conflicts, in the past and not so long ago, caused significant damage to the human population, not only in the form of deaths and long-term consequences for human health, but also for the entire ecosystem. Although a certain amount of chemical warfare agents still exists in the environment, the long-term impact of these agents on the environment and materials is still unclear. As some of these agents degrade over the time, their degradation products can be highly toxic and can affect especially on marine ecosystems. The main negative characteristic of this compounds is their extreme environmental persistence, which depends not only on their physicochemical properties, but also on their reactivity with various substances in the environment. Potential fate pathways for CWAs in the environment include volatilization, sorption, hydrolysis, photolysis, and microbial degradation. This paper provides an overview of previous research related to the impact of CWAs and their degradation products on the environment.

Key words: chemical warfare agents, degradation, environment, materials.

1. INTRODUCTION

The use and production of chemical warfare agents (CWAs) was first banned in 1899. by The Hague Convention. Although their use was banned, CWAs were used mostly in the First World War in the conflicts between Germany and France. Although the Geneva Conference1925. again banned the use of CWAs, military forces continued to use them. The Italian army used CWAs in the invasion of Abyssinia (present-day Ethiopia), and Japan used mustard gas in the war with China [1]. After World War II, the simplest and cheapest way to remove CWAs was to store them in the seas and oceans. This procedure caused concern that the Germans, after the defeat in 1945, might be tempted to use part of their arsenal, which amounted to 296,103 tons. Therefore, the weapon was captured and thrown into the sea. Also, in the period from 1945 to 1970, large quantities of chemical weapons were dumped into the sea, ie they were proven to be found in all oceans except the Arctic, and the largest quantities were dumped in the Baltic region [2]. To date, most of the countries that owned chemical weapons, and are also members of the Chemical Weapons Convention - CWC, have carried out the process of destroying

chemical weapons under the supervision of the Organization for the Prohibition of Chemical Weapons (OPCW). Today, in the 21st century, despite the existence of numerous conventions and organizations regulating the use and production of chemical warfare agents, they still exist and pose a danger not only to human health but also to the environment, and their use in wars and conflicts major damage to ecosystems [3]. Therefore, the aim of this paper is to provide an overview of the CWAs used in previous conflicts, their basic properties and try to analyze their degradation in the environment and environmental implications of chemical warfare.

2. BASIC PROPERTIES OF CHEMICAL WARFARE AGENTS

Mustard gas (HD) is a clear oily liquid that has the smell of mustard or garlic and changes color to yellow or brown on standing. Mustard gas is not easily flammable, and its vapors are heavier than air, very toxic and can be absorbed through the skin. When heated to decomposition, it emits highly toxic fumes of sulfur oxides and chlorine-containing compounds. At a temperature of 69°C, mustard gas quickly corrodes brass and corrodes steel. When it comes into contact with acid or acid vapors, it emits toxic vapors of sulfur oxides and chlorides, and when it comes into contact with metals, hydrogen is formed. Causes severe burns to the eyes, skin and respiratory tract. Mustard can be absorbed into the body by inhalation, ingestion and in contact with the skin and eyes. Exposure to liquid mustard gas will cause second or third degree burns and subsequent scarring. Vapor inhalation can cause chronic respiratory infections or death, increasing the risk of lung and respiratory tract cancer [4].

Nitrogen mustard gas (HN3) is a colorless liquid that changes color over time to pale yellow. It has a faint smell of fish and soap, but is odorless when completely clean. It is not flammable but begins to decompose when heated to a temperature of 256°C and when heated to decomposition, emits chloride and nitrogen oxides. It is less soluble in water than mustard gas and has a weaker diffusion capacity. It dissolves very well in organic solvents, and the solutions are unstable in polar solvents. When dissolved in water, it is a strong base. It can be absorbed into the body by ingestion, inhalation, contact with skin and eyes. It is a very toxic chemical and can damage the respiratory tract, eyes and skin and disrupt the function of the immune system. Symptoms appear only after a few hours and up to 2 days at most. Upon skin contact, redness develops within a few hours while blisters appear 6 to 12 hours later [5].

Lewisite is an oily liquid with a pleasant smell of geranium. It is colorless when pure, but upon standing even in its impure form it can appear amber to black. It is not flammable and does not burn, but it decomposes when heated to a temperature above 100°. It quickly hydrolyzes in moist air and 2-chlorovinylarsinoxide is obtained as a hydrolysis product. Lewisite is hydrolyzed in basic media as well as during decontamination with carbonate, alcohol and hydroxide solution. Lewisite is an extremely toxic agent that affects the lungs and the whole body. It irritates eyes

and mucous membranes in concentrations that are below the odor threshold, and can even penetrate through rubber, creating painful blisters on the skin. Exposure to large amounts can be fatal, with death occurring in as little as 15 minutes. It destroys tissue faster than mustard gas, and since it contains arsenic it has some similar effects of poisoning such as stomach upset and low blood pressure [5].

VX is odorless oily liquid. It is amber in color and is the least volatile of all nerve agents, so it is very persistent, which poses a great danger to the environment and materials. In stable weather conditions, it can last for several days on the objects with which it came into contact, and in cold weather it can last for months. VX is the most toxic of all nerve agents. VX can be taken into the body by inhalation and adsorption through the skin. VX is thought to be much more toxic than sarin by penetrating the skin, and slightly more toxic by inhalation. One drop of VX in contact with the skin is fatal. Symptoms of poisoning depending on the dose appear within a few minutes to a maximum of 18 hours after exposure [5].

Table 1. Chemical and physical properties of chemical warfare agents [6].

Parameter	Agent						
	HD (Mustard gas)	**HN3 (Nitrogen mustard)**	**Lewisite**	**VX**	**GA (tabun)**	**GB (sarin)**	**GD (soman)**
Chemical formula	$C_4H_8Cl_2S$	$C_6H_{12}Cl_3N$	$C_2H_2AsCl_3$	$C_{11}H_{26}NO_2PS$	$C_5H_{11}N_2O_2P$	$C_4H_{10}FO_2P$	$C_7H_{16}FO_2P$
Color	clear yellov	colorless/pale yellow	colorless (pure)	light amber	colorless to brown	colorless	colorless
Melting point	13-14°C	-3.7°C	-18°C	-39°C	-50°C	-56°C	-42°C
Boiling point	215-217°C	230-235°C	190°C	298°C	220-246°C	158°C	198°C
Volatility (mg/m^3)	920	0.12	4480	10.5	610	22000	3900
Vapor density (air=1)	5.5	7.1	7.1	9.2	5.6	4.9	6.3
Water solubility (g/L)	0.92	0.16	0.5	30	98	miscible	21 at 20%
Hydrolysis rate (half life)	8.5 min at 25°C	no data	rapid hydrolysis	1000 hr (pH 7)	8.5 hr (pH 7)	39 hr (pH 7)	45 hr (pH 6.6)

Tabun (GA) is a clear, colorless to dark brown liquid. Tabun has a scent reminiscent of bitter almonds. Exposure to tabun can cause death in just minutes. Tabun, like all nerve warfare agents, acts similarly to organophosphate pesticides that interfere with the normal function of the nervous system. Tabun can be absorbed into the body very quickly by inhalation, ingestion, and in contact with the eyes and skin, although

ingestion is not a common route of exposure. When heated, tabun vapors can form explosive mixtures with air, which poses a risk of explosion in open and closed spaces and in sewers. Tabun is flammable, which can produce irritating, corrosive and toxic gases. In acidic conditions, tabun hydrolyzes and forms hydrofluoric acid, and it also easily reacts with bases and acids.

Sarin (GB) is an extremely toxic synthetic organic phosphorus compound. It is not flammable and reacts with water and water vapor with the formation of corrosive and toxic fumes. It is a colorless, odorless and tasteless liquid. Sarin has a high volatility compared to other nerve agent poisons, so it is very easily taken into the body by inhalation, but it can even penetrate the skin. The clothing of a person who has been in contact with sarin can release sarin approximately 30 minutes after initial contact, which can ultimately lead to exposure of other people. Sarin is a very stable chemical compound, but at higher temperatures it becomes unstable.

Soman (GD) is a clear, colorless liquid that changes color from colorless to dark brown on standing. It emits a colorless vapor and smells like camphor. Hydrolysis produces hydrogen fluoride and a non-toxic derivative of phosphoric acid. It is quickly hydrolyzed by an aqueous solution of sodium hydroxide. Soman turns into a gas when slightly heated. Soman can be introduced into the body through food and through contaminated clothing so that clothing can release soman after contact with its vapor, which can lead to exposure of other people. Although soman may smell of camphor or fruit, the smell will not be noticeable at certain concentrations to warn people of exposure. People exposed to low concentrations of soman through inhalation, ingestion, or absorption through the skin may experience symptoms within seconds of exposure [5].

3. FORMATION OF DEGRADATION PRODUCTS AND ECOTOXICITY

HD degradation in the environment is based on its chemical and physical properties as well as on observations of persistence from both field and laboratory studies. The basic environmental fate mechanism of stored HD is hydrolysis with half-life of 4-8 min at 25°C in distilled water. HD is lost from the soil surface primarily by evaporation, beside buried deep in the soil, where it cannot vaporize or undergo weathering, can remain undecomposed for years. Volatilization from soil was related to temperature, wind speed, and soil type. HD will not travel through groundwater in solution because of its low solubility and rapid hydrolysis when dissolved, so is not normally found in groundwater. Even HD is extremely toxic to all species; its environmental action is limited by its low solubility. Some studies involving a variety of aquatic organisms, showed that fish are the most sensitive species (compared with phytoplankton and higher aquatic plants) [6].

Nitrogen mustard (HN3) is unstable in the presence of light and heat and form dimers at temperatures above 50°C. HN3 is considered environmentally persistent and not very soluble in water. There are no data on the biodegradation of nitrogen mustard, even theoretically can be biodegraded by reductive dehalogenation and

dehydrohalogenation mechanisms, but these processes would be very slow. No data were located on toxicity of the degradation products to terrestrial plants or wildlife.

Lewisite is considered non-volatile and although Lewisite is only slightly soluble in water (0.5 g/L), hydrolysis is rapid and results in the formation of the water-soluble dihydroxy arsine. Lewisite indicates intermediate persistence in moist soil and applied to soil may rapidly volatilize and can be converted to Lewisite oxide through exposure to soil moisture. Lewisite is easily hydrolyzed in soil, and minerals present in soil would increase the degradation rate. Furthermore, alkaline soils would neutralize Lewisite. Lewisite vapor is extremely phytotoxic [7].

VX is moderately persistent on bare ground and may remain in significant concentrations for 2-6 days, depending on temperature and moisture. VX is soluble in water, 30 g/L at 25°C, and is relatively resistant to hydrolysis. The reported half-life in water at 25°C and pH 7 ranges from 17 to 42 days. On the other hand, approximately 90% of VX is lost from soil in 15 days. Research has shown that all of the nerve agents are highly toxic to aquatic organisms, with 96-hr LC_{50} values of < 1 mg/L.

GA is more volatile than VX and will evaporate, but no data were located on concentrations or fate in the atmosphere. Hydrolysis is more rapid in acidic and basic solutions than in solutions of neutral pH. The half-life in seawater at 20°C is shorter (4.5 hr) than in freshwater, and GA is highly toxic to aquatic organisms. No information was located on the toxicity of unique degradation products to aquatic or terrestrial organisms.

GB is considered no persistent, as it is volatile, soluble in water, and subject to acidic and basic hydrolysis. The rate of hydrolysis under natural conditions is accelerated by the presence of ions in solution. Moreover, metal cations such as copper and manganese in seawater can increase the rate of hydrolysis. The fate of GB in soil induces hydrolysis, evaporation, and leaching. GB is highly toxic to fish species, with LC_{50} values of < 1 mg/L.

GD is less volatile than GB, evaporating at one fourth the rate of water. Like the other G agents, GD is subject to hydrolysis, but the rate of hydrolysis is slow under neutral conditions. It is less water soluble and more lipid soluble than the other G agents, which results in more rapid skin penetration and greater toxicity. No data were located on the ecotoxicity of GD [6].

4. IMPACT OF CWA ON MATERIALS AND ENVIRONMENT

The use of chemical weapons in wars and conflicts, in the past and the not-so-distant past, caused great damage to the human population, not only in the form of deaths and long-term consequences for human health, but also for the entire ecosystem at that time. After the Second World War, major world powers such as the United States (USA), the Soviet Union and others, released large quantities of CWAs and munition into the oceans and seas. European, Russian, Japanese and American coasts are the most affected areas. It is also known that there are a large number of such landfills in the Baltic and North Sea areas, and they are also the most studied areas in the context of the impact of CWAs on the environment. CWAs are

degraded in the environment and their decomposition products can be highly toxic and affect marine ecosystems. However, scientists constantly warn that there is a need for constant monitoring of such toxic substances at known disposal sites, especially in areas with developed fishing [8]. Of all the war poisons released into the seas and oceans, the largest amounts refer to mustard gas, lewisite and nerve agents such as sarin, tabun and soman. Tests conducted on marine organisms did not show large amounts of chemical agents or degradation products in their tissue, but did show evidence of chronic toxicity. Possible ways of degradation of CWAs in the environment include the processes of evaporation, sorption, hydrolysis, photolysis and degradation by microorganisms. Hydrolysis is the primary mechanism of their decomposition, especially in the aquatic environment, with a half-life of decomposition from a few minutes to a few days. The rate of hydrolysis depends on factors such as temperature, pH and water quality, and it is known that the rate of hydrolysis increases with increasing temperature [7]. Although the biodegradation of CWAs is theoretically possible, it has not been observed in practice due to their toxicity. The persistence of these substances is a very important property and persistent CWAs can cause long-term contamination of materials, hindering their use. The main reactions that can occur between CWAs and the environment are: hydrolysis with water in the environment, oxidation with atmospheric oxygen, photochemical reactions with sunlight, thermochemical decomposition, and other reactions with compounds present in the environment [9].

5. CONCLUSION

Despite the existence of numerous conventions (CWC) and organizations (OPCW) that regulate the use and production of chemical weapons, they still exist and represent a danger not only to humanity, but also a major problem for the environment. The easiest way to remove CWAs after the Second World War was their storage in the seas and oceans, which irreversibly damaged not only the marine environment, but the scale of such treatment is far more extensive and represents a real danger to the population of contaminated areas. Here, however, the question arises that the use of chemical weapons on a large scale could cause permanent environmental changes. One of the most important characteristics of CWAs is their persistence in the environment, therefore persistent CWAs will cause, in addition to casualties, long-term contamination of terrain and materials, hindering their use.

From all the above facts, understanding the processes and reactions that occur on contaminated surfaces is essential for predicting the long-term consequences of CWAs, which ultimately leads to the development and application of effective methods for their decontamination.

REFERENCES

[1] Padley, A.P.: Gas- the greatest terror of the Great War, Anaesth Intensive Care/ History Supplement (2016) 24-30.
[2] Chepesiuk, R.: "A Sea of Trouble?", The Bulletin of Atomic Scientists (1997) 40-44.
[3] Curry, A.: Chemical Weapons Dumped in the Ocean after World War II Could Threaten Waters Worldwide', *Smithsonian Magazine* (2016).
[4] Balali- Mood, M., Hefazi, M.: The clinical toxicology of sulfur mustard, Archives of Iranian Medicine, 8 (2005) 162-179.
[5] Gupta, R.C.: Handbook of Toxicology of Chemical Warfare Agents, Academic Press (2015).
[6] Munro, N.B.,Talmage, S.S., Griffin, G.D., Waters, L.C., Watson, A.P., King, J.F., Hauschild, V.: The Sources, Fate, and Toxicity of Chemical Warfare Agent Degradation Products, Environmental Health Perspectives 107 (12) (1999) 933-974.
[7] Bartelt-Hunt, S.L., Knappe, D.R.U., Barlaz, M.A.: A Review of Chemical Warfare Agent Simulants for the Study of Environmental Behavior, Critical Reviews in Environmental Science and Technology, 38 (2008)112–136.
[8] Curry, A.: Chemical Weapons Dumped in the Ocean after World War II Could Threaten Waters Worldwide', *Smithsonian Magazine* (2016).
[9] Gorzkowska-Sobas, A.A.: Chemical warfare agents and their interactions with solid surfaces, Norwegian Defence Research Establishment (FFI), FFI-rapport 2013/00574 (2013).

PERCEPTIONS AND ATTITUDES ABOUT WASTE MANAGEMENT ISSUES IN CROATIA

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Abstract: *Pollution and waste represent an existential threat to human health and environmental degradation. Whether waste will constitute problem or a resource all depends on how we manage it. This paper reviews perceptions of citizens about waste management. This study aims to assess the perceptions of the general public and to analyze the information and awareness of citizens about household waste management in Croatia, as well as their attitudes towards environmental issues. It is important to make citizens aware of the importance of recycling and zero waste habits because every individual action matters. The survey was conducted with a questionnaire and it was found that most responders separate waste from their households, but most of the responders believe that they are moderately informed about proper waste treatment.*

Keywords: *waste management, pollution, recycling, public perceptions, questionnaire survey*

1. INTRODUCTION

Pollution and unwanted waste that people release into air, land, and water represent an existential threat to human health and planetary health, and also threatens the sustainability of modern societies [1]. Solid waste was a problem even before water and air pollution issues attracted attention of human civilization [2]. Environmental problems threaten the health and economic prospects of many countries. One of the factors, which accounts for a substantial portion of global warming in addition to environmental degradation, is waste generation [3]. Waste represents one of the biggest problems today, and inadequate handling of waste also represents one of the biggest environmental problems in Croatia.

It is important that all countries perform their respective duties and obligations in environment management, in the joint efforts of planning economic development, social progresses and environmental protection in order to achieve mutual benefits for sustainable development of the world, and to create harmonious coexistence of humankind and environment [4].

Whether waste will constitute a problem or a resource, it all depends on how we manage it [5]. Anthropogenic activities produce waste materials that are often discarded because they are considered useless. Some of the waste is solid, and it is considered as useless and unwanted. But many of these waste materials can be reused and can be a resource for an industry. Waste management is one of the most important problems of our time since the development and subsequent use of materials generates huge amounts of wastes [2].

In 2020 in Croatia was generated 1.680.428 tons of municipal waste, or 414 kg per inhabitant, which is a decrease of 7% compared to the total amount from 2019. Also, 686 475 tons of municipal waste were collected separately. The rate of separate collection was 41%, which represents an increase of 4 percentage points compared to 2019 [6].

Several studies which deal with similar topic have been conducted, and it was established that whether or not people decide to recycle is influenced by several factors. These include physical features, behavioral patterns, knowledge levels, attitudes and perceptions, and the complex interrelationship between them [7]. Also demographic characteristics and social norms are important [8] as well as polices and incentive schemes [9], and also how mature the recycling society is [11]. The major impact on people's behavior have environmental laws and regulations. People usually see environmental problems as moral issues, and both law and morality serve to channel our behavior [12]. Health awareness also affects environmental and health behaviors [13], and people who have great concern for the environment are more likely to recycle [14].

2. MATERIALS AND METHODS

The survey was conducted in the period from June 6, 2022 to June 12, 2022. The aim of this study is to assess and discuss the perceptions of the general public about waste issues in Croatia. The survey included 16 questions which can be classified into several categories. First category of questions (1 to 4) included general information about responders (gender, age, county where they live, type of household). Second category (5 to 14) were questions about environmental attitudes and their habits when dealing with waste from households. Third category (15 to 16) tested responders' knowledge about waste management issues and about sources of information about that issue. The questionnaire survey was conducted based on a five-point Likert scale for measuring respondent's opinion or attitude towards a given subject.

3. RESULTS AND DISCUSSION

In the survey participated 104 citizens, of which 79 were females (76%) and 25 were males (24%) (Figure 1). Some of the previous research showed that gender can influence recycling habits and that women are more involved in separation of waste

than men [15]. According to Figure 2, the responders are mostly citizens up to 35 years, while three responders (2,9%) are older than 66 years.

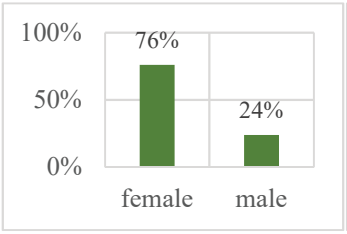

Figure 1: Gender of responders

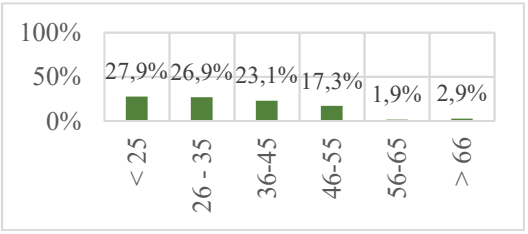

Figure 2: Age of responders

Most responders are mostly from Karlovac County (28,8%) and Zagreb County (20,2%) (Figure 3) and also the type of household in which the majority of responders live are houses (58,7%) (Figure 4).

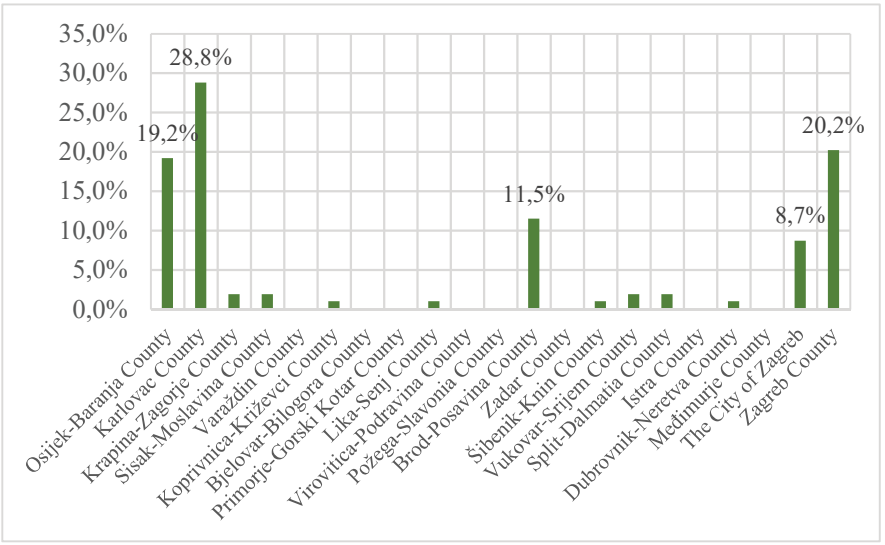

Figure 3: County in which the responders live

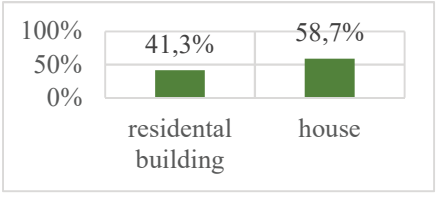

Figure 4: Type of household in which the responders live

There is 45,2% of the responders which believe that the biggest environmental problem is water, air and soil pollution and 28,8% of responders believe that the problem is waste (Figure 5). It is important that citizens are aware of the waste problem because public awareness is considered the most effective measure for increasing citizen participation in source separation and recycling plans [17].

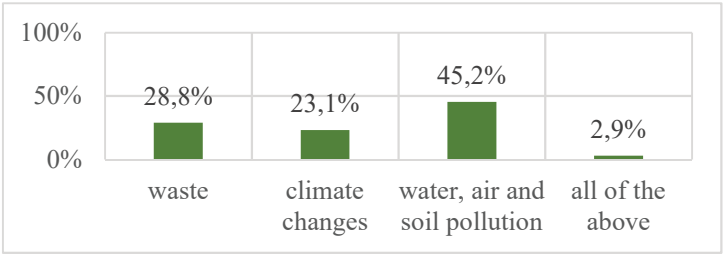

Figure 5: The biggest environmental problem according to responders

Most of the responders (44,2%) stated that they often separate waste from households at the designated recycling points and also most of them (41,3%) consider that they often separate the waste correctly into the appropriate containers (Figure 6 – 7).

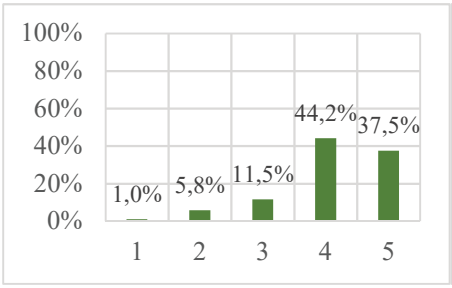

Figure 6: Do you separate your waste at the designated recycling points?

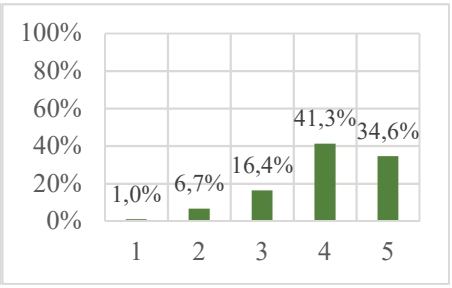

Figure 7: Do you think that you separate the waste correctly into the appropriate containers?

Containers for paper (93,3%) and plastic (90,4%) are available to the largest number of responders, while containers for textiles and metal are the least represented (Figure 8). The majority of responders (38,5%) believe that they have a sufficient number of containers near their household where they can dispose all types of waste (Figure 9).

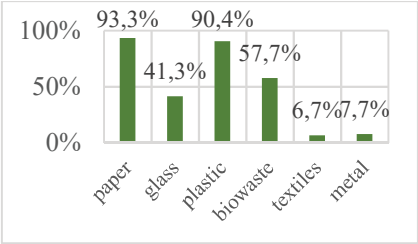

Figure 8: Which containers are available to your household for separating waste? (multiple answers possible)

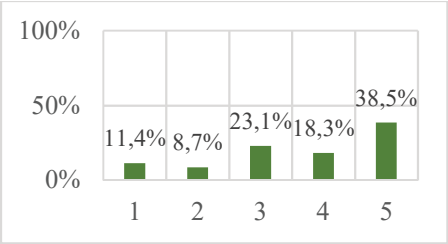

Figure 9: Are there enough containers near your household where you can dispose of all types of waste?

When it comes to returnable packaging, it is possible to see how the majority of responders (77,9%) decided to collect and return to stores (Figure 10), while 84,6% of them dispose non-returnable plastic and glass packaging in appropriate containers (Figure 11).

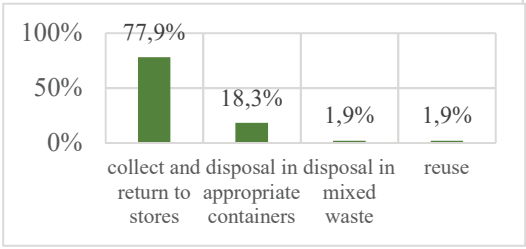

Figure 10: What do you do with returnable plastic and glass packaging?

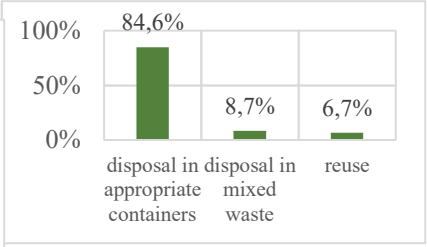

Figure 11: What do you do with non-returnable plastic and glass packaging?

Most responders (87,5%) dispose waste paper in appropriate containers (Figure 12).

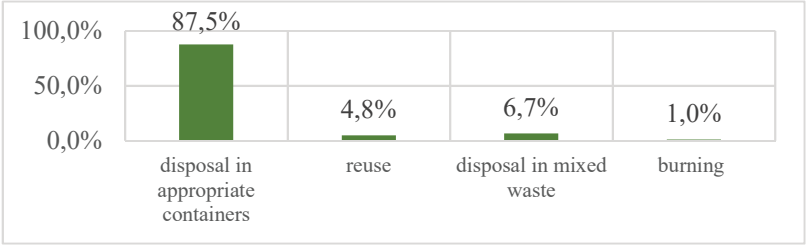

Figure 12: What do you do with waste paper?

For the disposal of biowaste, most of responders use biowaste containers (41,3%), but a large number of responders (40,4%) compost biowaste in the garden compost bins (Figure 13).

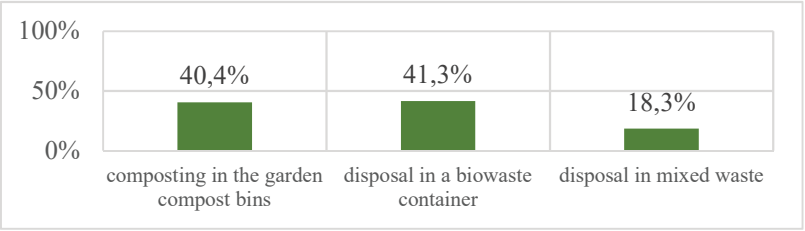

Figure 13: How do you dispose of biowaste?

The majority of responders deliver bulky waste to recycling yards (68,3%), (Figure 14).

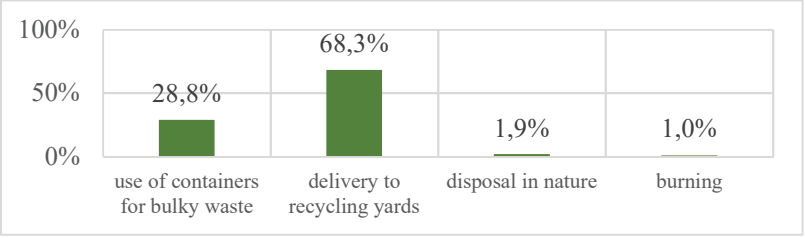

Figure 14: How do you solve the problem of bulky waste?

Most of the responders (37,5%) believe that they are moderately informed about the proper treatment of waste, and the main source of information about waste management is the Internet or various leaflets and brochures. (Figure 15 - 16).

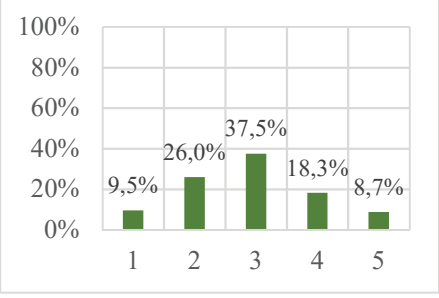

Figure 15: Do you think that citizens are sufficiently informed about the proper treatment of waste?

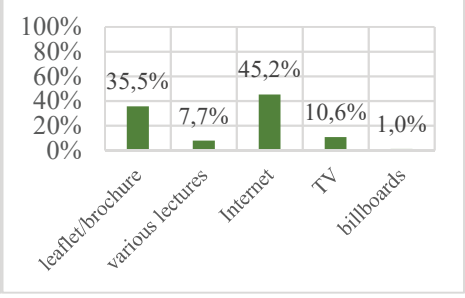

Figure 16: Source of information about waste management

4. CONCLUSION

Waste is an inevitable product of human activities and it causes a threat to human health. Also, it can cause a lot of negative effects on environment, but that could be improved if humans slightly amended their behavior. It is necessary to manage waste in a way that avoids disposal and reduces consumption by reusing products, which enables us to avoid creating unnecessary waste. Also, by separating and recycling the waste we create, the amount of waste that ends up in landfills can be reduced. Recycling and zero waste habits take time, but each individual step is important. Most of the responders try to recycle and handle waste from their households responsibly, but it can be noticed that some of them still have a lack of containers for separating waste, as well as a lack of information about the proper handling of certain types of waste. Because of that, it is important to upgrade the technical infrastructure, as well as to inform and motivate users for separate waste collection.

REFERENCES

[1] Fuller R., et al.: Pollution and health: a progress update, *Lancet Planet Health*, Vol. (2022) 6, pp. 535 – 547, *Available from:* www.thelancet.com/planetary-health, *Accessed*: 2022-06-01

[2] Chandrappa, R., Das, D.B.: *Solid Waste Management*, Environmental Science and Engineering, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-28681-0, Berlin, (2012), pp. 1 – 45

[3] Tan et al.: Research on the status and priority needs of developing countries to address climate change, *Journal of Cleaner Production*, Vol. (2021) 289, pp. 1 - 18, ISSN 0959-6526

[4] Jianping, L., et al.: Report on Global Environmental Competitiveness of the United States, In *Report on Global Environmental Competitiveness,* Current Chinese Economic Report Series, ISBN 978-3-642-54677-8, (2014), pp. 805-808

[5] EEA Signals 2014 - Waste: a problem or a resource?, *Available from:* https://www.eea.europa.eu/publications/signals-2014/articles/waste-a-problem-or-a-resource, *Accessed*: 2022-06-01

[6] Izvješće o komunalnom otpadu za 2020. godinu, *Available from:* http://www.haop.hr/sites/default/files/uploads/inline-files/OTP_Izvje%C5%A1%C4%87e%20o%20komunalnom%20otpadu%20za%202020.%20godinu_7_10_2021.pdf, *Accessed*: 2022-06-01

[7] Langley, J., Is Green a Grey Area? Sustainability and Inclusivity: Recycling and the Ageing Population, *The Design Journal*, Vol. (2012) 15(1), pp. 33–56, ISSN 1460-6925

[8] Marans, R.W., Lee, Y.-J.: Linking recycling behavior to waste management planning: A case study of office workers in Taiwan, *Landscape and Urban Planning*, Vol. (1993) 26, pp. 203–215, *Available from:* http://hdl.handle.net/2027.42/30543, *Accessed*: 2022-06-01

[9] Wagner, T.P.: Examining the concept of convenient collection; An application to extended producer responsibility and product stewardship frameworks, *Waste Management*, Vol. (2013) 33, pp. 499–507, PMID: 22818910

[10] Vining, J., Ebreo, A.: What Makes a Recycler? A Comparision of Recyclers and Nonrecyclers, *Environment and Behavior*, Vol. (1990) 22(1), pp. 55–73, ISSN 0013-9165

[11] Miafodzyeva, S., Brandt, N., Olsson, M.: Motivation recycling: pre-recycling case study in Minsk, Belarus, *Waste Management & Research*, Vol. (2010) 28, pp. 340–346, PMID: 20124319

[12] Shavell, S.: Law versus Morality of Regulators of Conduct, *American Law and Economics Review*, (2002), pp. 227 – 257, *Available from:* http://www.jstor.org/stable/42705411, *Accessed*: 2022-06-01

[13] Shimoda, A., Hayashi, H., Sussman, D., Nansai, K., Fukuba, I., Kawachi, I., Kondo, N.: Our health, our planet: a cross-sectional analysis on the association between health consciousness and pro-environmental behavior among health professionals, *International Journal of Environmental Health Research*, Vol. (2019) 29 (3), pp. 63–74, ISSN 1369-1619

[14] Domina, T, Koch, K.: Convenience and frequency of recycling: implications for including textiles in curbside recycling programs, *Environment and Behavior*, Vol. (2002) 34, pp. 216–38, ISSN 0013-9165

[15] Ekere, W., Mugisha, J., Drake, L.: Factors influencing waste separation and utilization among households in the Lake Victoria crescent, Uganda, *Waste Management*, Vol. (2009) 29, pp. 3047–3051, PMID: 19740642

[16] Padilla, A.J., Trujillo, J.C.: Waste disposal and households' heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia, *Waste Management*, Vol. (2018) 74, pp. 16–33, PMID: 29258776

[17] Hasan, S.E.: Public Awareness Is Key to Successful Waste Management, *Journal of environmental science and health*, Part A, Toxic/hazardous substances & environmental engineering, Vol. (2004) 39,2, pp. 483-92., PMID: 15027831

INFLUENCE OF CORROSION OF TEHCHNICAL MATERIALS ON THE ENVIRONMENT

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Abstract: *Corrosion as unintentional destruction or the wear process of technical materials leaves harmful consequences, which causes high costs, but also leads to environmental pollution and damage of human health. The negative influence of corrosion on the environment can be observed through pollution caused by corrosion products, as well as pollution due to leakage of media from pipelines or tanks, which are corroded. Harmful substances are also often used in corrosion protection measures, so preference is given to those methods that are more favorable from an ecological point of view. Due to all the above, it is necessary to implement measures to prevent corrosion of technical materials, in order to prevent negative influence on the environment, which is discussed in this paper. By preventing corrosion of technical materials, we take care of the environment and human health, and also costs are significantly reduced.*

Keywords: *technical materials, corrosion, environmental protection, health protection, measures for corrosion protection.*

1. INTRODUCTION

Care for the environment is justifiably becoming one of the main factors of human progress and survival today. Ecology is a science that studies the relationships between living organisms, their impact on the environment and the impact of the environment on them. No matter how you define ecology, it is always the relationship (connection) of a living organism and its environment.

Ecological aspects inevitably enter on all areas of human activity, so it is necessary to observed them also in the field of production engineering. This connection can be observed from the technological aspect, when we talk about environmentally friendly machining, or the concept of green production ("green manufacturing"). This leads to the concept of sustainable development, which means how it is necessary to live and work in a way that, by satisfying our needs, we take

care that the generations that come after us can qualitatively satisfy their own needs too.

In addition to environmentally friendly machining, there is another aspect in the field of materials and technologies in mechanical engineering, extremely related to ecology and environmental protection. It is the connection between corrosion processes and environmental protection, not only environmental protection, but also human health protection. This is discussed in this paper.

The influence of corrosion of technical materials on the environment can be observed from two aspects. One is environmental pollution by corrosion products, or leakage of media into the environment, which occurs due to corrosion, for which the best example is leakage from pipelines or tanks. The second aspect is related to corrosion protection measures, which can have the effect of toxic substances on the environment, and thus, of course, on human health. In addition to the negative influence of corrosion on the environment and human health, we must not forget the very high costs caused by the described processes.

Precisely because of all the above, it is the duty of engineers and experts in the technical field to ensure that corrosion and corrosion protection measures do not lead to environmental pollution and danger to the health of living organisms. Thus, we return to the definition of ecology as a natural science, which focuses on the connection between living organisms and their environment.

2. CORROSION AND CORROSION – RESISTANT MATERIALS

In standard EN ISO 8044, corrosion is defined as "physicochemical interaction between a metal and its environment, which results in changes in the properties of the metal, and which may lead to significant impairment of the function of the metal, the environment, or of the technical system of which these form a part".

The word corrosion comes from the Latin word „corrodere“, which means to corrode. Corrosion occurs if there is an affinity between the reactants (material and environment), which means that the material reacts chemically with the environment. Corrosion wears metallic and non-metallic materials, with degradation being a common term for non-metals.

The consequences of corrosion are manifested in the creation of large damages and high costs arising from the action of corrosion processes. Direct costs caused by corrosion relate to the maintenance and implementation of corrosion protection, as well as the replacement of corroded equipment. Indirect costs are product loss (primarily leakage for example from pipelines), pollution of products and the environment, reduced efficiency and stopping of production.

Corrosion can be divided according to the corrosion process mechanism and the second is geometric classification [2].

According to the corrosion process mechanism, corrosion can be chemical or electrochemical corrosion of metals, and degradation of non-metals in fluids. In the case of chemical corrosion, metals are combined with oxygen from hot gases, so most often when working at very high temperatures. Electrochemical corrosion of

metals and alloys occurs on the surface of metals or alloys by the action of electrolytes (water and aqueous solutions of acids, alkalis and salts). The second classification of corrosion is geometric classification. According to this, the basic division is into general and local corrosion.

No matter what type of corrosion it is, it can cause great damage, environmental disasters and costs. That is why it is important to know corrosion-resistant materials, where corrosion-resistant steels are primarily discussed.

The basic conditions for corrosion resistance of steels are: at least 12% Cr and single-phase microstructure which can be: austenitic, ferritic or martensitic, and therefore the division of corrosion-resistant steels is common.

Ferritic steels have less than 0.1% carbon and 13 to 17% chromium. They are relatively soft, magnetic, and poorly weldable and poorly deformable by deformation. They have a lower price than other groups of stainless steels. They cannot harden by heat treatment processes because they do not have phase transformations.

Martensitic steels have an increased mass fraction of carbon (from 0.15 to 1.0% C). They are magnetic and can be easily hardened by a heat treatment process. Hence, they can achieve superior strength and hardness levels in comparison to ferritic and austhenitic stainless steels. Amongst other, application of martensitic stainless steels includes steam, gas and jet turbine blades, valves and also extending to the surgical tools as well as aerospace components. Wear resistance is ensured by the increased mass fraction of carbon.

Austenitic steels have high corrosion resistance, thanks to a high degree of alloying with chromium and nickel. Due to the austenitic microstructure, they are non-magnetic and can harden by cold deformation. They have satisfactory toughness at low temperatures. They also have good machinability and weldability, as well as excellent mechanical properties. Austenitic stainless steels are the most commonly used group of corrosion-resistant steels.

Austenitic-ferritic (duplex) steels are magnetic and have very high corrosion resistance. This group of corrosion - resistant steels has (as its name suggests) a two - phase, austenitic - ferritic microstructure with 40 to 60% ferrite.

Precipitating hardened steels are magnetic; they can be thermally hardened and have medium corrosion resistance [3].

In addition to corrosion-resistant steels, alloys of copper, aluminum and titanium are also suitable choices, because these materials have increased corrosion resistance to the action of external media.

3. CORROSION PROTECTION AND ECOLOGICAL ASPECTS

In corrosion protection measures, the following procedures can be considered: material selection, protection by alloying, construction and technological measures (design measures), electrochemical measures, protection by coatings, inhibitor protection and temporary protection measures [4].

We have already talked about the material selection in the previous chapter and when it comes to protection by alloying, it should be said that the most important alloying element is certainly chromium (Cr), which in a minimum of 12% forms a passive film on steel, but today's corrosion-resistant steels have up to 30% Cr, which provides the greatest protection, but also slightly worse mechanical properties. Therefore, it is necessary to find the optimal combination of corrosion resistance and mechanical properties of the material for each application. The next alloying element is nickel (Ni), which causes the formation of passive films and repassivation, as well as good mechanical properties. Of the other alloying elements in corrosion-resistant steels, manganese (Mn) and molybdenum (Mo) stand out. For carbon (C), which is not even considered an alloying element in steel (because it is an integral part of it), it is desirable that its content is as low as possible, because it creates carbides, ie if it binds chromium in chromium carbides, then steel loses corrosion resistance, so in stainless steels, the highest possible chromium content and the lowest possible carbon content is desirable.

Design measures - when designing new forms of products, adequate design to reduce corrosion is as important as the choice of material. In many structures we can find examples in which the lack of consideration of the shape of the structure for corrosion control is seen. When selecting the material, the designer must take into account the specific environment, use and corrosion control parameters.

The most common parameters for corrosion control on the structural side include:

- Wall thickness - corrosion involves degradation of the material and continuous reduction of its thickness. Therefore, when designing tanks and pipes, the product must be dimensioned to ensure a sufficient amount of material due to wear. The experiential method is to make the wall thickness twice as thick as that required for the desired service life of the structure.
- Adequate drainage - storage containers and outdoor poles should be designed in such a way that they can be easily dried and cleaned. Therefore, all transitions should be smooth. Taps on the tanks should be placed so that the tank can be completely emptied (Figure 1).
- Parts Joining - butt joints ("V" or "I") should be used instead of folding joints. Welding should be preferred over riveting in tanks and prestressed bolted joints on bridges. It is a good practice and subsequent treatment of welds by sandblasting and protection with waterproof tape or paint.
- Homogeneity - the general rule when applying the material is to avoid heterogeneity. Different materials react differently to stress, temperature, and where there is a difference in potential we have the possibility of corrosion. We should strive to minimize bimetallic corrosion by joining compatible materials without the risk of galvanic corrosion.
- General design guidelines - sharp corners should be avoided as it is difficult to paint them with a uniform thickness of preservative. Complex geometry and narrow gaps prevent adequate surface protection such as painting, cleaning and drying. In general, the structure should be designed to prevent moisture retention if this is not its primary function. Even if the structure is protected by paint, prolonged exposure to adverse conditions will cause the protection to deteriorate (Figure 2).

Figures present design measures.

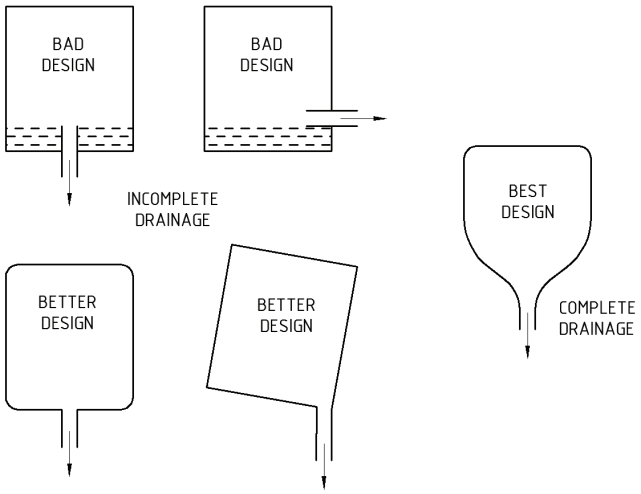

Figure 1: Design for corrosion protection.

Figure 2: Base of public lighting poles in the city of Karlovac. Left - bad design; corrosion occurance due to weld accumulation in sharp corners. Right – good design, small pockets eliminate weld accumulation and provide better drainage.

Electrochemical measures include anodic and cathodic protection and certainly belong to those measures that cause the least damage for the environment.

Protection by coatings is the most widely used and can often have a negative influence on the environment due to the use of harmful substances. Protection by coatings includes: surface preparation, coating application and finishing. Sources of harmful substances are degreasing, varnishing and painting, then mechanical preparation of the substrate, chemical preparation of the substrate, processes of galvanization, metallization, enameling [1].

Corrosion inhibitors are those substances that are added to an aggressive medium to slow down the corrosion of a particular metal. The disadvantage of a large number of effective inhibitors is their toxicity, so in recent times efforts have been made to find and use environmentally friendly inhibitors - plant extracts, for example, which may have inhibitory properties, are being investigated. In environmentally friendly inhibitors, the biodegradability property is also important.

Proper disposal of hazardous waste also plays an important role in preserving the environment.

4. CONCLUSION

Environmental problems are the problems of today and it is the task of all, including technical engineers, to take all measures within their activities to save the environment and living organisms.

Corrosion as a process that inevitably affects the technical materials can significantly ruin the natural balance in the environment by pollution. This paper deals with the influence of corrosion on the environment.

In addition to polluting the environment, many harmful substances are used in corrosion protection measures, which pollute the environment and this measures have negatively influence on the human health.

In the past, corrosion protection measures were not observed from an ecological point of view, but only their effectiveness was important, so the harmful effects of toxic substances were neglected. However, today it is regulated by the laws, and people's consciousness has changed, so caring for the environment and human health has become an integral part of our life.

In conclusion, we can contribute to the protection of the environment and the quality of life by preventing the corrosion of technical materials and using environmentally friendly corrosion protection measures.

REFERENCES

[1] Esih, I.: *Osnove površinske zaštite*, Sveučilište u Zagrebu, Fakultet strojarstva i brodogradnje, ISBN 953-6313-56-1, Zagreb, (2007)

[2] Juraga, I.; Šimunović, V.; Stojanović, I.; Alar, V.: *Mehanizmi zaštite od korozije,* Sveučilište u Zagrebu, Fakultet strojarstva i brodogradnje, skripta, Zagreb, (2012)

[3] Kostadin, T.:Čelici i željezni ljevovi, Materijali II, Veleučilište u Karlovcu, ISBN (online) 978-953-7343-91-0, Karlovac, (2017)
[4] Pomenić, L.: *Zaštita materijala,* Sveučilište u Rijeci, Tehnički fakultet, nastavni materijal, Rijeka, (2009).

THE EFFECT OF EXHAUST GAS EMISSIONS ON URBAN RESIDENTS

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abstract: This work will provide an explanation of the way in which road motor vehicle exhaust gas emissions affect urban residents' health. The aim is to include all measures of prevention for active and passive participants. The purpose of this paper is to help guide the implementation of improvements of the urban residents' life quality, which can be achieved through education and other preventive measures.
key words: urbanism, health, exhaust gas emissions, education.

1 INTRODUCTION

Air pollution is evident in the changes in the environment and human health, especially in urban environments. A big factor causing these changes is urban road traffic since networks of traffic routes and different road constructions and test stations have become a constituent part of today's urban environments. Motor vehicle exhaust gas emissions have a harmful effect on the totality of the natural surroundings. This effect is most significantly caused by road traffic, especially when compared to other modes of traffic.

2 THE EFFECT ON HUMANS

Complete combustion effectively does not happen, fuels contain additives, and unwanted chemical reactions occur at high combustion temperatures.

In the Otto engine, the percentage of harmful substances in front of the catalytic converter at working temperature is 1% of the total amount of combustion products. [1] (Figure 1).

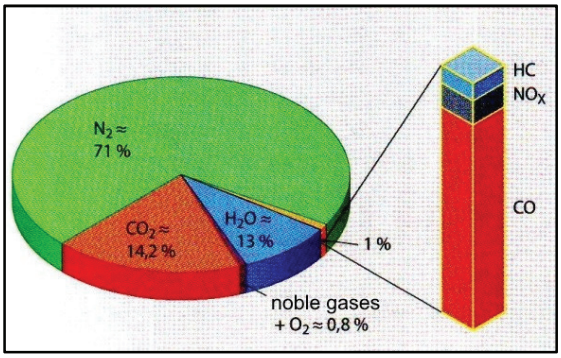

Figure 1: Composition of exhaust emissions in front of the catalytic converter

Lawmakers dictate the maximum allowed values of harmful substances in exhaust gas emissions during the testing process of vehicles for the purpose of issuing use certifications and the subsequent testing of harmful substance emissions. [1] (Table 1).

Table 1: Harmful substance thresholds for personal vehicles and lorries with the Otto engine in Europe in [g/kg], except for PN (1/km)

M1 (≤ 2,5 t, ≤ 6 seats)	CO	HC	NO_x	PM	PN
Euro III from 2000.	2,30	0,20	0,15	-	-
Euro IV from 2005.	1,00	0,10	0,08	-	-
Euro V from 2009.	1,00	0,10	0,06	0,005*	-
Euro VI from 2014.	1,00	0,10	0,06	0,005*	$6 \cdot 10^{11}$
* for direct injection 0,0045					

Children and people chronically suffering from pulmonary and heart diseases are especially sensitive to polluted air. The most obvious effect of polluted air on human health are respiratory diseases such as bronchitis, asthma, pulmonary emphysema, and lung cancer. The easiest way pollutants from the atmosphere enter the human body is through the respiratory system. The effects of different pollutants differ based on the time it takes to detect the first symptoms of the disease. Exhaust gas emissions can irritate the eyes, and the respiratory tracts and are dangerous to health when inhaled.

Depending on the length of exposure to harmful substances, there are acute and chronic effects of air pollutants. Acute effects manifest after only a brief exposure lasting a few days, while chronic effects become apparent only after exposure lasting a longer period of time. The effects of polluted air are significantly more dangerous because much more time is needed to detect them.

Transport and traffic together cause 23.70% of the total carbon dioxide emissions, while road traffic makes up 72% of that share. This means that road traffic is the biggest air polluter among all transport activity. Road traffic emits a 98 times greater amount of carbon monoxide and a 22.6 times greater amount nitrogen oxide compared to railway traffic.

Carbon emissions are 95 times greater in road traffic, while sulphur dioxide emissions are 7.4 times greater in road traffic. The emission of solid particles is also 17 times greater when compared to railway traffic.

2.1. The effect of polluted air on human health

Human health – exhaust gas emissions generally cause diseases of the cardiovascular, respiratory, and nervous systems, as well as blood and blood-generating organ diseases, sensory organ diseases, and can cause mental disorders.[3]

The most obvious effect of polluted air on human health are respiratory organ diseases such as bronchitis, asthma, pulmonary emphysema, and lung cancer. The easiest way pollutants from the atmosphere enter the human body is through the respiratory system. The effects of different pollutants differ based on the time it takes to detect the first symptoms of the disease. Exhaust gas emissions can irritate the eyes, and the respiratory tracts and are dangerous to health when inhaled.

Sulphur dioxide (SO_2) is a colourless gas with an acidic taste that irritates respiratory tracts and dissolves in the mucosae of the eyes, the mouth, the nose, and the bronchus. Trials have determined that sulphur oxides increase respiratory diseases such as bronchitis and lung cancer. In contact with dust, there is increased danger of SO_2 because an acidic aerosol that can more easily reach the internal respiratory organs is created.

Carbon monoxide causes headache, weakening of the cardiovascular system and vomiting. In larger amounts it can even cause death. Its danger lies in the fact that it is hard to detect since it has no smell. When it enters the blood, it blocks the transfer of oxygen because it has a 200 to 300 times greater tendency to bind to haemoglobin.

Various nitrogen oxides (NO_X) are also dangerous to human health. Nitrogen dioxide is an irritant gas that dissolves in the mucosae, while nitrogen oxide has a toxic effect and creates methaemoglobin in the blood.

Ozone (O_3) is a stifling colourless gas. It is a component of photochemical smog. This gas has an irritating effect that causes coughs and increases sensitivity to infection. Additionally, it is important to mention that lead (Pb) affects small children's brains and builds up sediments in human bones.[3]

2.2. Preventive measures for health protection of urban residents

Since urban residents are exposed through their everyday activities in places where exhaust gasses of different compositions build up, measures for improving health protection are crucial. The following measures are suggested.

- use of medical protective masks during exposure to greater concentrations of vehicle exhaust gas emissions

Figure 2: A medical protective mask [4]

- a mask that can serve to protect the respiratory tract and eyes

Figure 3: A mask for eye protection and protection from exhaust gas inhalation [5]

- periodic medical examinations of urban residents

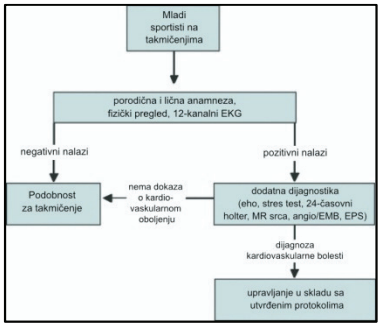

Figure 4: Medical examination algorithm [6]

3 EU STRATEGIES FOR DEALING WITH CO_2 EMISSIONS

Target groups are urban residents and heads of car testing stations.

The aim of the EU is to encourage specific preventive measures for urban residents and to prevent specific risks, to reduce respiratory diseases above all else. The first city in history to have faced the problem of exhaust gas emissions is Los Angeles. Empirical research in 1956. showed that exhaust gas emissions initiate respiratory diseases. [7]

The International Agency for Research on Cancer (IARC) has classified the exhaust diesel engine as carcinogenic for humans based on sufficient evidence on exposure being connected with increased risk of lung cancer (IARC, 2012). IARC classifies petrol exhaust gases as possibly carcinogenic.

4 OUR AIMS

We are aware that exposure to exhaust gas emissions is a risk for all urban residents. This is why we wish to start developing a local system of preventive activities with the goal of removing air pollution and educating all citizens of different categories. The project regarding the reduction of exhaust gas emissions was endorsed by various active and passive participants. They were all very interested in the development of an efficient system of preventive activities to protect their health in the best way.

Preparatory activities have already been held and we are also planning on continuing with the education of active and passive participants under the title: "Strategies for the reduction of motor vehicle CO_2 emissions".

ECO driving is one of the methods for both protecting the environment and saving fuel. It is a new, modern style of driving based on safeguarding the awareness of environmental protection. ECO driving fosters fuel consumption reduction, thereby also drastically reducing harmful substance emissions.

5 CONCLUSION

It is scientifically proven that harmful substances, created as a consequence of road motor vehicle use, greatly affect the general state of the environment. Human health is under threat from a certain concentration of different toxic substances to a greater or lesser extent. Technical and exhaust performances of systems, as well as ergonomic characteristics and noise are taken into consideration.

It is our wish to hold educational workshops in periodic cycles to educate all residents of urban areas and beyond, vehicle testing station employees and their superiors, and, if needed, all those interested in this issue. We have already started with preparatory information and individual educations in the Samobor city area.

After that, we are planning on continuing and expanding the preventive-educational workshops in the Koprivnica-Križevci county.

LITERATURE

[1] Bohner, Max [et.al]. Motor vehicle technology [*Tehnika motornih vozila]*, Public Open University Zagreb, Zagreb, 2013.

[2] Golubić J: Traffic and the environment [*Promet i okoliš*], Zagreb, 1999.

[3] Missoni, E: The Human Factor in Traffic *[Ljudski čimbenik u prometu*], Faculty of transport and traffic services, Zagreb, 2017.

[4]: Downloaded from: https://www.zutiklik.hr [Accessed: April 2022]

[5]: Downloaded from: http://www.polimer.hr/ [Accessed: April 2022)

[6]: https://www.sportskamedicina.hr [Accessed: April 2022]

[7]: https://nashipoezda.ru/hr/utility/vliyanie-vyhlopnyh-gazov-na-organizm-lyudei-primernyi-sostav-vyhlopnyh.html [Accessed: April 2022]

IMPACT OF WATER ON HUMAN ORGANISM AND HEALTH

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Abstract
According to the UNESCO report, Croatia is at the top in Europe and in the world in terms of wealth and availability of water resources per capita. It is one of the few countries in Europe and the world that has significant reserves of untreated, healthy drinking water. Water is a component of all living beings and an indispensable ingredient in food. It is important for the normal functioning of the human body - it participates in all biochemical reactions in the human body and protects body parts from shocks. It makes up about 60-70% of an adult's body weight and slightly more in children. It is therefore necessary and important for life and health. Water participates in the breakdown and absorption of food and facilitates digestion, rids the body of harmful substances, is a source of important minerals and electrolytes, regulates body temperature, serves as a protector of organs and bodies and keeps skin healthy and slows aging.
Keywords: *water, health, protection*

Introduction

Water, which man has been collecting and nurturing with admiration since ancient times, is, unlike other natural phenomena, inseparable from himself. Among the various elements that surround man on Earth, only water occurs almost everywhere - as perfect, fruitful, unique. Most probably that is why its spiritual symbolism as a source of life, a means of purification and a means of renewal. The miraculous life

of water is never lost from the surface of the Earth and the constant movement, from the gaseous state like steam, to the liquid and solid in the form of snow and ice, gives it vitality. Through its movement in the hydrological cycle, water also participates in chemical reactions with atmospheric gases, rocks, plants and various substances, whether of natural or anthropogenic origin. [7] The result of the interaction of water and these substances in the atmosphere are changes in the chemical composition of water, but also changes in the substances with which water reacts. These changes, along with other changes in the atmosphere, contribute to the establishment of total chemical conditions on the Earth's surface, which is reflected in the final shape of global geochemical cycles of major chemical elements (Na, K, Ca, Mg, Si, C, N, S, P, Cl, O and H) in the environment, which are closely related to the hydrological cycle (Figure 1)

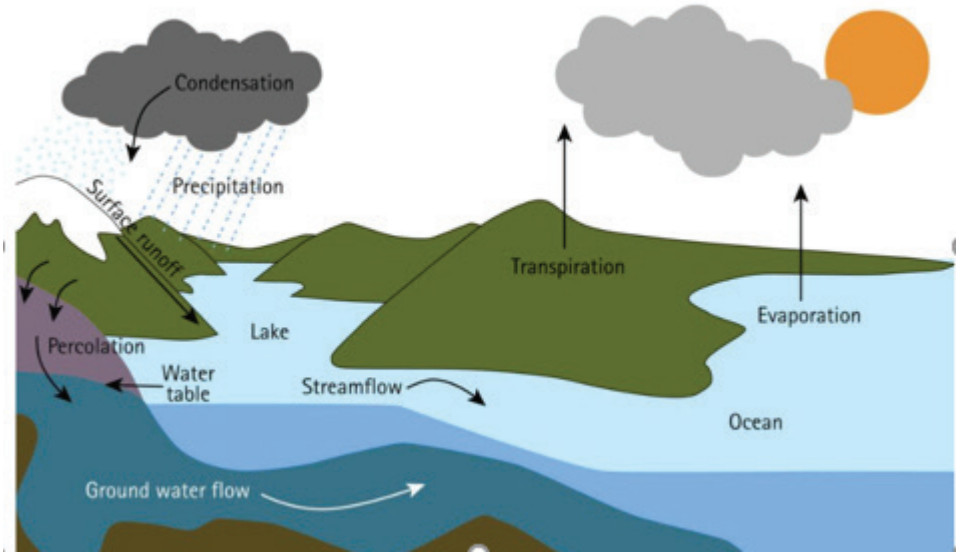

Figure 1: Hydrologic Cycle

Water is the most important component of the human body, so the embryo consists of 90% water, newborn 75%, adolescent 60%, adult 57%, and the elderly 50% water, which indicates the fact that without water there is no life. [11] Water is a means in which all metabolic processes take place, and plays an important role in detoxifying the body. It is impossible to survive without water for more than a week, and even shorter in extreme temperatures, so it is extremely important to get the necessary daily amounts of water into the body. [8] According to all the recommendations for daily intake, due to the importance of water in our body, it is necessary to drink 1,5 dm^3 of water.

HOW DOES WATER AFFECT HUMAN HEALTH?

There are 16 key reasons why water is essential for health and why it is important to drink water: [1,4]

1) Helps to create saliva. Water is the main component of saliva. Saliva also includes small amounts of electrolytes, mucus and enzymes. It is essential for breaking down solid foods and keeping your mouth healthy. The body usually produces enough saliva by regular fluid intake. However, saliva production may decrease as a result of age or certain medications or therapies.
2) Regulates body temperature. Maintaining hydration is crucial to maintaining body temperature as the body loses water through sweating through physical activity and in warm environments. Sweat keeps the body cool, but body temperature will rise if the lost water is not made up. This is because the body loses electrolytes and plasma when it is dehydrated.
3) Protects tissues. Consumption of water helps to lubricate and cushion the blows to the joints and protects cartilage, spinal cord and tissues. It helps with physical activity to reduce the discomfort caused by conditions like arthritis.
4) Helps excrete toxins through sweating, urination and defecation. The body uses water for sweating, urination and stool. Sweat regulates body temperature during physical activity, and water is needed to make up for lost fluids from sweat. The kidneys are also important for filtering waste through urination. Adequate water intake helps the kidneys work more efficiently and prevents the formation of kidney stones.
5) Helps maximize physical activity and affects strength and endurance. Adverse effects of physical activity at high air temperatures without sufficient water can cause serious health problems such as low blood pressure and hyperthermia.
6) Helps prevent constipation - Eating fiber is not the only way to prevent constipation. It is important to maintain water intake so that the stool contains enough water. If not enough water, magnesium and fiber are ingested, there is a possibility of constipation.
7) Helps with digestion. Experts have confirmed that drinking water before, during and after a meal helps the body break down and digest food more easily, and get the most out of the meal as the body adapts to changes in food consistency and stomach content, whether solid or liquid.
8) Helps with nutrient absorption. In addition to helping to break down food, water is also necessary for dissolving vitamins, minerals and other nutrients from food, and supplies vitamin components to the rest of the body for use.

9) Helps to lose weight. Studies link body fat and weight loss to water, because a lot of water during dieting and physical activity can help to lose extra pounds.
10) Improves blood oxygen circulation. Water carries beneficial nutrients and oxygen throughout the body. Achieving a daily intake of water will improve circulation and positively affect the overall health of the body.
11) Helps fight disease. Drinking enough water can prevent certain health conditions, which include: constipation, kidney stones, exercise-induced asthma, urinary tract infections, and hypertension. Water helps absorb important vitamins, minerals and nutrients from food, which increases the body's ability to stay healthy.
12) Helps strengthen energy. Water can activate metabolism, and boosting metabolism is associated with a positive impact on energy levels. One study found that 500 ml of water boosted metabolism by 30% in both men and women, and that these effects lasted for more than an hour.
13) Helps with cognitive functions which includes: ability to think logically, learning and memory, language, executive functions, attention, perceptual-motor and social cognition. Proper hydration is key to the development of both bodily and cognitive functions and that insufficient water in the body can negatively affect focus, alertness and memory.
14) Helps improve mood. In addition to affecting our physical health, water affects the psyche and mood. Our brain consists of 75% water and feels even the slightest signs of dehydration. When we do not drink enough fluids, we become irritable, feel tired, anxious and lose concentration.
15) Helps maintain beautiful skin because water is the best friend in the fight against aging. Adequate water intake can help keep skin hydrated and can boost collagen production. However, water intake alone is not enough to reduce the effects of aging.
16) Prevents total dehydration or lack of water in the body. Dehydration occurs when the loss of water from the body is greater than its receipt. Lack of water usually causes an increase in sodium levels in the bloodstream. Dehydration can be caused by vomiting, diarrhea, use of diuretics (drugs that force the kidneys to excrete increased amounts of water and salt), excessive heat, fever, and decreased water intake for any reason. Some diseases such as diabetes, diabetes insipidus and Addison's disease can lead to dehydration due to excessive water loss.

POLLUTIONS IN DRINKING WATER AND THEIR IMPACT ON HEALTH

It is estimated that the total volume of water on Earth is about 1.4 billion cubic kilometers, or 365 million square kilometers occupied by water, which is as much as 71% of the Earth's surface. However, it is not uncommon for this same, much-needed, liquid, in addition to all its beneficial effects, to hide numerous dangers if it

contains unwanted substances harmful to our health. Namely, since a large amount of wastewater from industry and agriculture ends up in watercourses and groundwater, which introduces metals into the environment. Pesticide residues, medicines, cosmetics, paints, detergents, oils, etc., most of which are biodegradable pollutants. There are almost no areas, including water, that do not contain heavy metals such as lead, mercury and cadmium, which most often accumulate and are very toxic to the body. [2,3]

• **Lead** - in the form of divalent metal ions is very widespread in natural waters, and the highest concentrations were recorded in groundwater with a pH value <5.5, while in surface waters its concentrations are lower and range around 0.05 mg/L . Lead is a poison that accumulates in the skeleton, and toxicological effects were measured based on the concentration of lead in the blood. Lead is toxic to both the central and peripheral nervous systems, causing harmful neurological effects in behavior. It also causes harmful effects on the reproductive, cardiovascular, immune and gastrointestinal systems. (Figure 2)

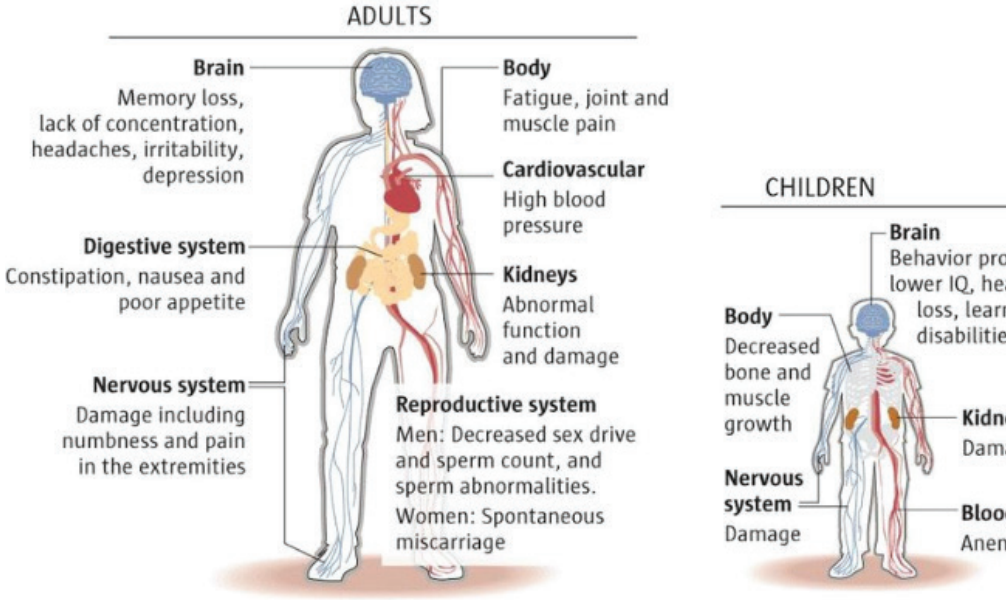

Figure 2: Effects of lead poisoning

The results of long-term epidemiological studies suggest that prenatal exposure to lead may have early effects on the mental development of children up to 4 years of age. There are also data on the impact of low concentrations of lead on the occurrence of kidney disease, blindness, cancer and neurotoxic effects on human health, which can be fatal. Lead is a cumulative poison to humans, and acute

poisoning is very rare. [6] Typical symptoms of lead poisoning are anemia, gastrointestinal upset, tenderness, and gradual muscle paralysis, lethargy. According to recent research results, it has been determined that lead can be even more dangerous to human health than previously thought. Even at low concentrations in the human body, in addition to damaging the kidneys, lead can also cause high blood pressure (hypertension).

• **Mercury** - like lead, is a heavy metal that can cause very serious adverse health effects. It is one of the inorganic pollutants that can occur in the environment from natural sources such as volcanic eruptions, soil erosion, and bacterial decomposition of organic mercury compounds. The most significant anthropogenic sources of mercury are municipal waste incinerators, fossil fuel combustion plants, electrolysis plants where mercury is used as an electrode, etc. From which it can enter water supply systems.
The fundamental problem of mercury water pollution is that its organometallic compounds can accumulate and metabolize in the biosphere, which is very well illustrated by the most famous case of mass mercury poisoning through the aquatic ecosystem that occurred in Minamata Bay, Japan.
In lower concentrations, mercury in the human body can cause disorders of the kidneys and nervous system. Prolonged exposure to mercury can result in permanent damage to the brain, kidneys, or cause adverse effects on fetal development.
• **Arsenic** - in groundwater and surface water most often occurs in the form of its inorganic compounds that are carcinogenic and are more dangerous to the body than its organic compounds. It enters the water as a result of natural erosion processes, but also from mine tailings, waste dumps of the pharmaceutical industry, paint industry and pesticides. Arsenic is carcinogenic, damages the heart, lungs, stomach, liver and kidneys, and has negative effects on the nervous system. Namely, acute arsenic poisoning leads to changes in the central nervous system, gastrointestinal and respiratory systems, as well as on the skin, can cause coma, and in a concentration of 70-180 mg/L leads to death. Chronic arsenic poisoning is manifested by general muscle weakness, loss of appetite, nausea and skin changes. When skin poisoning, there are signs of hyperpigmentation of the skin, thickening of the upper layer of the skin (hyperkeratosis), inflammation of peripheral nerves (polyneuritis). Chronic arsenic poisoning mainly occurs with high occupational exposure to arsenic or with the population using drinking water with high concentrations of arsenic for a long time. Arsenic in the human body can take other forms of adverse health effects such as one type of diabetes with characteristic persistent hyperglycemia and a number of other disorders (complications of the eyes, kidneys, nerves and blood vessels). At a concentration of arsenic in drinking water higher than 100 g/L, arsenic causes ischemia of the heart, high blood pressure or cancer of the skin, lungs and internal organs (bladder, kidneys, liver).
• **Hydrocarbons** - are also among the pollutants that enter the environment through water. They are discharged from various anthropogenic sources into wastewater, then into watercourses, or by spillage in incidental situations they reach the ground and from there into surface and groundwater. These compounds, when they enter the environment, leave traces of their harmful effects in various ways, from the accumulation on the surface of the water (e.g. oil spills into the sea), while its

physical properties endanger flora and fauna because it prevents photosynthesis, respiration, until entering the food chain and the occurrence of harmful effects on humans. The negative effects of hydrocarbons on the human body are diverse, but what is most significant are their mutagenic and carcinogenic properties, especially when their presence is determined in the vicinity of water wells. Ingestion of hydrocarbons in humans can cause nausea, vomiting, and abdominal cramps and severe diarrhea, and prolonged contact with contaminated water on the skin may cause irritation or dermatitis due to hypersensitivity.

• **Nitrates** - as very important pollutants in water, arouse great interest of all experts involved in both environmental protection and human health, because they can cause very harmful health effects. The largest source of nitrate in water is considered to be mineral fertilizers from arable land and a smaller part of manure that is still used in field cultivation, or inadequately built septic tanks. However, given the total content and very easy distribution in water, the most important and by far the most dangerous source of nitrate is fertilization with mineral fertilizers. Namely, as nitrates are very soluble in rainwater, and do not have the ability to bind to the adsorption complex of the soil, they are very mobile and leach into deeper soil layers, thus reaching drinking groundwater. The intake of nitrate ions (NO^{3-}) by the digestive system is associated with the acceleration of the growth of the bacterial flora, which converts nitrates into nitrites, and these with amines form nitro compounds whose carcinogenicity has been unequivocally proven. Although the intake of nitrates and nitrites in the body is normal, because they are also contained in food, their excessive amount in the body can cause adverse health effects. Therefore, the World Health Organization recommends a limit of permissible intake of nitrate in the human body of 5 mg/kg body weight, while for nitrites the equivalent dose is 0.4 mg/kg. According to the current regulations in the Republic of Croatia, the maximum permissible concentration (MAC) of nitrates in drinking water is 50 mg/L, while the recommended value for nitrates in EU drinking water is 25 mg/L NO^{3-}. Nitrates and nitrites in the body convert iron hemoglobin into oxidized form causing methemoglobinemia where methemoglobin cannot carry oxygen or carbon dioxide, thus reducing oxygen transfer to cells.

• **Pesticides** - together with mineral fertilizers, over the past century, and their popularity is reflected in the ability to deal with various pests in the fattening of plants and animals. However, pests gradually developed resistance to pesticides and forced farmers to resort to new chemical formulations, which very quickly led to pollution and even endangerment of the environment. The presence of pesticides in the environment was first determined in surface and groundwater, which led to the first recorded adverse effects on human health. Data on the content of organochlorine pesticides in surface and groundwater in the Republic of Croatia began to be collected in the late 1970s. Then, in groundwater, as a potential source of drinking water, at several locations in eastern Slavonia and Istria, the presence of compounds such as y-hexachlorocyclohexane (y-HCH), DDT and their metabolites, hexachlorobenzene (HCB); etc. Subsequent research has identified the occurrence of pesticides in Dalmatian rivers, and the highest concentrations of these compounds were measured in the rivers of continental Croatia (Sava, Drava, Korana, Dobra and Kupa). Due to their toxicity, pesticides have detrimental effects on human health,

and depending on the type of pesticide and the amount ingested, the symptoms of poisoning can be very different but the clinical picture is similar. Initially, respiratory, digestive and neurological disorders occur as a result of the direct action of the active substance. When poisoned through the skin, a yellow color sometimes appears due to liver damage, which can sometimes end in death. Fatalities are most commonly observed in accidental ingestion, and less frequently as a result of inhalation. In both cases, the immediate cause of death is the cessation of the function of vital centers in the form of paralysis of the respiratory centers, asystole and pulmonary edema. Very common side effects of poisoning with these compounds, especially with organophosphorus poisoning are: narrowing of vision, increased salivation, difficulty and irregular breathing, nausea, diarrhea, short-term increase in blood pressure, general physical weakness, fatigue, dizziness, nervousness, cessation of breathing.

• **Microbiological contamination in drinking water** - in some parts of the world up to 80% of all diseases and about a third of all deaths are related to the use of unhealthy water contaminated with microbiological contaminants. Microorganisms in wastewater are most often of fecal origin (California bacteria), human and animal, and originate from sanitary wastewater settlements, and from septic tanks in areas where they are still used. Wastewater reaches natural water recipients and feces from septic tanks are absorbed into the soil and into groundwater. In areas with an inadequate water supply system, especially in areas where continuous water health testing is not carried out, these agents can also enter drinking water. If pathogenic bacteria, viruses and parasites are also present in the feces, they will also enter the wastewater and natural waters together with the coliform bacteria.

CONCLUSION

Water is the accumulator and transformer of all energies that originate on earth and in space, and the base of life on our planet. When it falls to the ground in the form of rain, it is completely clean and does not contain any foreign minerals and elements. In order to pass the complete hydrological cycle, you first need to sink into the ground, reach geothermal springs and pick up salts. It then returns up, driven by the gases it has created by dissolving carbon compounds. When it is mature, it comes out on its own. It contains minerals and energy, carries nutrients from the depths and delivers them to the body. If water were drunk from such sources, there would never be cancer or heart disease. [9,10] The development of technology, industrial production, agricultural activities and accelerated urbanization are disrupting drinking water sources and reducing the amount of natural water reserves that are expected in the future. Water needs are growing, and the number of pollutants is growing, which is why good environmental awareness of people, permanent preventive action and strict control over drinking water and water supply facilities are necessary. Adequate supply of quality drinking water is one of the basic prerequisites for a healthy life. The quality of the water we drink can radically affect our health. That is why it is vital to drink only the purest water.

Literature

[1] Valić F, Antonić K, Beritić-Stahuljak D, Brumen V, Cigula M, Doko-Jelinić J. *Zdravstvena ekologija*. U: Anđa Raič. Zagreb: Medicinska naklada; 2001.
[2] Fawell J, J. Nieuwenhuijsen M. *Contaminants in drinking water*. Br Med Bull (2003) 68 (1): 199-208.
[3] Rajković MB, Stojadinović MD, Lačnjevac ČM,.Tošković DV,.Stanojević DD. Detekcija i određivanje nekih teških metala u vodi gradske vodovodne mreže naselja Vidikovac-Beograd preko izdvojenog kamenca iz vode. *Zaštita materijala*. 2009; 50(1):35-34.
[4] Puntarić D, Miškulin M, Bošnir J. *Zdravstvena ekologija*. U: Anđa Raič. Zagreb: Medicinska naklada; 2012.
[5] World Health Organization. *Guidelines for Drinking-water* Quality fourth edition. [Internet]. 4 izd. Geneva: World Health Organization; 2011 [pristupljeno 15.06.2016.] Dostupno na: http://apps.who.int/iris/bitstream/10665/44584/1/9789241548151_eng.pdf
[6] Ritter L, Solomon K, Sibley P, Halll K, Keen P, Mattu G., i sur. *Sources, pathways, and relative risks of contaminants in surface water and groundwater*: A perspective prepared for the Walkerton inquiry. J Toxicol Environ Health. 2002;65:1 (1), 1-142.
[7] Beritić-Stahuljak D, Žuškin E, Valić F, Mustajbegović J. *Kemijski čimbenici radne okoline*. U: Anđa Raič. Medicina rada. Zagreb: Medicinska naklada;1999.Str. 43-69.
[8] World Health Organization. Cadmium in Drinking-water: Background document for development of WHO *Guidelines for Drinking-water Quality.* [Internet] Geneva: World Health Organization ; 2011 [pristupljeno 15.06.2016.]. Dostupno na: http://www.who.int/water_sanitation_health/dwq/chemicals/cadmium.pdf
[9] World Health Organization. Mercury in Drinking-water: Background document for development of WHO *Guidelines for Drinking-water Quality.* [Internet] Geneva: World Health Organization; 2005 Dostupno na:http://www.who.int/water_sanitation_health/dwq/chemicals/mercuryfinal.pdf
[10] World Health organization. Chromium in Drinking-water: Background document for development of WHO *Guidelines for Drinking-water Quality.* [Internet] Geneva: World HealthOrganization; 2003 [pristupljeno15.06.2016.]. Dostupno na: http://www.who.int/water_sanitation_health/dwq/chemicals/chromium.pdf
[11] EPA United States Environmental Protection Agency. [Internet]. United States Environmental Protection Agency-Chromium; [pristupljeno15.06.2016.]. Dostupno na: https://safewater.zendesk.com/hc/en-us/sections/202366458

BUSINESS CONTINUITY MANAGEMENT IN THE IT INDUSTRY USING RENEWABLE ENERGY SOURCES

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Abstract: *Organizations of any kind, and especially the IT industry, face internal and external factors and influences related to the supply of electricity. In order to minimize the consequences of the disaster caused by the collapse of the energy system for the business of the IT sector, it is desirable to install renewable energy sources in the power supply system.*

In this paper, we will explain how the use of renewable sources can provide the IT industry with enough energy to achieve energy continuity of operations. Through a practical analysis of the success of the energy continuity plan, the profitability of investing in alternative energy sources was pointed out.

Keywords: *disaster, infrastructure, IT industry, business continuity, renewable energy sources*

1. INTRODUCTION

Business continuity planning (BCP) is the process of creating and refining a logistics plan that provides guidance on how to avoid, mitigate, and in the worst case, recover, i.e. restart business, after damage caused by an accident.

Every BCP strategy includes three fundamental components: risk assessment, contingency planning, and the actual disaster recovery process. BCP should cover all types of business interruptions. From the smallest power outage to the worst possible natural disaster.

Nowadays, it is difficult to imagine life without the use of information technology in all segments of business and modern life. Taking into account the importance of the IT industry, it is necessary to foresee their uninterrupted work when an extraordinary event occurs. The biggest influence on the work of the IT industry is electricity, energy sources, and the lack of it results in lost data and interruptions in communication. The time it takes for the IT system to recover from such an event significantly affects business continuity. In order to avoid such situations, it is necessary to create a plan. That is, avoid risk or mitigate it.

When creating a business continuity plan in the event of a power outage, renewable energy sources can greatly help us. Renewable energy, often called clean energy, comes from natural sources that are constantly renewed. For example, sunlight or wind continue to shine and blow, even if their availability depends on the weather and time of day. When there are more and more innovative and cheaper ways to capture the sun's energy, renewable sources become an increasingly important source, forming part of the production system. The application of renewable sources ranges from rooftop solar panels on buildings that can produce energy for the operation of electrical devices to solar cells for mass consumption. The goal is to modernize the electricity grid, making it smarter, safer and better integrated in the field of the IT industry.

In order to analyze the impact of power outages on the continuation of business, we will apply the risk management guidelines of ISO 31000:2009. This paper focuses on technical measures that can be taken and implemented in the existing system with the aim of improving disaster response, specifically on the impact of power outages and examining the benefits that new technologies such as solar energy could bring in this area.

2. BUSINESS CONTINUITY

Large-scale disasters, from natural ones such as earthquakes to anthropological disturbances, such as supply disruptions, diversions and war destruction, significantly affect the work of the IT industry, which has infiltrated all branches of company operations as well as society in general.

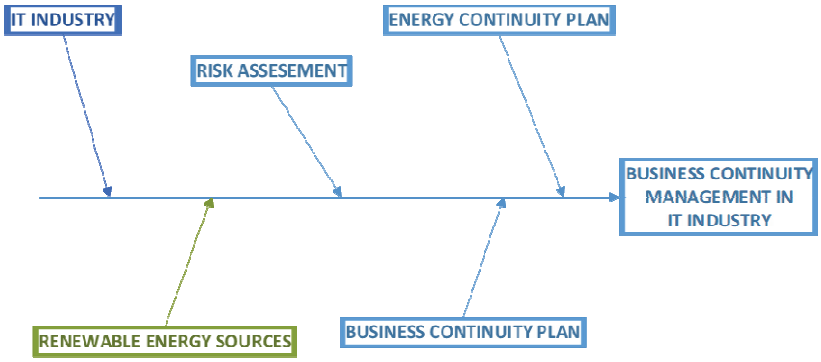
Taking into account the risks that affect the continuity of business brought to us by extraordinary events such as power outages it is necessary to take further actions. Accordingly, we can talk about planning an energy continuity plan, which is crucial in case of longer power outages.

2.1. Developing an energy continuity plan

As part of the IT industry's overall business continuity plan, it is necessary to study the possible consequences of energy shortages. Based on this, it’s mandatory to make a plan in case of risks and respond to them accordingly.

The energy continuity plan must include how to quickly restore the electricity supply to all essential parts of the system (servers, workstations, air conditioning, and lighting).

Figure 1: Business continuity management in IT industry



In order for business continuity management in the IT industry (Figure 1) to lead to positive effects, the following must be taken into account:

- IT industry - comprehensive operations arising from this sector on which the clients depend (banks, telecommunications),

- constant assessment of existing and future risks that may affect business continuity in dependencies on the maintenance of existing system functions,

- drawing up a plan and implementation of energy continuity - electricity affects the operation of all systems and it is necessary to give special attention to ensure a constant source of electricity as the basic driver of business,

- inclusion of renewable energy sources, which includes developing self-awareness about secondary energy sources.

3. ANALYSIS OF BUSINESS CONTINUITY IN THE IT INDUSTRY IN CASE OF AN EMERGENCY SITUATION

By analyzing business continuity in the IT industry in the event of an emergency, we will especially consider how to quickly restore the electricity supply in a certain location. The whole process needs to be improved and perfected through several stages until the desired goal is reached.

After each phase, it is necessary to revise the cycle for every real case of an unexpected disaster - power outage. Disaster preparedness will never be perfect without proper preparation and planning.

3.1. Energy continuity plan

Through 3 phases, the energy continuity management system is planned and improved so it can provide independence and the need to operate all parts of the

system that are necessary for adequate support. It refers to the case of loss of electricity supply. The starting point is careful planning the continuity of the electricity supply and everything that it entails.

We have to take into account the degree of organization of the existing situation in an IT company that deals with the production and maintenance of application software used by external companies for work such as banks and telecommunications services. The current system consists of a server, workstations (computers), air conditioning system and lighting. For situations without electricity there are built-in power failure measures (uninterruptible power supplies (UPS)) for servers and workstations. The current system in the event of a power failure provides only a basic function with the help of continuous power supplies – the completion of the current/started work by the employee, but without the possibility of providing support to external clients.

For the need to create and implement an energy continuity plan, a 48-hour power outage period was taken.

Table 1: Phaseses

Phaşe 1		
PLAN	DO	CHECK
Provide the continuous operation of computers, servers, air conditioning, lighting and the employees themselves in the event of a power outage.	Introduction of renewable energy sources. Installation of solar panels that will supplement the uninterrupted power supplies that are used as a source of power supply during power outages.	In the event of a power outage, uninterruptible power supplies in combination with solar panels affect the length of operation of uninterruptible power supplies only in case of short-term power interruptions, while in the long term the continuation of business was not possible.
The introduction of solar panels shows some progress for the continuation of business in the event of a power outage, however, it is necessary to invest additional funds in order to ensure sufficient energy for a longer period.		
Phase 2		
PLAN	DO	CHECK
Improve the operation of solar panels.	Procurement of additional batteries that will store electricity.	Due to power outages, continuous power supplies in combination with solar panels and additional batteries significantly affected the length of operation of all parts of the system.
Although at first the results look very favorable, in the event of a power outage, it would be necessary to review the necessity of the operation of all systems in the building in order to		

ensure the longest possible operation, i.e. the continuation of business and support for users.

Phase 3		
PLAN	DO	CHECK
Install smart switches and, if necessary, limit operation only to necessary systems.	Devices were selected based on priority, consumption was rationalized by limiting device power, and priorities were set for battery power.	Rational consumption of limited electrical energy by redistribution to the most essential parts of the system enabled the continuous operation of the server until the arrival of a stable source. The work of workstations was limited only to certain workplaces, without which the company's business would not be possible.
The current solution offers favorable results in the event of an extraordinary event such as a power outage and ensures maximum work efficiency and ensuring the availability of services that the company provides to its users.		

3.2. Business continuity analysis

The analysis of the success of the energy continuity plan looks at the success of the continuation of business throughout the duration of the interruption and the consequences for the business at each stage.

Table 2: Analysis of the success of the energy continuity plan

Phase	Action description	Interruption duration (hours)	Consequence	Success of continuing work
1	Installation of solar panels in combination with UPS power supplies	40	Stalls in business for a long time	50%
2	Improving the technical performance of installing solar panels in combination with UPS power supplies	24	Shorter downtimes in business	65%
3	Redistribution of electricity	0	No downtime in business	99%

Phase 1 - installation of solar panels provides some progress in terms of business continuity, resulting in a 50% success rate in business continuity. In phase 2, by improving the technical performance of the installed solar panels in combination with UPS power supplies, the first set goal was achieved, meeting the success rate of 65% of business continuity in the IT business. From the above, we can conclude that by the improvement of the plans as well as the performance itself, taking into account renewable energy sources, and in conjunction with solar panels, we achieved optimal results, which was proven by the final solution in phase 3.

3. CONCLUSION

By analyzing the success of the energy continuity plan, we can conclude the following:

1. the implementation of new technological solutions related to the installation of solar panels enables longer autonomy of the system,
2. it is needed to make additional investments to achieve better performance - improvement of the system of independent energy supply
3. the combination with an advanced system for the redistribution of electricity enables the stability and constant service that is expected from the IT sector to users for a given period,
4. in case of longer power outages (>48 hours), the use of renewable energy sources is not sustainable.

Continuous investment in progress, especially one that does not depend on external influences such as availability and dependence on electricity producers, provides security in the context of business continuity in terms of providing a service on which society as a whole depends. In order for the established technological improvement to survive, it is necessary to continuously work on business continuity plans, taking into account:

- expected duration of downtime,
- the effects on the organization in the event of a power outage or other extraordinary event,
- the financial cost of activating the energy continuity plan.

LITERATURE

[1] International Electrotechnical Commission: *Microgrids for disaster preparedness and recovery*, International Electrotechnical Commission, ISBN 978-2-8322-1151-9, Switzerland, (2014)
[2] AIG: *Building a Business Continuity Plan*, American International Group, UC4520T0P3, England, (2013)

[3] Williamson, John: *Business Continuity Planning: A Primer for Management and IT Personnel*, The AnyKeyNow Group, (2002)
[4] Wikipedia: Business continuity planning, *Available from* http://en.wikipedia.org/wiki/Business_continuity_planning *Accessed:* 2022-06-05.
[5] International Organization for Standardization: ISO 31000 Risk management, Available from https://www.iso.org/iso-31000-risk-management.html Accessed: 2022-06-12.

THE INFLUENCE OF COTTON/POLYESTER FABRIC STRUCTURE TO ITS ALKALINE PRE-TREATMENT

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Abstract: *The influence of fabric structure of cotton/polyester blend to its alkaline pre-treatment has been researched. For this purpose, three fabrics of different weft density in twill weave were pre-treated in NaOH with addition of anionic surfactant. The characterization of fabrics was performed by electrokinetic analysis (SurPASS, Anton Paar). The fabric changes were determined by standard methods: breaking force and elongation (ISO 13934-1:2013), fabric count (ASTM D3775-17e1), mass per unit area (ISO 3801:1977), degree of whiteness (ISO 105 J02:1997), water retention value (ASTM D2402-07(2018)), and the liquid moisture management properties (AATCC TM 195-2017). Due to different weft density, swelling capacity of fabrics is different and for that reason the pre-treatment results in different level of modification, absorption ability and liquid transport.*

Keywords: *cotton/polyester blend, alkaline pretreatment, zeta potential, mechanical properties, WRV, moisture management*

1. INTRODUCTION

Cotton fiber is cellulose fiber of high absorbency and exceptional comfort. In scouring cotton fiber natural impurities i.e. pectin, waxes, organic acids, proteins and minerals are removed, but colored substances - pigments remain. Chemical bleaching of pigments results in fiber whiteness, but oxidative damage of cellulose sometimes occurs, resulting in low fiber strength. Therefore, alkali treatment, i.e. mercerization process can be done to obtain better strength and brightness, and even higher absorption ability [1-4]. Another possibility is blending with synthetic fibers, i.e. polyester or polyamide for that purpose. Polyester fibers, on the other hand, have exceptional strength, resistance to chemicals, light and microorganisms, dimensional stability and fast drying, but due to high degree of crystallinity (65-85%) it has low moisture absorption and no swelling. Therefore, the surface of polyester fibers can

be modified with hydrolysis (alkali, enzyme), aminolysis or plasma treatment or blended with natural fibers as cotton or wool [5,6].

Since modification or treatment results in change of the number of surface active groups of fiber, i.e. blocking and/or adding, their dissociation results in different thickness and distribution of the electric double layer that results in change of fabric interface phenomena [1, 2, 7]. The change in interface phenomena of cotton and polyester fibers in single-fiber fabrics has been thoroughly researched, but the dependence of fabric structure as well as its alkali modification in blend, has not.

Therefore, in this paper the influence of fabric structure of cotton/polyester blend to its alkaline pre-treatment has been researched through its interface phenomena (zeta potential, water retention, liquid moisture management – absorption and transport) and mechanical properties (breaking force and elongation, mass per unit area, fabric count).

2. MATERIAL AND METHODS

The cotton/polyester 50/50 blended fabrics supplied by Čateks d.o.o. (Čakovec, Croatia) were used. All fabrics are in twill 3/1 having end (warp) count 38 threads/cm and different in pick (filling, weft) count: 19, 22 and 25 threads/cm. Fabric mass per unit area is declared as: 160, 165 and 178 g/m^2, respectively. Fabrics were scoured and bleached under industrial conditions. Fabrics were pre-treated with 1.5 M NaOH with addition of 4 g/l surfactant Subitol MLF (CHT-Bezema) by exhaustion method at 80°C for 20 min in the drum of Turbomat P4502 (Mathis) at LR 1:10. After the treatment, fabrics were rinsed in hot, warm and cold distilled water; neutralized with 1% HCl, then rinsed with distilled water to pH 7 and air dried.

The characterization of fabrics was performed by electrokinetic analysis using electrokinetic analyser SurPASS (Anton Paar) using the AGC (Adjustable Gap Cell) [8]. Zeta potential (ZP, ζ) was measured in the dependence of pH (pH 2-9) of electrolyte, 0.001 mol/l KCl by streaming current technique. The zeta potential was calculated according to Helmholz-Smoluchowsky equation [7]. The IEP (isoelectric point) was determined as well [7,8].

The changes in mechanical properties were analysed by determination of breaking force and elongation according to ISO 13934-1:2013 *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method* using the dynamometer TensoLab (MESDAN-LAB), fabric count according to ASTM D3775-17e1 *Standard Test Method for End (Warp) and Pick (Filling) Count of Woven Fabrics,* and the mass per unit area was determined by weighing on a digital scale ALJ 220-5DNM (KERN) with an accuracy of 0.0001 g according to ISO 3801:1977 *Textiles — Woven fabrics — Determination of mass per unit length and mass per unit area*.

Degree of whiteness according to CIE was determined according to ISO 105 J02:1997 *Textiles — Tests for colour fastness — Part J02: Instrumental assessment of relative whiteness* using the remission spectrophotometer Spectraflash SF 300 (Datacolor).

The Water Retention Value (WRV) was determined according to ASTM D2402-07(2018) *Standard Test Method for Water Retention of Textile Fibers (Centrifuge Procedure),* and the ability to manage liquid moisture according to AATCC TM 195-2017 *Liquid Moisture Management Properties of Textile Fabrics* using the Moisture Management Tester MMT M290 (SDL Atlas).

3. RESULTS AND DISCUSSION

In this paper, the influence of fabric structure of cotton/polyester blend to its alkaline pre-treatment was researched. For this purpose, three fabrics in twill 3/1 weave of different weft count were pre-treated with 1.5 M NaOH with addition of anionic surfactant Subitol MLF (CHT-Bezema) by exhaustion method.

The characterization of fabrics was performed by electrokinetic analysis through the results of zeta potential (ZP) measured on SurPASS (Anton Paar) presented in Figure 1 and Table 1.

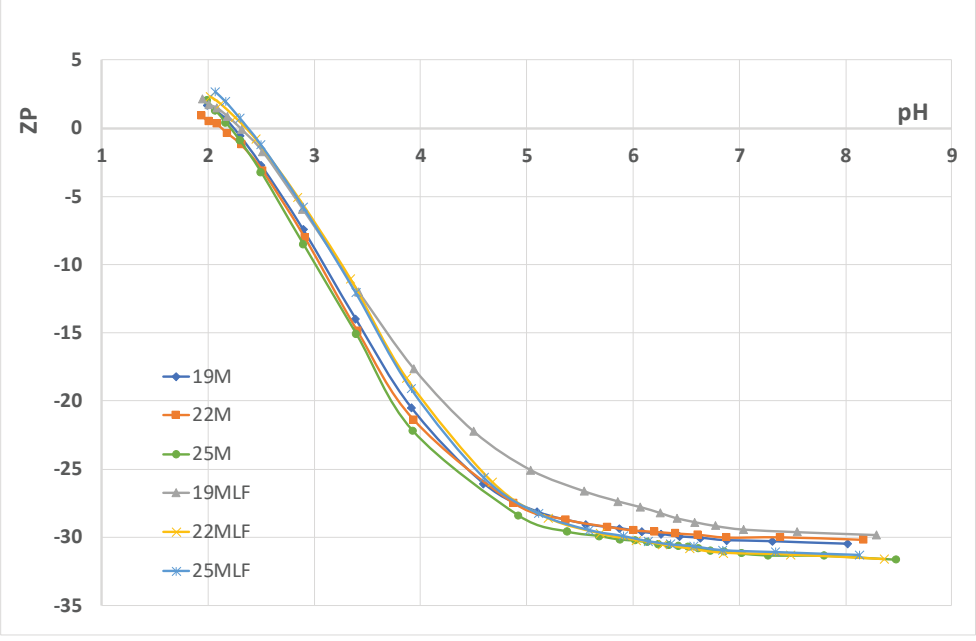

Figure 4: Zeta potential (ZP) of the cotton/polyester fabrics before and alkali pre-treatment *vs*. pH of 0.001 M KCl

The zeta potential (ZP) of the cotton/polyester fabric at pH 9, where the curves have plateau, is between -31.7 and -30.2 mV due to dissociation of hydroxyl and carboxyl groups. Dissociation of hydroxyl groups result in ZP -20 to -24.5 mV for cotton, and in ZP -69 mV for polyester because of carboxyl groups and its hydrophobic surface [7]. Blending of fibers in fabric results in more negative ZP than for cotton and more positive than for polyester. Comparing fabrics regarding fabric count, it can be seen that the lowest weft count, 19M, has the highest zeta potential. That is because it has the lowest porosity between fabrics, so it can swell more than other. According to the literature [7], hydrophilic surfaces have the ability of water adsorption (hydration) and swelling, and therefore show off higher zeta potential. Alkali pre-treatment results in cotton swelling [4] and the availability of active groups. Polyester gets hydrolyzed what results in increased number of surface active groups as well. Even thou there are more negative groups on the fabric surface, coming from both components in the blend, increase swelling capacity and fabric shrinkage leads to higher zeta potential. This phenomenon is the most enhanced for fabric with 19 wefts, and especially visible at pH 4-7, i.e. -17.6 mV for 19 MLF. This finding confirms WRV. It can be seen that that WRV increased with alkali pre-treatment. The obtained results show that all the fabrics have IEP at pH lower than 2.5, with no significant difference.

From the results of degree of whiteness (W_{CIE}) presented in Table 1 can be seen that the treatment did not significantly change the whiteness of blended fabrics.

Table 1: Zeta potential (ZP) at pH 9 and 4, Isoelectric point (IEP), water retention value (WRV), and degree of whiteness (W_{CIE}) of cotton/polyester fabrics

Fabric	*ZP* at pH 9 [mV]	*ZP* at pH 4 [mV]	IEP [pH]	WRV [%]	W_{CIE}
19M	-30.5	-20.5	2.23	19.07	80.8
22M	-30.3	-21.4	2.14	19.47	80.8
25M	-31.7	-22.2	2.23	19.66	81.4
19MLF	-29.8	-17.6	2.31	19.30	79.6
22MLF	-31.6	-19.0	2.35	19.75	80.1
25MLF	-31.3	-19.2	2.36	19.77	80.5

The results of mechanical properties, i.e. breaking force and elongation, fabric count and mass per unit area of cotton/polyester fabrics before and after alkali pre-treatment are collected in Table 2. Declared warp count of 38 threads/cm was found, and it did not change in alkali pre-treatment process. For declared weft count and mass per unit area, slightly lower values were found. However, it can be seen that fabric shrunk, and number of weft threads increased as well as mass per unit area. The reason for that is cellulose component that swells in wet processing, and the fabric shrinks after drying. Since only the cellulose component in the blend swells, this increment is not so high, only 2-4%. This phenomenon again is more enhanced for fabric with 19 threads, because it has more space for swelling. Polyester fibers are known to have excellent mechanical properties. From the results of breaking

force there can be observed that the breaking force is the highest for the fabric of the highest warp count, 25M. After alkali pre-treatment, it can be observed that fabric has better elongation, while the loss in breaking force is only 4-7%. The reason for that is controlled hydrolysis of polyester, cotton swelling and shrinkage that contribute keeping the fabric strength.

Table 2: Breaking force (F) and elongation (ε), fabric count and mass per unit area of cotton/polyester fabrics

Fabric	F [N]	ε [%]	Warp [threads/cm]	Weft [threads/cm]	m [g/m^2]
19M	1142.00	11.25	38.3	18.8	159.28
22M	1144.50	11.70	38.5	21.5	164.89
25M	1166.50	12.30	38.3	23.8	178.35
19MLF	1094.50	15.45	38.5	21.4	165.59
22MLF	1077.50	15.60	38.7	22.4	170.33
25MLF	1077.00	16.04	38.7	24.6	181.72

The results of liquid moisture management properties are shown in Tables 3 and 4, by mean values and coefficient of variation (CV) for each measured property for the Top surface (T), and for the Bottom surface (B). The results obtained are: Wetting Time (WT), Absorption rate (AR), Maximum wetted radius (MWR), Spreading speed (SS), Accumulative One-way Transport Capability (R) and Overall (liquid) Moisture Management Capability (OMMC).

Table 3: Moisture management properties of cotton/polyester fabrics

Fabric property		19M		22M		25M	
		Mean	CV	Mean	CV	Mean	CV
WT (s)	T	2.512	0.1704	2.413	0.0664	2.613	0.0342
	B	2.605	0.1473	2.554	0.0552	2.589	0.0624
AR (%/s)	T	64.356	0.0194	64.052	0.0411	66.835	0.0532
	B	63.003	0.0193	63.809	0.0292	64.191	0.0236
MWR (mm)	T	25	0	22.5	0.1283	22.5	0.1283
	B	30	0	25	0	25	0
SS (mm/s)	T	6.845	0.0222	6.021	0.0557	5.621	0.0478
	B	7.185	0.0325	6.168	0.0299	5.747	0.023
R (%)		121.272	0.0386	110.192	0.1195	101.383	0.1601
OMMC		0.588	0.012	0.578	0.027	0.569	0.038
Type		*Moisture Management Fabric*		*Moisture Management Fabric*		*Fast Absorbing and Quick Drying Fabric*	

Table 4: Moisture management properties of cotton/polyester fabrics after alkali pre-treatment

Fabric property		19MLF		22MLF		25MLF	
		Mean	CV	Mean	CV	Mean	CV
WT (s)	T	2.226	0.0209	2.468	0.0738	2.418	0.0899
	B	2.320	0.0203	2.539	0.0554	2.582	0.0679
AR (%/s)	T	58.779	0.0261	63.853	0.0104	65.207	0.0162
	B	60.370	0.0111	61.555	0.0163	62.117	0.0077
MWR (mm)	T	26.25	0.0952	25	0	25	0
	B	30	0	25	0	25	0
SS (mm/s)	T	7.594	0.0381	6.775	0.0375	6.487	0.011
	B	7.734	0.0063	6.558	0.0305	6.231	0.0174
R (%)		107.718	0.1644	85.572	0.1412	81.106	0.101
OMMC		0.565	0.036	0.544	0.028	0.540	0.018
Type		*Moisture Management Fabric*		*Fast Absorbing and Quick Drying Fabric*		*Fast Absorbing and Quick Drying Fabric*	

The results confirm hydrophilicity of cotton/polyester fabrics: the wetting time is quick, MWR is 30 mm, excellent transport was achieved and fabric type is "Moisture Management Fabric". It can be noticed that the spreading speed for the fabric of the highest weft count is slightly faster, there is more polyester component of better capillarity, so the fabric is “Fast Absorbing and Quick Drying Fabric”. Alkali pre-treatment enhance these results, WT and MWR are higher. Due to better absorbency, speeding speed is slower. Lower accumulative one-way transport capability (R) suggests that the liquid introduced to the bottom surface is slowly transferred to the top surface, so the fabrics are “Fast Absorbing and Quick Drying Fabric” as well.

3. CONCLUSION

The influence of cotton/polyester fabric structure to its alkaline pre-treatment has been researched. Fabrics of different weft count were alkali pretreated and its interface phenomena and mechanical properties were analyzed and compared. It has been found that fabric of the lowest weft count, has the highest zeta potential and absorbency because it can swell more than others. On the other hand, fabric of the highest weft count has more polyester component, swells les but has better mechanical properties and capillarity.

REFERENCES

[1] Stana-Kleinschek, K.; Strand, S. & Ribitsch, V.: Surface Characterization and Adsorption Abilities of Cellulose Fibers, Polymer Engineering and Science **39** (1999), pp. 1412-1424, ISSN 0032-3888
[2] Tarbuk, A.; Grancarić, A. M. & Leskovac, M.: Novel cotton cellulose by cationisation during mercerisation - Part 2: Interface phenomena; Cellulose **21** (2014) 3, pp. 2089-2099, ISSN 0969-0239.
[3] Soljačić, I. & Žerdik, M.: Cotton mercerization. *Tekstil* **17** (1968), pp. 495-518, ISSN 0492-5882.
[4] Pušić, T.; Čunko, R.; Tomljenović, A. & Soljačić, I.: Study of Cotton Fiber Swelling Affecting the Degree of Mercerization. *American Dyestuff Reporter*, **88** (1999) 6, pp. 15-18, ISSN 0002-8266.
[5] Grancarić, A.M.; Soljačić, I.; Rukavina, I. & Čavar, T.: Utjecaj obrade na efekte alkalne hidrolize poliestera, *Tekstil* **37** (1988.) 12, pp. 689-694, ISSN 0492-5882
[6] Čorak, I.; Tarbuk, A.; Đorđević, D.; Višić, K. & Botteri, L.: Sustainable Alkaline Hydrolysis of Polyester Fabric at Low Temperature. *Materials* **15** (2022), 1530. https://doi.org/10.3390/ma15041530, ISSN 1996-1944
[7] Grancarić, A. M.; Tarbuk, A. & Pušić, T.: Electrokinetic Properties of Textile Fabrics, *Coloration Technology*, **121** (2005) 4, pp. 221-227, ISSN 1472-3581
[8] Luxbacher, T. et al.: The zeta potential of textile fabrics: a review; *Tekstil*, **65** (2016) 9-10, pp. 346-351, ISSN 0492-5882

Acknowledgments:
This work has been supported in part by Croatian Science Foundation under the project UIP-2017-05-8780, Hospital protective textiles HPROTEX.

7

PERSONAL PROTECTIVE EQUIPMENT

3D PRINTING OF REINFORCEMENT ON GLOVES FOR WHEELCHAIR USERS

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Abstract: *This paper presents finger reinforcements for wheelchair user's gloves. Wheelchair users may experience injuries from constant use of their hands for pushing. Reinforcements should ensure good grip and support, avoid tension, possible difficulties and allow easier movement in the wheelchair. Reinforcements should be made to measure for each individual. They must cover the areas under the greatest tension and have a good fit. For this purpose, technology of 3D scanning and 3D printing are used. Thermoplastic polyurethane (TPU) was used to make the reinforcement. Textile material is integrated into the 3D printed reinforcements. The shape of the reinforcement is defined on the cutting parts of the gloves and towards the knuckles to ensure uninterrupted use.*

Keywords: *3D printing, wheelchair, gloves, TPU, reinforcements for wheelchair, knitted fabric, woven fabric*

1. INTRODUCTION

This paper presents finger reinforcements for wheelchair users. Hands are very important for wheelchair users because in a way they replace their legs. Wheelchair users may experience blisters or other injuries from constant use of their hands for pushing, stopping and turning. Reinforcements should ensure good grip and adequate support, reduce tension, lessen possible difficulties, and allow for easier movement in the wheelchair [1].

Each person's hands are unique, fingers vary in thickness, form, and length while palms can be wide or narrow. Therefore, reinforcements should be made to measure for each individual. They must cover the areas under the greatest tension and have a good fit. In order to design and produce reinforcements that will suit wheelchair user's characteristics, it is important to collect all of the necessary information, such as which parts of the hands or fingers should be covered, and which parts of the hands should be reinforced. Reinforcements should be positioned so as not to impair movement of the hands but to improve grip and dexterity. Additionally, in the

design and construction of these reinforcements, it is essential to take into account how bones, muscles, tendons and the like move [1].

3D printers are used for individualized production of objects. There are many 3D printing technologies, some of them are Stereolithography (SLA), Digital light processing (DLP), Selective laser sintering (SLS), Fused Deposition Modeling (FDM) and Fused Filament Fabrication (FFF). For this purpose, FDM/FFF technology is used [2].

2. METHOD

For the purpose of this research, 3D scanning technology, 3D modeling in computer programs and 3D printing technology, is used. The hand of a male person is scanned in a 3D scanner. The finger reinforcements are modeled after the scanned hands. The scans are then printed with a 3D printer, in several different thicknesses. The filament with which the reinforcements are printed is thermoplastic polyurethane (TPU) and the materials on which they are printed are knitted and woven polyamide. The figure 1 shows a sketch of the reinforcement and the position where the reinforcements will be located [1].

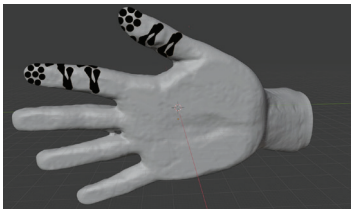
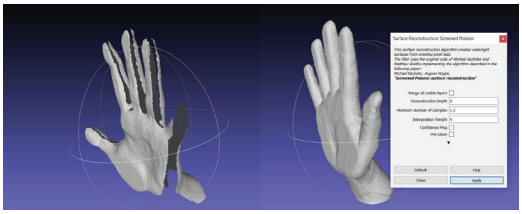


Figure 1: Sketch of the reinforcement

2.1. 3D Scanning

In order to produce quality reinforcements for wheelchair users it is vital to properly scan their hands, for that purpose a 3D scanner is used. A Pedus 3D scanner was used to scan the hands. It is necessary to define the scan parameters before the start of the scanning. After scanning, data processing is performed and, as a result, a 3D point cloud is displayed on the screen describing the surface of the scanned object. The resulting object on the screen needs editing, cleaning, inspecting, rendering, or reconstructing [1, 2]. This is done using multiple computer programs. MeshLab is one such program, which is used to edit the 3D scan, that offers several solutions for reconstructing the shape of an object and prepared for further use. MeshLab automatically fill the gaps (Fig. 2) [4].



a) b)

Figure 2: 3D hand scan a) original 3D scan; b) reconstructed 3D scan [1]

2.2. 3D Modeling

After all the flaws of 3D hand model are fixed, Marvelous Designer is used. It is a design software that allows users to create 3D virtual clothing. The program consists of 2D and 3D interfaces that can be worked on simultaneously which is why it allows for easy operation. 3D hand model is imported, and the reinforcements are tailor-made for the hand. A 2D flat template for the reinforcements is created while monitoring the entire process in the 3D view. The construction tool is used to draw the outlines of the model, for example the part of the finger that will be covered by the reinforcement. In this phase, it is important to define the positions on the fingers such as the finger outlines and the location of the joints. The program also offers tools for creating flat and curved segments and connecting and cutting different segments. After the reinforcements template is made, it can be positioned and bent around the finger. This way the fit of the 3D printed reinforcements to the hand can be tested [5].

The 2D template is then imported into computer software Blender to make the actual reinforcements. Blender is an open-source computer program that is used to create 3D models, VFX images and animations. First the template needs to be leveled on the X/Y axis so that it can be viewed correctly from different angles. Then the 3D modeling of creating the reinforcements for the fingers can start [6].

For the fingertips, multiple cylindrical shapes are used. After the first joint, bone-like shapes are used which continue until the end of the finger. The shape is constructed by slicing one cylinder and then stretching the halves using the “move” tool until they are joined into the desired shape. Unlike the fingertip, here the reinforcements are made so that they also wrap around the finger. On the joints, empty spaces are set instead of shapes because otherwise it would reduce the mobility of the fingers. For the entire reinforcement, multiple smaller shapes are used instead of one large shape because they help avoid stiffness in the fingers while still providing adequate support.

When the desired result is reached (Fig. 3), the thickness of the model can be adjusted. This is done by selecting the first layer of dots and stretching the model by the Z axis using the “move” tool. The model is exported in multiple thicknesses so that the different thicknesses can be tested for the best balance of support and fit.

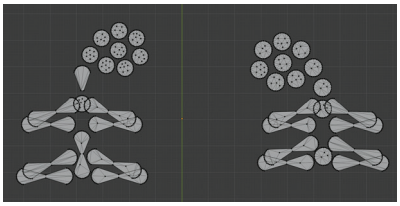


Figure 3: The resulting reinforcements model for forefinger and thumb created in computer program Blender

2.3. 3D Printing

After creating the reinforcement's model, it needs to be prepared for 3D printing. The model should be converted to G-code, using PrusaSlicer. G-code is a standard format for 3D printing. In the program, various parameters need to be defined such as the type of 3D printer, length, width and height of the print space and nozzle diameter [7, 8].

The Creality CR-10 Max 3D printer is used for printing the reinforcements. The printer platform is 450x450 mm and the available height for printing is 470 mm. The printing platform and nozzle temperature need to be adjusted depending on the filament used. In this case the platform temperature is set to 50 ºC and the nozzle temperature to 240 ºC [9].

The printer uses the FDM/FFF printing method. The filament is fed into the nozzle which can regulate the amount of flow. The nozzle moves along the printing platform. The reinforcements are printed in layers, until the entire object is complete. The filament is quickly cooled and hardened by a fan attached to the nozzle [10].

The reinforcements are constructed in three steps. First, only one layer is printed on the platform and the printer paused. Then a sample of a fabric is placed on top of the printed layer. Finally, the rest of the layers are printed on the surface of the fabric. This way the fabric sits in between the printed layers. Because of the thin and airy structure of the fabric, the printed layers are strongly attached to each other through the fabric.

2.4. Materials

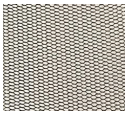
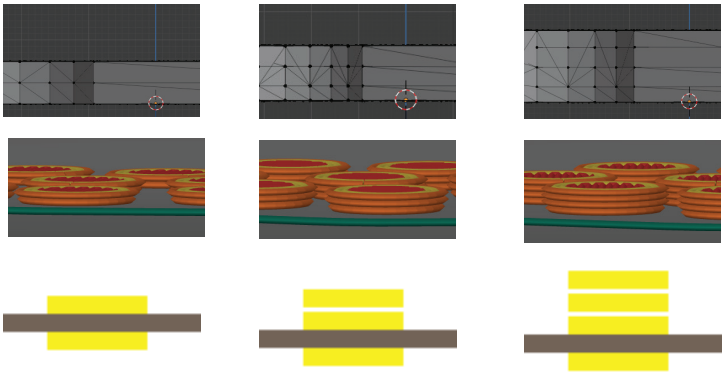
The filament used for the reinforcement is Thermoplastic polyurethane (TPU). TPU is a type of thermoplastic elastomer. It is extremely flexible and at the same time it is harder than other types of thermoplastic elastomers. It is also transparent and oil and abrasion resistant which is ideal for this use case [10].

Two models of the reinforcements are created with integrated with different textile materials. One fabric was woven and the other knitted. Both are made of polyamide (PA). It is very strong and has good resistance to mechanical wear. PA

also has good resistance to both low and high temperatures even after long periods of exposure [11].

Table 1 shows samples of knitted and woven polyamide fabric. On the right side of the table there are reinforcements with the number of layers and the thickness of each layer.

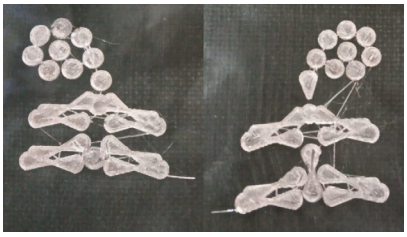
Table 1: Fabric, samples, layers and the layers dimensions

Textile material	3D model		
	2 layers 0,65 mm	3 layers 0,95 mm	4 layers 1,25 mm
Knitted fabric (PA)  Woven fabric (PA) 			

3. RESULTS

Models of gloves for wheelchair users are made based on the scanned male hands. The filament used for printing is TPU. And the material on which it is printed is PA. It is a polyamide woven fabric and polyamide knitted fabric. A total of three TPU filament thicknesses are printed on both fabrics.

Figure 4 a shows the reinforcements printed on the woven fabric. Figure 4b shows the reinforcements printed on the knitted fabric. Figure 5 shows the reinforcement on the thumb and forefinger when stretched out and bent.



a) b)

Figure 4: a) TPU filament on woven fabric; b) TPU filament on knitted fabric

Figure 6: Reinforcement on thumb and forefinger

4. CONCLUSION

The paper presents the entire process of making glove reinforcements for people using wheelchairs. It starts with the idea and research of required data. Then it continues to the elaboration of the idea and finally to the construction of the reinforcements.

The hands are scanned with a 3D scanner. Then the models are constructed from the scanned objects. After a model is made that meets all the requirements, the reinforcements are printed using a 3D printer.

According to the results of this work, it can be concluded that the glove reinforcements should be made to measure for each individual user, for better fit and mobility. Reinforcements serve to prevent the formation of blisters or other injuries and to increase comfort. They must also be designed to provide flexibility, good grip, and adequate support, to avoid tension and possible future injuries and to generally make it easier to use a wheelchair. If they are made to measure, they can greatly facilitate the life of people in wheelchairs, so they must be designed and constructed to ensure full functionality.

Based on the obtained results, it can be seen that the reinforcement printed on the woven fabric has better properties. The reason for this is that the fabric is firmer and less elastic, so the printed pattern is better. The fabrics are not densely packed either, so the lower and upper filaments are well joined, and since the fabric is stronger, it contributes to better reinforcement strength overall. When printing the reinforcements on the knitted fabric, the threads of the fabric are torn because of its elasticity. Although, the layers blend better on the knitted fabric as it is less dense than the woven fabric. The best results of flexibility are obtained by a sample printed in two layers. The sample wraps around the finger the best. The pattern printed in three layers provides better finger protection. Whereas a pattern printed in four layers has less flexibility around the finger due to having more layers.

REFERENCES

[1] Bogović, S.; Turčin, M. M.: Konstrukcija i računalno modeliranje rukavica za osobe u invalidskim kolicima, *Zbornik radova 5. Znanstveno-stručno savjetovanje: Kulturno nasljeđe Ujević*, Ujević, Darko (Ed.), pp. 279-282, ISSN 2623-49982, Krivodol, Croatia, September 2019, Kulturno-umjetnička udruga Ujević, Krivodol: (2019)
[2] The 9 Different Types of 3D Printers. https://3dinsider.com/3d-printer-types/ (accessed 2022-01-10)
[3] Milošević P., Bogović S.: 3D Technologies in Individualized Chest Protector Modelling, *Textile & Leather Review*, **1**, (2018), 2, pp. 46-55, ISSN 2623-6281
[4] MeshLab. https://www.meshlab.net/ (accessed 2022-01-11)
[5] Marvelous Designer. https://www.linkedin.com/showcase/marvelous-designer (accessed 2022-01-12)
[6] Blender- Introduction. https://docs.blender.org/manual/en/latest/getting_started/about/introduction.html (accessed 2022-01-10)
[7] Gcode Guide. http://wiki.solidoodle.com/gcode-guide (accessed 2022-01-12)
[8] PrusaSlicer. https://github.com/prusa3d/PrusaSlicer (accessed 2022-01-13)
[9] Creality. https://www.creality.com/goods-detail/cr-10-max-3d-printer (accessed 2022-01-11)
[10] Xiao, J.; Gao,; Y.; The manufacture of 3D printing of medical grade TPU. https://www.researchgate.net/publication/317204598_The_manufacture_of_3D_printing_of_medical_grade_TPU (accessed 2022-01-13)
[11] Čunko, R.; Andrassy M.; *Vlakna*, University of Zagreb Faculty of Textile Technology, ISBN 953-155-089-1, Zagreb, ZRINSKI d.d. (2005.)

PROTECTIVE EQUIPMENT IN SEARCHES FOR WOUNDED GAME ANIMALS WITH A TRACKING DOG

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Tracking for wounded game animals with a tracking dog is one of the most demanding disciplines of hunting cynology. Tracking demands sharp skills, concentration and specialized equipment both for the dog handler and tracking dog. Equipment must be practical and functional with protective features at the same time. Tracking can be done through whole year around, from warm and dry to cold and wet weather conditions. Terrains can be very different from sharp rocks or high forests to thick and thorny bushes or even mud plains. Besides that, there is a high risk of getting wounded by a wild animal while tracking. Therefore, equipment must also be impenetrable and durable. In this paper you can read more about specific equipment for dog handlers and tracking dogs.

Keywords: protective equipment, search, wounded game animals, tracking dog

1. INTRODUCTION

The tracking dog is of great importance for every hunting ground where large game is bred and hunted [1], which is confirmed by the results of research on the economic viability of using a tracking dog [2, 3]. In addition to hunting, wounded game is also sought after traffic accidents and injuries caused by agricultural machinery. Tracking for wounded game animals with a tracking dog is one of the most demanding disciplines of hunting cynology [2], and the best results are achieved by specialized breeds: Bavarian and Hanoverian scenthounds, which have been selected and trained over the centuries for that purpose [4]. Tracking demands sharp skills, concentration and specialized equipment both for the dog handler and tracking dog and can be done through whole year around, from warm and dry to cold and wet weather conditions. Terrains can be very different from sharp rocks or high forests to thick and thorny bushes or even mud plains. Besides that, there is a

high risk of getting wounded by a wild animal while tracking. Therefore, equipment must be practical and functional with protective features (impenetrable and durable) at the same time.

2. DOG HANDLER EQUIPMENT

In recovery for wounded game dog handler must be operational at best, in any situation, on any terrain, in any weather. The equipment must be chosen very carefully because everything must be based on practicality and functionality because if hunting in certain environments can be hard, recovery in the same environments is always incredibly more difficult [5]. The game retreats into the thickets and in most impenetrable bushes, on the most rugged and steepest slopes that may exist on its territory. There is no "standard" equipment that is suitable for every situation. Dog handler must be equipped for specific needs that depend on terrain and weather conditions at same moment. Main parts of equipment (Fig. 1) are: Tracker Jacket which protects hunter when searching or tracking for wounded game. It must be highly visible, wind and water repelling. The sleeves should be made of puncture proof material with inserts for all round protection. The jacket should be cut long below the hips and with elastane in the material mix with pre-formed elbows that provide freedom of movement. The upper body area should be made with thornproof material. The lined collar should have a drawcord for adjustment, so you can keep out leaves, needles and twigs. The shoulder trim made of tough Cordura so rucksack straps or a rifle sling do not slip and cause no wear. For good air circulation there should be a spacer material on the back plus mesh lined ventilation openings under each arm and under the back flap. The tracker jacket should be fitted with: two vertical breast pockets, right with an eyelet for marking tape and left with an opening for a radio, two zip-up side pockets lined with fleece, left with a lanyard for keys and one sleeve pocket, a poacher's pocket and an inside pocket, each with a zip, inner pocket with a Velcro fastening flap for a first aid kit and adjustable cuffs with storm cuffs belt loops for belts up to 6 cm wide. There should also be adjustable waistband with buttons and side zips with wide reflective stripes front and back in full length front zip which can be used when wearing gloves. Trousers can be made of sturdy canvas, leather or artificial material. General requirements are: lightweight, highly effective against wild boar bites and tusk punctures, puncture-proof material over safety-relevant zones, front side complete puncture protection, back side puncture protection from below to over the hollow of the knee, the leg seams completely underlaid with the protection insert and individually sewn, spacer material to absorb impact energy and reduce impact force, improved air circulation due to the spacer material, robust Cordura outer material with stretch sections, wearing comfort and optimal freedom of movement retained, front and lower leg areas must be waterproof, cut higher at the back with an elastic comfort waistband, attachments for braces, with narrow ventilation zones on the front side made of robust mesh material, with zip-up leg ventilation vent on the back, mesh-lined for effective temperature regulation during strenuous activity, knees further reinforced with robust Kevlar material, two zip-up pockets, two flap pockets with snap buttons,

one zip-up back pocket, sturdy knife pouch, leg ends with internal gaiters for optimum tick protection and with shoe hooks. Head cover – cap for open ground or helmet for hard terrain with rigid visor which protect eyes and forehead from thorns and branches. Safety glasses with lens that closes on the side, gloves made of leather or neoprene (depend on weather conditions) and gaiters also come in handy in some situations. Shirts and underwear should be made of stretch material with minimal moisture absorption, fast drying, low-weight, extremely elastic, odourless and in neon colors for high visibility. Footwear - rubber boots are only suitable for swampy and muddy plains and high boots for any other situation with next requirements: waterproof and extremely breathable, slip-resistant but stable and stiff with ultimate wearing comfort for the whole day long. A rifle designed for trackers and dog handlers should be light (cca 3 kg), with short barrel and overall length up to 100 cm and preferably in robust orange color plastic stock that has an excellent feel and does not lose its grip even in rain and dirt. Sling swivels should be attached to the muzzle of the barrel and on side of the stock so they can be removed and rotated. A firing pin safety device should be installed for maximum safety. A 3-dot driven hunt sight that sits on the barrel, which forms a good contrast to the forest and the surroundings is essential. Detachable magazine with 4+1 rounds and the adjustable fine trigger should be as standard option. Preferred calibers are 30.06, 8X57 and 9,3X62. Rifle sling should be “backpack – gun sling” for a hands and arm-free carry in high visible color, with very broad Neoprene strap material with an ergonomic cut and rugged, briar-proof Cordura material on the outside that provides long-lasting comfort, wear resistant trim in military specs, adjustable length on both sides for individual sizing and with wide snap locks for easy to reach for quick open/close – with or without gloves. Today everyone has mobile phones but 2-way radio is even better because it is always left on and can be heard at the same time by all involved in game search. Usually, the handler carries with him a knife, cartridges, paper tape, hair book, some water and protein bar, first aid kit, rope and some other small things.

Figure 1: Dog handler equipment

3. TRACKING DOG EQUIPMENT

Tracking dogs and their handlers form a team and together they encounter the same dangers [6] while searching for wounded game animals. However, unlike their handlers, the canine partner frequently lacks sufficient personal protective equipment (PPE) [6] during an encounter with wounded animal. Limited PPE is available for canines and mostly developed for dogs used by police, military forces or search and rescue service professionals; examples include ear protection ("Mutt Muffs"), eye protection ("Rex Specs" & "Doggles"), paw protection (dog boots) and protective vests (including ballistic vests) [7]. PPE for canines is often impractical due to either a lack of tolerance by the animal or because the PPE is an impediment to the performance of the dog's duties. Dog boots may decrease traction or increase the risk of the animal becoming trapped and ear muffs could interfere with communication between the dog and handler [8, 9, 10]. Coverings designed to protect the respiratory system interfere with the dog's ability to use its olfactory system [8, 11]. Dogs cool themselves by panting; in warm climates or during

exertion interference with airflow can contribute to overheating and subsequent heat exhaustion [9]. Standard equipment for tracking dogs (Fig. 2) includes tracking collar made of wide leather (cca 4-6 cm) with a swivel and large buckle [12]. Instead of leather, Biothane material is often used because it is very light, extremely strong (breaking strength 450 kg or more), tear proof but still remains flexible and waterproof at low temperatures. It is easily cleaned and the color (often neon red or yellow) never fades. Dogs are often equipped with GPS tracking devices. These can track a dog from a range of up to 14.5 km to avoid losing the dog because the cost of a trained searching dog is high. The leash (9-12 m long and 20 mm width) made of leather or Biothane, is also used. It should be highly visible, soil, scratch and odour resistant with long durability. The harness (if used instead of tracking collar) must be flexible and elastic; the dog must be unencumbered in its movements so he can freely track with its nose close to the ground. It should fit perfectly to dog's contour but still be made of rugged, yet comfortable materials: Neoprene, Cordura or webbed fabric; with colour combination that ensures optimal visibility between handler and dog. Protective vests are used when searching for big wild boars or male red deer. They must protect against bites and puncture wounds but still allow freedom of movement even under adverse conditions. They are made of multiple layers. The outer layer is made of Kevlar or Cordura which is a soft but almost completely tear-proof material. The next layer of material is made of Dyneema fibres. These fibres can bear enormous tensile forces and are often used for winch ropes. The lower layers are Molton padding which is soft and breathable, making the vest comfortable for your dog and regulating its temperature. The vest must be also water-repellent and UV-resistant with neon color and washable up to 40°C.

Figure 2: Tracking dog equipment

4. CONCLUSION

As mentioned above, tracking for wounded game animals with a tracking dog is very demanding and dangerous for both, a dog handler and a dog. It is of great importance for economic impact for hunting ground. Quality and durable protective equipment is extremely important for the safer conduct in searches for wounded game animals.

REFERENCES

[1] Varga, E.: *Pas krvosljednik*, Lovačka knjiga, Zagreb, (1958)
[2] Novotny, Z., Pintur, K., Dumić, T., Fabijanić, N.: Analiza iskanj obstreljene divjadi na območju državnega odprtega lovišča VII/15 ¨Zapadna Garjevica¨ (RH), *Zlatorogov zbornik*, (2019) No. 6, pp: 37-43, ISSN 2232-6499

[3] Dević, M., Ristić, Z.: Ekonomska opravdanost upotrebe pasa krvoslednika u lovištima, Zbornik radova Međunarodnog naučnog savetovanja o krupnim zverima i tragačima po krvi, Živković, B. (Ed.), pp. 81-85, Žagubica, Srbija, May 2008., Lovačko udruženje Žagubica, Žagubica, (2008)
[4] Fabiani, L.: *Barvarji in krvosledništvo*, Zlatorogova knjižnica, Ljubljana, (2009)
[5] Fabiani, L., Ponti, F.: *Tracking dogs - Understanding, training and handling*, Cluj-Napoca, Coppell, TX (USA), (2022)
[6] Jarrett, C. L., Brathwaite, M., Gogal, R., M., Holladay S. D.: Working Dog Service, Harmful Agent Exposure and Decontamination, *Frontiers in Veterinary Science*, Vol. 9 (2022): 892998
[7] Anonymous: Dog Protective Gear, *Available from* https://www.rayallen.com/wellness/first-aid/protective-gear/ *Accessed*: 2022-06-16
[8] Gordon, L. E.: Injuries and illnesses among urban search-and-rescue dogs deployed to Haiti following the January 12, 2010 earthquake, *J Am Vet Med Assoc*. (2012) 240, pp. 396–403
[9] Slensky, K. A., Drobatz, K. J., Downend, A. B., Otto, C. M.: Deployment morbidity among search-and-rescue dogs used after the September 11, 2001 terrorist attacks, *J Am Vet Med Assoc*, (2004) 225, pp. 868–73
[10] Wyatt, T. H., Wilkerson, H., Gordon, L. E., Cole, G., Henderson, A., Millis, D.: Training and common injuries of urban search and rescue dogs, *J Vet Sci Res*, (2016) 1, pp. 1–8
[11] Gwaltney-Brant, S. M., Murphy, L. A., Wismer, T. A., Albretsen, J. C.: General toxicologic hazards and risks for search-and-rescue dogs responding to urban disasters, *J Am Vet Med Assoc*, (2003) 222, pp. 292–5
[12] Numßen, J., Balke, C.: *Nachsuchen wie die Profis – Erfolgreich auf der Schweißfährte*, BLV Buchverlag, München, (2012)

USE OF PROTECTIVE GLOVES AMONG HAIRDRESSING APPRENTICES: A 3-YEAR PROSPECTIVE COHORT STUDY

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Abstract: *Hairdressers and hairdressing apprentices (HA) are exposed to various chemicals while performing hair washing, dyeing, bleaching, curling, cutting, and styling. Beside irritant and allergic effects on skin, some hairdressing chemicals have respiratory effects, or suspected systemic effects. The aim of this study was to assess the frequency of glove use in 408 Croatian HAs while performing hairdressing tasks during practical training, in a cohort study with 3 follow-ups at the end of each school year. Proportion of HAs who wore protective gloves at the 1st, 2nd, and 3rd follow-up was for: dyeing hair 86%, 90% and 91%, respectively; washing dyed hair 50%, 60% and 55%, respectively; washing hair 8%, 11% and 9%, respectively. It is evident that majority of HAs wear gloves while dyeing hair, but glove use was not adequate while washing dyed or non-treated hair, neglecting dermal contact with harmful chemicals and irritative effects of wet work on skin. This indicates poor implementation of safety at work measures among HA and the need for additional education in this field.*

Key words*: protective gloves, hairdressing apprentices, hairdressing tasks, health effects, safety at work.*

1. INTRODUCTION

1.1. Occupational contact dermatitis

Hairdressers and hairdressing apprentices (HA) are regularly exposed to wet work and contact with various chemicals while performing hair washing, dyeing, bleaching, curling, cutting, and styling. Most of these chemicals and wet work have hazardous effects on skin in a form of skin irritation (for example wet work, tensides, hydrogene peroxide) or sensitization (for example hair dyes, hair bleach, curling substances). This combined exposure to hairdressing chemicals and wet work increases the risk for the development of occupational contact dermatitis (OCD) in hairdressers (Figure 1). Contact dermatitis is an inflammatory skin disease characterized by erythema, vesicles, papules, scaling, and fissures, in addition to subjective symptoms of itching, burning and occasional skin soreness due to the skin

contact with external harmful substances [1]. Based on the mechanism of inflammation, contact dermatitis can be allergic contact dermatitis and irritative contact dermatitis [2], with irritative contact dermatitis being more common (80% of contact dermatitis) [3]. It is known that hairdressers are a high-risk profession for the development of OCD. The frequency of OCD on hands is estimated to be almost three times higher in hairdressers than in the general population (38.2% vs 14.5%, respectively) [4]. Approximately half of the hairdressers' 3-year vocational training include practical training in school and salons, and HA have the first contact with skin irritants and allergens already during the first year of education. Studies from Scandinavia showed that the majority of hairdressers reported the debut of OCD during apprentiship [4].

Figure 1: Occupational allergic contact dermatitis in hairdressing apprentice from this study (Picture source: author of the text)

1.2. Protective gloves

Protective gloves protect hands at work from mechanical hazards, cold and hot objects, physical and biological harms and harmful chemicals [5]. Chemical resistance of gloves depends on factors such as the type of chemical, temperature and concentration, thickness of the glove wall and the length of exposure to the chemical, and the type of glove material. The most common materials of which gloves are made are natural rubber- latex, butyl, neoprene and nitrile rubber, polyvinyl chloride (PVC) and polyvinyl alcohol (PVA) (Figure 2). Gloves made of natural rubber provide good protection when working with acids, alcohols and ketones, but can cause allergic skin reactions. Protective gloves from nitrile rubber are suitable for working with oils, ointments and solvents. Neoprene rubber gloves

provide good protection against oils, fats, organic hydrocarbons and acids. When working with strong acids, it is advisable to use butyl rubber gloves. PVA gloves provide good protection against organic solvents, while PVC gloves provide adequate protection against acids and alkali and do not cause an allergic reaction of the skin [6].

Figure 2. Gloves of various materials, from left to right from the least elastic to the most elastic- Vinyl, Elastic Vinyl, Nitrile and Latex (Picture source: Wikimedia Commons)

Use of gloves often carries risks of unwanted phenomena, such as stronger strength required when clenching a fist, reduced sensation of the fingers, increased risk of injury due to grip on the glove and harmful effect on the skin of the hands. The use of gloves can lead to irritative contact dermatitis due to the "wet climate" under the glove or mechanical injury, or to allergic contact dermatitis due to the sensitization to latex or rubber accelerators (mercaptobenzotiazoles, thiurams, carbamatates, etc.) [5]. In hairdressing profession some sorts of gloves, like latex gloves, can pull hair, and are, therefore, not suitable for use.

The aim of this study was to assess how frequently Croatian hairdressing apprentices use protective gloves while performing hairdressing tasks during practical training.

2. STUDY DESIGN AND METHODOLOGY

The research included 408 HA from 25 hairdressing schools in the Republic of Croatia (Zagreb, Krapina, Čakovec, Varaždin, Oroslavje, Ivanić Grad, Opatija, Split, Makarska, Omis, Sinj, Imotski, Garešnica, Slavonski Brod, Osijek, Beli Manastir, Đakovo, Vinkovci, Županja, Samobor, Velika Gorica, Sisak, Đurđevac, Vukovar and Našice) who were examined at the beginning of education and monitored in 3 follow-ups at the end of each school year. Ethical approval for this study was granted by the Ethics committee of the Institute of Medical Research and Occupational Health, Zagreb, Croatia, and by the Ethics Committee of the School of

Medicine, University of Zagreb, Croatia. Work-related conditions during practical training (frequency of performing hairdressing tasks and glove use) were assessed with the Croatian translation of the EvaHair questionnaire [7].

3. RESULTS

Percentage of hairdressing apprentices wearing protective gloves while performing particular hairdressing tasks more than 30 minutes per day is presented in Figure 3. Proportion of HA who wore protective gloves at 1., 2., and 3. follow-up while performing the most hazardous hairdressing tasks was: while dyeing hair 86%, 90% and 91%, respectively; while washing dyed hair 50%, 60% and 55%, respectively; while washing hair 8%, 11% and 9%, respectively. We found no significant changes in glove use across 3 follow-ups.

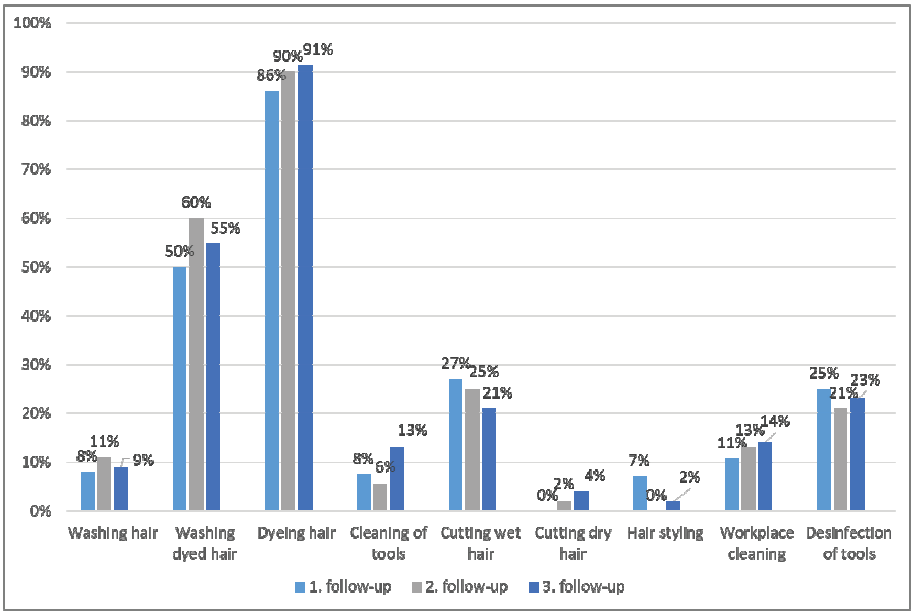

Figure 3. Percentage of hairdressing apprentices wearing gloves while performing particular hairdressing tasks more than 30 minutes per day

4. DISCUSSION

These results are in line with the results of an earlier study in Croatian hairdressing students in the third grade of vocational school where the majority of

students (91%) said they wore gloves when dyeing hair, but less than half (45%) reported wearing gloves during rinsing of dye from hair, and the least of them during hair washing (4%) [8]. Likewise, a study in Croatian hairdressers showed that gloves are mostly used when treating hair with chemicals (88%), and the least when washing hair (13%) [7]. Such results are showing important ignorance of the fact that the contact with chemicals are much greater during rinsing than applying chemicals, and lack of the knowledge about the irritative effects of wet work on the skin in Croatian hairdressers and HA. Other studies point to the problem of improper use of hairdressing gloves by hairdressers and HA, for example, it was found in a Danish study that all analyzed HA inadequately applied gloves [9].

Protective gloves in the hairdressing profession must fulfill the European Norm 374 (EN), "Protective gloves for chemicals and microorganisms". For all typical hairdresser activities (coloring hair, etc.), single use gloves made from nitrile rubber or polyvinyl chloride ("vinyl") are appropriate, and suitable for clients because they do not pull hair. They are to be disposed after single use. In general, nitrile rubber has a higher level of protection compared to polyvinyl chloride, so the single use nitrile gloves are preferable [10]. It should be mentioned that process for standardization of protective gloves for hairdressing trade is in progress at EU level. If used repeatedly, the gloves may no longer be able to carry out their protective function due to the thinness of the material. For cleaning and disinfection, reusable chemical gloves with high thickness (>0.3 mm) are to be used. For workers with developed allergy to rubber accelerators (such as mercaptobenzothiazoles, carbamates, thiurames) which may be contained in protective gloves made from natural or synthetic rubber, special accelerator-free protective gloves are available [10]. The same applies to disposable vinyl gloves, which potentially contain plasticizers with allergenic properties (phthalates). Wearing protective watertight gloves often leads to a blockade of moisture and heat. To reduce this, gloves should be changed frequently, and cotton undergloves should be worn, or a sweat-reducing skin protection cream can be applied [10].

5. CONCLUSION

It is evident that majority of HA wear gloves while dyeing hair but smaller proportion while washing dyed hair or washing hair, neglecting exposure to chemicals while rinsing them from hair, and irritant effects of wet work on skin. It should be mentioned that gloves protect not only from hazardous effects on skin, but from possible systemic toxicity of hairdressing chemicals after dermal absorption. Therefore, these results indicate poor knowledge and implementation of safety at work measures among Croatian HA. Evidently, there is a need for a pragmatic approach to ameliorate safety at work for apprentices in Croatian hairdressing schools.

REFERENCES

[1] Brasch, J.; Becker, D.; Aberer, W.; Bircher, A.; Kränke, B.; Jung, K: Guideline contact dermatitis: S1-Guidelines of the German Contact Allergy Group (DKG) of the German Dermatology Society (DDG), the Information Network of Dermatological Clinics (IVDK), the German Society for Allergology and Clinical Immunology (DGAKI), the Working Group for Occupational and Environmental Dermatology (ABD) of the DDG, the Medical Association of German Allergologists (AeDA), the Professional Association of German Dermatologists (BVDD) and the DDG. *Allergo J Int*. Vol. 23 (2014) No. 4., pp. 126-138, ISSN 21970378.

[2] Lipozenčić, J.: Dermatitis. In *Dermatovenerology*. Medicinska naklada, ISBN 9531769923, Zagreb, (2004).

[3] Bains, S.N.; Nash, P.; Fonacier, L.: Irritant Contact Dermatitis. *Clin Rev Allergy Immunol.* Vol. 56 (2019) No. 1., pp. 99-109, ISSN 1080-0549.

[4] Havmose, M.S.; Kezic, S.; Uter, W.; Symanzik, C.: Prevalence and incidence of hand eczema in hairdressers-A systematic review and meta-analysis of the published literature from 2000-2021. *Contact Dermatitis*. Vol. 86 (2022) No. 4., pp. 254-265, ISSN 01051873.

[5] Bogadi Šare, A.; Bubaš, M.; Kerner, I.; Macan, J.; Pejnović, N.: *Pristup profesionalnim bolestima kože u medicini rada.* Hrvatski zavod za zaštitu zdravlja i sigurnost na radu, Hrvatsko društvo za medicinu rada Hrvatskog liječničkog zbora, Institut za medicinska istraživanja i medicinu rada, ISBN 978-953-58324-0-9, Zagreb (2014).

[6] Pejnović, N.; Bogadi-Šare, A.: Osobna zaštitna sredstva za zaštitu ruku. *Sigurnost*. vol 53 (2011) No. 4, pp. 357-370, ISSN 0350-6886.

[7] Kujundžić Brkulj, M.; Macan, J.: Skin Protection at Work in Croatian Hairdressers (Results of the Evahair Questionnaire Developed Within the Eu Project „Safehair"). *Arch Ind Hyg Toxicol*. Vol. 64 (2013) No. 2., pp. 295-303, ISSN 0004-1254.

[8] Samardžic, T.; Varnai, V.M.; Bakotic, M.: Skin health and safety at work in Croatian hairdressing apprentices. *Contact Dermatitis*. Vol. 75 (2016) No. 1., pp. 25-31, ISSN 01051873.

[9] Oreskov, K.W.; Søsted, H.; Johansen, JD.: Glove use among hairdressers: Difficulties in the correct use of gloves among hairdressers and the effect of education. *Contact Dermatitis.* Vol. 72 (2015) No. 6., pp. 362-366, ISSN 01051873.

[10] Sonsmann, F.; Beaumann, A.; Wilke, A.; John, S.M.; Sulfhorst, B.: Occupational skin diseases in the hairdressing trade - Medical reference document. EU Project SafeHair 2.0, University of Osnabruck, 2011. *Available from* https://www.imi.hr/wp-content/uploads/2016/08/SafeHair_dokument-5.pdf Accessed 2022-07-08.

SAFE WORK WHEN FEELING TREES IN THE FOREST

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Abstract: *Forest is an important part of human's life. For a long time, it has been a source of food and resources for humans. One of those resources is wood, which has always been a really important resource, because it can be used as construction material and as a source of heating energy. To get wood, we first need to get timber assortments. The most important part for a worker is to cut down the tree, that's how we get the assortments, which are further worked on later. Tree cutting is also one of the most dangerous physical jobs. Accidents while tree cutting can be quite common and can be deadly, so plenty of caution is needed. In this paper, we're going to look at the equipment that is used by the tree cutters using chainsaws. A chainsaw is one of the most useful tools in forestry. To use one, a worker needs to have a lot of knowledge and caution, to reach the smallest possible risk for injuries and at the same time reach the highest effectives of the tool. While working with chainsaws, a few simple rules are important. In the paper, the safe methods of cutting down the trees are presented, specially in those situations that could be dangerous to the cutter. The protective clothes that are used must be comfortable, effective, and safe. A cutter must use safety helmet, shoes, trousers, and a vest. The most important thing about tree cutting is that the right equipment is used, so nobody is put at a risk while doing their job.*

Keywords: *chainsaw, protection at work, tree felling, workers safety, protective equipment*

1. INTRODUCTION

Working in the forest is one of the most dangerous tasks. Accidents in the forest are most common in the felling process and require a lot of attention in the future. Logging is work with special working conditions. Mainly for convincing tree felling accidents. It happens a lot that an accident happens in the forest due to ignorance and little attention to safety. When felling trees, the human body is differently exposed to damage. The most common are 30% of the legs and 23% of the palms

[1]. To carry out safe felling of trees in the forest, it is important to know the methods of felling, the use of felling tools and, most importantly, knowledge of human protection equipment and rules for safe work. Even before we start working, it is necessary to know how to make assortments, which method to use, how to properly protect yourself when working with a chainsaw, and to get acquainted with the environment in which you work. By learning all these elements, one can start working safely. In the following, safe work on logging in the forest, felling methods and chainsaw management will be presented.

2. CUTTING METHODS

To make assortments, it is important to choose the desired method based on the final goal. Knowledge of felling methods is important for human safety in the production of assortments. We know methods such as assortment, combined, thick and tree methods in the production of assortments. Assortment method, as one of the most common, where we do assortments at 4, 8, 12 m. Combined method, where 2 or more assortments are harvested from the forest in one piece. The thick method, best known where whole trees are harvested from the forest in one piece and are only pruned. The tree method, which is useful when you want to get the most wood mass, and the whole tree is harvested from the forest, most often by cable car. The pruning is done on a forest road.

2.1 Tree felling tools

The tools used in the forest depend on the type and thickness of the trees. A tool for work can be chosen based on knowledge of trees. In addition to mechanized methods of felling trees, there are also the most well-known and old methods, such as felling trees with a chainsaw, which has been used for quite some time. The chainsaw can be used for various purposes such as felling trees, pruning, making assortments and other non-forestry purposes such as clearing shrubs and preparing agricultural land. So, a chainsaw is a multi-purpose tool. But it is necessary to pay attention to the correct choice of chainsaw, for productivity and safe and pleasant work. Anyone who works with a chainsaw should only know the tools they work with.

2.2 Chainsaw

The chainsaw includes safety parts that protect the worker from injury and long-term illness. Before a person picks up a saw, we educate him with important parts in case of accidents and to persuade accidents. Important safety components are the gas safety lever, the lower part of the handle that protects the hand from tearing the chain, the left arm guard and the chain brake, the chain catcher that protects us from

falling out of the bracket, rubber pins to reduce vibration. The most important component is the chainsaw chain, which wears out quickly in the event of incorrect maintenance and poses the greatest danger at work. The chain must be protected with a plastic guard when moving from one place to another. And it is important that the electrical switch for extinguishing and ignition is flawless [1]. When working with a chainsaw, there are basic rules that must be followed for safe work.

2.3 Faults and maintenance of the chainsaw

Just as it is important to know the chainsaw, felling methods and management. one of the important things is knowing when a breakdown occurs and when urgent chores are needed. When using any tool, disturbances and malfunctions occur, which can be a cause of injuries and accidents due to neglect. It is important to read all the instructions that come with a chainsaw when handling to prevent incorrect operation and reduce damage. The instructions describe in detail the maintenance, if it depends on the frequency of use on a monthly, weekly, or annual basis. It is also important that the user notices the errors and corrects them immediately without neglect.

2.4 Instructions for safe work with chainsaw

The first was eliminated by the correct posture of man when operating a chainsaw. The body of the incisor should be stable, as upright as possible to reduce tension in the spine. The saw is held as close to the body as possible, it is not worked over the head, it is held with both hands, the lower handle is always in the embrace of the thumb. Vibration of the chainsaw leads to white finger disease, which occurs because of the death of blood vessels and nerves. Blood flow to the fingers is reduced and tingling of the hands occurs. The ability to feel by touch is reduced, and injuries to the joint of the hand occur. As protection against vibration of the equipment on the chainsaw is advised regular and proper maintenance of the saw, the use of gloves and more frequent breaks during work. In addition to vibrations, noise is present at work, which can cause damage to the worker's hearing. Silencers are used as protection. There is an article in the Rules on safety at work in forestry in Slovenia that refers to work with a chainsaw. The duration of work with a chainsaw is determined for individual types of saws based on the results of the physiology of work in forestry. The chainsaw can be worked without a break for a maximum of two hours, or four hours with breaks. The chainsaw must not be used if the outside temperature is less than -15 ºC due to the possibility of fuel freezing, in case of rain and snow the work is not safe for the worker due to slippery ground and possible injuries to the worker. In case of strong winds and storms, the work must not be

done. In the chapter on the type of saw, a kick-back blow is mentioned, which occurs when the chainsaw is used incorrectly. This can be avoided by holding the saw firmly with both hands. The chainsaw is used at full power, the leading chain is observed, no more branches are sawed at once, it is never sawed only with the end of the chainsaw because in this case there is a great possibility of kick-back. The method of starting the saw is also important for safety. The safest method is on the floor then the starting method between the legs. With both methods, it is important to remove any obstacles where the chainsaw chain may get stuck. the safest method of starting is on the ground, but it is better for the posture of the worker between the legs, due to the lower load on the back. The chainsaw is never started in free moss.

3. CUTTING DOWN THE TREES

Once the felling instructions are known, the tree can be felled. Felling a tree is one of the important processes for safe work in the forest. To safely fell a tree, it is important to know the direction of the wind, the inclination of the trees, the percentage of dry branches, obstacles, the direction of felling and the direction of retreat. Before taking a chainsaw and starting sawing, it is important to decide on the direction of felling the tree. The direction of demolition is extremely important. There should be no obstacles and no other tree on which the felling tree could stop. After choosing the direction, you can easily start cleaning the surroundings or just working around the hive. The next step is the processing of the rootstock, which is properly processed and burned before the start of production for safe work. The shape and depth of the cut is made, which depends on the tree species, the shape of the canopy, the length and size of the branches, damage, the health of the tree and others. The most important thing is the thickness and center of gravity of the tree. Due to the diversity of the tree species, each tree is demanding and specific only to itself. For depth, the most is 1/4 to 1/3 of the diameter of the tree hive. Most often, problems occur when felling a tree, and when determining the center of gravity of the tree. Because of this, accessories such as wedges are used. It can happen that due to an incorrect assessment of the center of gravity, the tree traps the chainsaw and that the worker is injured [2].

3.1 Safe tree felling

The felling of trees begins with the felling. For safe work with lard, it is important that the posture is as straight as possible, stability due to the correct direction of the lard, the correct angle of the lard and that movements are controlled.

Depth and angle of cut are important because the tree would not fall in the wrong direction or on the worker.

When felling trees, retreat is an important step. We retreat and at an angle of 45º because of the branches which are falling and because the trunk can swing sideways. When retreating, he must not run with a chainsaw or other tools, he must not panic, and he must pay attention to the steps we take when walking. It often happens that a tree gets stuck on an adjacent tree when it is felled. For safety reasons, it is recommended that winches be used as a solution. Do not walk under a trapped tree where the branches can loosen, and the tree falls on the worker.

4. WORKER PROTECTIVE EQUIPMENT

Clothing for forest workers is extremely important. For safe work, forest workers must have and use personal protective equipment such as a safety helmet, mufflers, an eye protection net, a live-color protective jacket so that the cutters can see each other. Protective gloves that protect the worker from cold and mechanical damage. Protective trousers made of non-cut mesh, safety boots with metal cap and non-cut mesh. Clothing should be protected from cold and moisture and should not dissipate too much human heat. Regardless of the weather conditions, the suit should be suitable for working in the forest. Most damage occurs due to neglected equipment. Cutters often do not have a helmet, or do not wear all protective equipment. To prevent dangerous work and injuries, it is important to monitor and teach cutters the importance and characteristics of protective equipment.

5. CONCLUSION

It is important to have knowledge and experience for safe work in the forest when felling and harvesting trees. For safe work, the worker needs to be taught about safety at work. When hiring a woodcutter, foremen need to take courses to get acquainted with a chainsaw, and about all the dangers that can occur when felling. Getting to know the consequences of improper handling of a chainsaw and convincing of accidents. A logger in the forest needs to be experienced in felling trees, choosing directions and methods of obtaining assortments. It is important that the cutter quickly finds a solution in case of danger. The foreman of the cutter has a great responsibility for the correct equipment and control over the use of the cutter equipment, for the sake of safe work. Most injuries occur due to improper use of equipment, neglect of helmets, earmuffs, and clothing. We can avoid injuries by using the equipment properly no matter how much this equipment interferes with our work.

REFERENCES

References should be indicated in the text using consecutive numbers in square brackets, e. g. [1]. In the bibliography (by ISO 690) they should be cited including the title of the paper:

[1] Medved, M. & Košir B.: *Varno delo pri sečnji*, Gozdarska založba, 961-6142-05-4, Ljubljana, (2002), 98
[2] Ljubetić, L.: *Zaštita na radu kod sječe šuma*, Veleučilište u Karlovcu, Karlovac, (2016), 61

PERSONAL PROTECTIVE EQUIPMENT FOR FORESTRY WORKERS

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Abstract: *Despite the great development of techniques and technology many workplaces are still very risky. To enable a safer work activity, personal protective equipment is developed for individual types of activities to protect workers from potential hazards and injuries. The paper presents personal protective equipment for forestry workers, which includes protective clothing, gloves, shoes and a protective helmet. Proper use of personal protective equipment significantly reduces the risk of injuries and occupational accidents.*

Keywords : *personal protective equipment, forestry worker, protective clothing and footwear*

1. INTRODUCTION

Working people are exposed to various adverse and difficult working conditions on a daily basis, and personal protective equipment has the task of protecting the body from external influences. For the protection of the organism and parts of the body, personal protective products, i.e. protective equipment, are provided to persons who are exposed to certain types of hazards and damage in the course of their work if the effects of circumstances and damage cannot be eliminated by other occupational health and safety measures [1]. The Occupational Safety and Health Act [2] and the Regulations for the Use of Personal Protective Equipment [3] regulate the necessity and conditions for the use of personal protective equipment. According to the regulation, all equipment worn, held or used by the worker during work so that it protects him from one or more sources of danger or harm that could endanger his safety and health.

In forestry, some work operations are harmful and hazardous to workers' health, and certain work practices are considered to involve an increased risk of injury and damage to health. One of the risky work procedures is working with a hand-held chain saw, which involves a high noise level and vibrations as well as the risk of

cutting injuries [4]. Past practice has shown that the body of the user of hand-held chain saw can be protected relatively successfully by clothing, footwear and other personal protective equipment in accordance with the HRN EN 381 standard. Table 1 gives an overview of the standards for the field of protection of forestry workers.

Table 1: Overview of the standards for the field of forestry workers

HRN EN 381-1:2001	Protective clothing for users of hand-held chainsaws -- Part 1: Test rig for testing resistance to cutting by a chainsaw (EN 381-1:1993)
HRN EN 381-2:2003	Protective clothing for users of hand-held chain saws - Part 2: Test methods for leg protectors (EN 381-2:1995)
HRN EN 381-3:2001	Protective clothing for users of hand-held chain-saws - Part 3: Test methods for footwear (EN 381-3:1996)
HRN EN 381-4:2001	Protective clothing for users of hand-held chainsaws - Part 4: Test methods for chainsaw protective gloves (EN 381-4:1999)
HRN EN 381-5:2003	Protective clothing for users of hand-held chain saws -- Part 5: Requirements for leg protectors (EN 381-5:1995)
HRN EN 381-7:2001	Protective clothing for users of hand-held chainsaws - Part 7: Requirements for chainsaw protective gloves (EN 381-7:1999)
HRN EN 381-8:2001	Protective clothing for users of hand-held chain saws - Part 8: Test methods for chain saw protective gaiters (EN 381-8:1997)
HRN EN 381-9:2001	Protective clothing for users of hand-held chain saws - Part 9: Requirements for chain saw protective gaiters (EN 381-9:1997)
HRN EN 381-10:2003	Protective clothing for users of hand-held chainsaws - Part 10: Test method for upper body protectors (EN 381-10:2002)
HRN EN 381-11:2003	Protective clothing for users of hand-held chainsaws - Part 11: Requirements for upper body protectors (EN 381-11:2002)

Personal protective equipment for the protection of forestry workers includes protective clothing (upper and lower body protectors, usually in the form of a jacket and trousers), protective gloves, protective boots/shoes, safety helmet with mesh visor and hearing protectors.

2. FORESTRY PROTECTIVE CLOTHING

Despite the enormous development of techniques and technologies, many workplaces are still very risky and workers are often exposed to adverse working

conditions. Nowadays, fibres and materials have been developed to protect the worker from potential hazards. In the manufacture of protective clothing, it is necessary to harmonise the method of production with the properties of the materials, which, in addition to functionality and wearing comfort, protect the user from the intended hazard [5].

According to HRN EN 340 2004 - Protective clothing, General requirements - protective clothing is defined as clothing that covers or replaces personal clothing and provides protection against one or more risks that may endanger the safety and health of a worker at work.In order to be effective and functional, protective clothing must have the following characteristics:

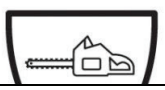
- Universal in terms of design performance, as there is no subdivision into women's and men's clothing
- It is manufactured in various clothing sizes that allow it to be used in a wide range of static anthropometric parameters
- Ergonomically designed according to the dynamic anthropometric conditions of use and must ensure a high level of comfort and freedom of movement when performing activities
- Specially designed taking into account all the possibilities that may arise during use, such as carrying tools, accessories, breathing apparatus, etc.

In forestry, cuts from a chainsaw are common, with the most vulnerable parts of the body being the arms and legs. The protective clothing of forestry workers for protection against cuts with a hand-held chain saw is based on the use of three principles of action [4]:

- Chain sliding - the chain does not saw (cut) the material when it is in contact with it, but slides over it
- Clogging - the chain pulls the fibres into the drive sprocket and blocks the movement of the chain
- Chain braking - fibres have a high cutting resistance, absorb motion energy and thereby reduce chain speed.

The standard HRN EN 381-5- Protective clothing for users of hand-held chain saws – Requirements for leg protectors specifies four classes that correspond to the chain speeds used in tests, Table 2.

Table 2: Classification of protective clothing according to classes

Class	Cut resistance when using the chainsaw at a speed of [ms^{-1}]	
Class 0	16	

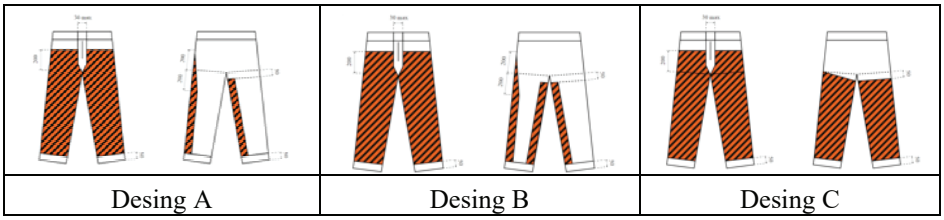
Class 1	20	
Class 2	24	
Class 3	28	

The same standard specifies three different types (designs) of leg protection according to the size of the defined protected area of the lower part of the body that must be covered, Figure 1.

Type A –covers each leg partly (180°) and 5 cm to the interior part of the right leg and 5 cm the exterior part of the left leg. Protection starts at max. 5 cm from the bottom of the leg and ends at min. 20 cm above the crotch.

Type B – is identical to Type A, but it provides an additional 5 cm of protection on the inside of the left leg.

Type C – covers each leg all around (360°) protection. The protection starts at max. 5 cm from the bottom of the leg and ends at min. 20 cm above the front of side of the crotch and at min. 50 cm under the back side of the crotch.



Desing A	Desing B	Desing C

Figure 1: Specified protection area for the lower body of types (designs) A, B, C

The material from which the cut-resistant clothing is made often contains 7 to 9 layers of protective fabric made of long-fibre materials with high cut resistance, which must comply with the test methods for material resistance.

Type A and B lower body protectors are intended for normal use by professional forestry workers when handling a chain saw. Type C is intended for workers who periodically use a chainsaw in their work.

Standard HRN EN 381-11- Protective clothing for users of hand-held chainsaws -- Part 11: Requirements for upper body protectors (EN 381-11:2002) specifies the design of the protective jacket when handling a hand-held chainsaw. Protective layer (Figure 2) on the front and back of the jacket must be on the shoulders, arms and chest. On the front of the sleeves, the protective layer shall cover at least 80 % of the total surface area, and the unprotected part of the surface area from the end of the sleeve shall not exceed 7 cm.

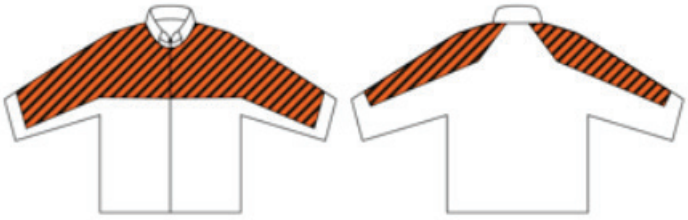


Figure 2: Specified protective surface area for the upper body

Figure 3 shows the trousers and jacket for forestry workers.

Figure 3: Protective jacket and trousers for forestry workers

The Sioen forestry jacket (Fig. 3) is manufactured according to HRN EN 381-11. The material from which it is made is called Cordura, which contains 94% polyamide fibre and 6% elastane fibre. Polyamide fibre is known to be seven times stronger than cotton and is used to reinforce clothing in places exposed to particularly severe conditions. The Sioen jacket has reinforced protection in the neck, shoulder and arm area, which is necessary when breaking through neglected and rough terrain and when carrying a chainsaw. It is classified as class 1 where the chain speed of the chainsaw is 20 m/s. This jacket type fits to the body so as not to affect various objects when moving around the terrain or using a chainsaw itself. It is also waterproof and dirt-repellent and has ventilation openings under the armpits and on the back [6].

The Sioen forestry chainsaw trousers (Fig. 3) are made in accordance with HRN EN 381-5:2003. The Sioen trousers are made of 86% Cordura material containing 100% polyamide fibres and 14% Spandex material (elastane fibre). The classic Zion trousers have a belt loop as an accessory, two side pockets with zipper, a flap

pocket on the left trouser leg, a waterproof pocket for the mobile phone (it protects against rain and sweat) and is stretchable in all 4 directions. They are reinforced on the back and in the knee and ankle area. They fit the figure completely, are comfortable, have integrated gaiters with hooks to attach the trousers to shoes or boots, zips on the back for ventilation and are waterproof at the same time. They are classified as Class 1 and Category A [6].

Cordura and Coolmax are well-known materials for the production of forestry protection suits. Cordura is a special polyamide fibre (Fig. 4) with exceptional damage resistance and represents air-textured polyamide knitted fabric. Cordura is the most commonly used textile material for outdoor surfaces when multiple layers, reliability and durability are required. This material consists of a 100% polyamide fibre [7].

Coolmax is a material characterised by lightness, high breathability and fast drying and is one of the most effective materials. They are made of a unique polyester fibre for improved moisture absorption. Coolmax materials absorb moisture 30% and dry 50% faster than cotton.

Clothing made of Coolmax material is easy to care for, remains soft and does not slip off the skin. It is resistant to shrinkage, unpleasant odours and stretching. Suitable for all activities in warm climates, in summer and in case of increased sweating.

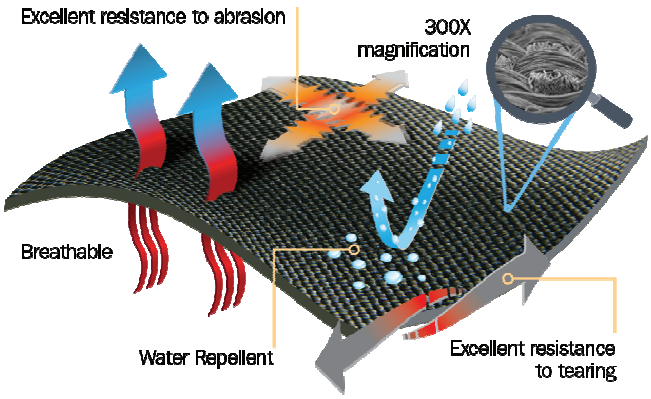


Figure 4: Illustration of Cordura material properties [7]

3. PROTECTIVE GLOVES

Protective gloves belong to the personal protective equipment that protects the hands or parts of the hands from hazards and damage during work. Gloves must provide

the worker with adequate protection against the mechanical, chemical and other risks encountered in the work process [8].

The Croatian standard HRN EN 420 2004 defines the general requirements that should be met by all protective gloves regardless of their specific application. In addition to the definition of protective gloves, the standard specifies parameters such as the design and manufacture of gloves, requirements for the safety of the material, instructions for use and care, requirements for comfort, feel and dexterity when wearing gloves, waterproofing, electrostatic properties and the size and marking of the gloves. Each area of glove application must also meet the standards specific to that area.

Forestry gloves are used to protect against mechanical risks by protecting the hands from sharp, pointed and rough objects that can cause injury to the skin and deeper tissues in the form of scratches, cuts, wounds, bruises and contusions from stabbing, cutting or tearing. The most common injuries are caused by stabs with sharp objects such as blades and spikes from tools and scissors, screwdrivers, saws, etc. In addition, forestry gloves should have vibration protection when using a hand-held chainsaw. These gloves must be flexible to allow unimpeded handling, reduce the effort required to pick up the tool and reduce the transmission of vibrations to the worker's hands. Therefore, forestry gloves shall be compliant with HRN EN 388 2004, HRN EN 381-4 2001 and HRN EN 381-7 2001.

Gloves for protection against mechanical risks are tested according to HRN EN 388 2004 and are marked with a corresponding hammer-shaped pictogram with ratings for four types of resistance such as abrasion, cutting, tearing and puncturing (Tab. 3, 4) [9]. The rating range for each resistance is from 1 to 4 and 5 for cutting.

Table 3: Illustration of the pictogram for protection against mechanical risks with resistance values

	a: abrasion resistance (0-4) b: cut resistance (0-5) c: tearing strength (0-4) d: puncture resistance (0-4)

Table 4: Level of resistance to mechanical risks

Resistance test	Resistance level				
	1	2	3	4	5
Abrasio-number of cycles	100	500	2000	8000	-
Cutting - index	1,2	2,5	5,0	10,0	20,0
Tearing [N]	10	25	50	75	-

Puncturing N]	20	60	100	150	-

Protective gloves against mechanical risks are usually made of bovine leather, with the palm made of thicker smooth leather and the top and sleeve made of thinner leather and strong fabric. The thumb, the index finger and the tips of the other fingers can be further reinforced..

Figure 5: Protective gloves for forestry workers

Sioen forestry gloves (Fig. 5) suitable for trimming branches, consist of protection in the inner wrist area, elastic cuffs on the dorsal side of the wrist, have padded palms to protect against vibrations and protect against injuries with a chainsaw. They are made according to the standard HRN EN 381. The material they are made of is bovine leather, while the seams are made of aramid threads. They are classified as type III [6].

4. PROTECTIVE FOOTWEAR FOR FORESTRY WORKERS

Protective footwear is footwear designed to protect the feet from cold, falls of heavy objects on the legs, punctures and cuts, slipping, exposure to fats, oils and chemicals. Protective footwear includes protective footwear and protective boots made of leather, rubber or synthetic materials, i.e. a combination of the above materials. Depending on the intended use of the protective footwear, additional protective equipment such as steel toecaps, bulletproof soles, protection for heels and lower legs, antistatic strips, etc. can be incorporated. [10,11]. Such footwear should not be heavy and uncomfortable, i.e. it must be designed in accordance with ergonomic standards, i.e. requirements.

For the protection of the legs when using hand-held chain saws and in other similar work processes, it is recommended to additionally use lower leg protectors.

According to the Ordinance on the use of personal protective equipment, the employer must determine the type of footwear corresponding to the situation in the workplace taking into account the level of risk, the frequency of exposure to risks,

the characteristics of the workplaces, the circumstances, the time and the conditions in which the worker must use them. Depending on the characteristics mentioned above, there is a whole range of protection possibilities that personal protective equipment designed to protect the legs and feet can offer its user, but such footwear should not cause blistering or sweating of the legs during work, i.e. other problems when working and moving. [12]

Safety footwear can also be divided into classes (Tab. 5) according to the standard HRN EN ISO 17249 2013 - Safety footwear with resistance to chain saw cutting [12]

Table 5: Classification of protective clothing according to classes

HRN EN ISO 17249:2013 - Safety footwear with resistance to chain saw		
Class	Cut resistance when using the chainsaw at a speed of [ms^{-1}]	Symbol
Class 1	20 m/s	
Class 2	24 m/s	
Class 3	28 m/s	
Class 4	32 m/s	

The basic material for the production of protective footwear for forestry workers is high-quality natural leather with a thickness of 1.6 to 2.5 mm. The protective leather is waterproof, resistant to liquids and abrasion. Cordura can also be used as a basic material which, again in addition to the leather, is used for individual parts of the footwear, the upper part of the shoe or the part around the ankle. The inner lining of the shoe must be especially strong and breathable. Lining materials used in the production of protective footwear include natural leather, polyamide, waterproof and vapour-permeable membranes that allow normal foot breathing, and special materials. Insoles and basic soles are made of natural or artificial materials, depending on the conditions set by the user. The sole consists of a resistant insole and an outer layer. The outer layer should be able to absorb shocks and be resistant to abrasion and slipping. At the same time, it must be uniformly thick in the longitudinal direction and have high strength; it must be antistatic and resistant to oil and gasoline. The resistant insole is in direct contact with the foot and is required for all protective and safety footwear except for rubber boots. It must be incorporated in such a way that it cannot be removed. The sole can be made of rubber, polyurethane and a combination of rubbers. The protective cap is usually made of steel, but can also be made of plastic or aluminium. The heel cap must provide a strong lateral support in the heel area [11].

Figure 6: 3D foot image of a forestry worker safety boot

Figure 7: Example of protective footwear for forestry workers

Protector Alpin HAIX protective boots (Fig. 7) are the best forestry boots for challenging terrain. The upper part of the shoe is made of high quality Nubuck leather as thick as 2.2 -3.0 mm, Kevlar material, which has a protector against damages with a chain of 28 m/s over the entire surface, and it also belongs to class 3. The substrate consists of four layers of Gore-tex material that is extremely abrasion resistant. The substrate in the upper part provides optimal comfort for intensive, daily use. The midsole is made of artificial material to ensure greater stability and a more even arrangement of pressure points. An integral part of these shoes are the steel outsole and steel toe cap and laces that do not absorb water.

4. FORESTRY SAFETY HELMETS

Various head injury hazards exist in the performance of different activities, including forestry, where the greatest hazards are from falling or flying objects, impact with the head against sharp or blunt objects, and contact with moving or rotating parts of machinery and equipment. In forestry in particular, safety helmets must be worn when cutting, dragging and stacking tree trunks, but also during other work processes.

All parts making up the safety helmet must be so designed that they cannot injure the worker in the event of an accident. There should be no metal parts or other hard protrusions or sharp edges on the inside of the helmet to avoid possible injury when the shell is deformed. The safety helmet must cover the head well and tightly, regardless of the position and movement of the worker. Around the brim of the cradle there must be a system, part of which is the headband, which gives the worker the opportunity to adjust the helmet according to the size of his head.

Industrial safety helmets are used for forestry work according to the standard HRN EN 397 2013 – Industrial Safety Helmets [13.] Each helmet must meet the basic and additional requirements when tested according to this standard.

Table 10: Materials safety helmets manufacturing

Thermoplastics	**Duroplastics**
ABS – polyacrylonitrile	GPU - polyester
PA – polyamide	SP-PF – phenol
PC – polycarbonate	
PE – polyethylene	

Figure 8: Example of a forestry safety helmet

The Protos Integral Arborist Forest Helmet (Fig. 8) is a revolutionary helmet with integrated head, face and hearing protection that sets new standards for safety and comfort when working in the forest. This helmet offers increased safety with a flip-up visor with a wide field of vision, is brightly coloured for increased visibility, has integrated, detachable hearing protection antiphons and complies with HRN EN 397 2013 – Industrial safety helmets, HRN EN 352-3:2004 – Hearing protectors and HRN EN 1731:2008 - Personal eye protection -- Mesh eye and face protectors.

This helmet is more comfortable thanks to its intelligent ventilation system, a replaceable, washable inner lining that absorbs shocks and sweat, the patented three-point attachment system and is easily adjustable to size for a perfect head fit. It is functional unlike classic safety helmets because it contains a visor mesh with 16 or 39 openings per cm^2, has an adjustable range of 54 to 62 cm, its life time is three years for forestry workers and has a large selection of accessories (chin strap, neck protection against rain, etc.).

5. CONCLUSION

This paper deals with personal protective equipment for forestry workers performing forestry activities and gives an overview of the materials from which they are made. In particular, the production and design parameters, according to which this protective equipment is manufactured, are described. Since the worker spends most of the day in work clothes and shoes, it is important to meet the requirements prescribed by the standards and to use modern high-quality materials and modern manufacturing technologies.

It is extremely important that forestry protective equipment is made of high quality materials to prevent the worker doing the work from being cut and injured. The materials described are of the highest quality, so it is important that the workwear is made of polyamide fibres that are extremely dense, elastic and abrasion resistant. It is important to emphasize that protective trousers contain reinforcements in the knee and ankle areas to protect against possible cuts. The reinforced parts of the trousers are made of several layers of polyamide yarn, which prevents the chainsaw from puncturing the material in such a way that the polyamide fibers get caught in the chain and thus stop the operation of the chainsaw.

The protective gloves are very ergonomically adapted and are made of bovine leather and aramid fibres. These materials have proven to be of particularly high quality due to their special strength. Mechanical gloves used in forestry are reinforced around the palms, thumb, index finger and fingertips to protect the worker from vibrations, sharp, pointed and rough objects that can injure the worker in various ways.

To protect the leg and the foot of the forestry worker, it is necessary to use protective shoes made of high-quality natural leather, polyamide and aramid fibres. However, the materials themselves are not sufficient for high-quality protection, so it is necessary to integrate a protective cap into the shoes. The protective cap is usually made of steel and is placed on the front and back of the shoe to provide protection and a strong support.

To protect the head, it is important that safety helmets are made of suitable materials, i.e. thermoplastics and duroplastics, to provide safety and resistance to punctures and shock absorption. Thermoplastic and duroplastic materials are made of synthetic polymers and therefore provide adequate protection for the worker. Thermoplastics and duroplastics are materials made of synthetic polymers and as such provide adequate protection for the worker. It is extremely important for the employer to anticipate absolutely all possibilities of risk reduction and therefore to supervise the use and effectiveness of personal protective equipment in accordance with the Occupational Safety and Health Act, using the regulations. This means that the employer is obliged to provide all his workers with the correct personal protective equipment and to ensure that workers use it regularly. Safe working conditions as well as safe working procedures are achieved exclusively on the basis of general principles of occupational safety and health.

REFERENCES

[1] Pejnović, N.: Osobna zaštitna oprema za zaštitu tijela, Sigurnost 57, (2015.),3, 229-242
[2] Zakon o zaštiti na radu (NN 71/14,118/14,154/14,94/18,96/18
[3] Pravilnik o uporabi osobne zaštitne opreme (NN5/2021-111)
[4] Horvat J., Regent A.: Osobna zaštitna oprema, Veleučilište u Rijeci, Rijeka, 2009., ISBN 978-953-6911-43-1
[5] Pejnović N., Bubaš M., Krišto D., Mihalinac Bolanča M., Škreblin J.: Zaštitna odjeća, Zbornik radova 5. međunarodno stručno-znanstvenog skupa „Zaštita na radu i zaštita zdravlja“, Kirin, S. (ur.), 17.09.-20.09.2014., Zadar, Hrvatska, ISSN 1848-5731
[6] https://www.zavas.hr/proizvod/14/sumska-zastitna-oprema.html,pristupljeno 31.05.2022.
[7] https://www.cordura.com/Fabrics/classic-fabric, pristupljeno 31.05.2022.
[8] Pejnović N., Bogadi-Šare A.: Osobna zaštitna sredstva za zaštitu ruku, Sigurnost, 53 (2011.), 4, 357-370
[9] Kirin, S.: Zaštitne rukavice kao važan faktor u zaštiti ruku, Book of Proceedins of 11th International Scientific Conference on Production Engineering Development and Modernization of Production - RIM 2017, Hodžić A., Omer E.S., Hodžić D.(ed.), October 4-7, 2017, Sarajevo, Bosna i Hercegovina, 703-708, ISSN 2566-3275
[10] Hursa Šajatović A., Rogale D., Dragčević Z.: Zaštitna obuća – vrste, kriteriji odabira i tehnologija izrade, Zbornik radova 5. međunarodno stručno-znanstvenog skupa „Zaštita na radu i zaštita zdravlja“, Kirin, S. (ur.), 17.09.-20.09.2014., Zadar, Hrvatska, ISSN 1848-5731
[11] HRN EN ISO 17249:2013: Sigurnosna obuća otporna na zarezivanje lančanom pilom, http://31.45.242.218/HZN/Todb.nsf/wFrameset2?OpenFrameSet&Frame=Down&Src=%2FHZN%2FTodb.nsf%2F51ab863e2feef8fec1256d4a00370fd8%2F71a

b8bdce0342967c1257a6f0046ea7b%3FOpenDocument%26AutoFramed, pristupljeno 31.05.2022.
[12] Mikulčić, M; Kovačević, S.; Skenderi, Z.: Materijali za izradu zaštitnih čizmi za radnika u šumarstvu, Koža i obuća 68, (2019.), 1, 32-36
[13] https://www.titan.com.hr/za%C5%A1titna-oprema-i-odje%C4%87a%20-%2070/za%C5%A1titne-kacige%20-%201050, pristupljeno 31.05.2022.

APPLICALILITY OF WET CLEANING FOR FUNCTIONAL FABRICS WITH SHIELD EFFECT PROPERTIES

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Abstract: *The research is focused on investigation of six functional textiles (FF1 to FF6) before and after 10 cycles of wet cleaning through analysis of shield effectiveness (SE) at frequencies 1.8 GHz and 2.1 GHz. Functional protective materials differed in structural features as well a metal type (copper, silver and stainless steel) integrated in the structure. The results showed differences in the degree of protection of the analyzed protective materials depending on both variation. The highest durability in shield effectiveness (SE) possessed functional fabrics with integrated stainless steel (FF5 and FF6) after the 10th wet cleaning cycle, while fabrics coated with copper (FF1) lost protective properties. The research indicates the importance of monitoring the durability of functional properties under maintenance conditions.*

Keywords: *functional fabrics, shield effect, wet cleaning, stainless steel, Cu, Ag*

1. Introduction

Electrical and electronic devices, e.g. modems, digital computers, calculators, printers, digital circuits, transmission lines and electronic household devices (including Wi-Fi and mobile phones) emit electromagnetic (EM) waves that can create electromagnetic interference (EMI) problems [1].

The application of electrically conductive materials is quite wide. They are used in different areas where it is necessary to protect people and devices from increased EM radiation that can have a harmful effect on human health and environmental pollution.

People who work in fields of greater exposure to electromagnetic waves use workwear that provides protection against the harmful effects of electromagnetic and electrostatic fields [1]. Textile materials that contain metal threads or have metal coating are also used for protection from effects of radiation [2-6].

Various textile structures in knitted, woven, non-woven forms ot hybrid forms, e.g. composites with certain electromagnetic shielding efficiency (EMSE) are often used to shield electronic and electrical devices from EM radiation due to their convenient properties, e.g. light weight and flexibility [7].

Workwear can have different protective properties depending on the composition of the textile material, thickness, type and amount of metal content, additional finishing or working conditions demands. Therefore, depending on the type and purpose of the conductive textiles, the durability of functional properties is evaluated by different methodology [8, 9].

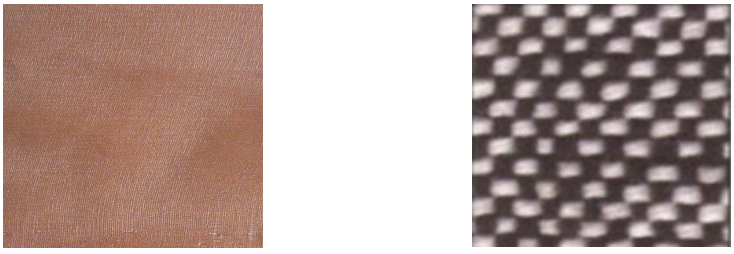
This study is focused on investigation of six functional textiles (FF1 to FF6) before and after 10 cycles of wet cleaning through analysis of shield effectiveness (SE) at frequencies 1.8 GHz and 2.1 GHz.

2. Materials and methods

2.1. Materials

Six textiles differed in structural features as well a metal type (copper, silver and stainless steel) integrated in the structure labeled as F1, F2, F3, F4, F5 and F6 are presented by specific characteristics, photo and digital image.

Functional fabric FF1 composed from polyamide filament coated with copper is patented by tt. Kufner GmbH, Germany. This light and transparent fabric in a plain weave (P1/1), colored like copper with a surface mass of 57 g/m^2 and a thickness of 0.11 mm is shown in Fig. 1.

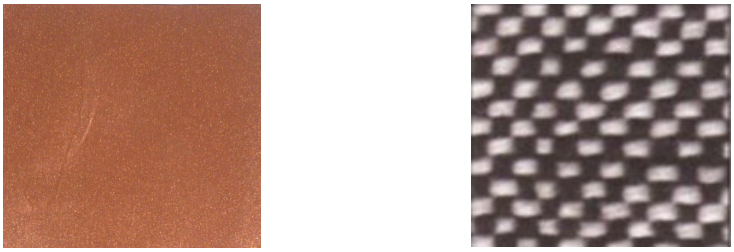


a. b.

Figure 2: Polyamide fabric with Cu (FF1): a. photo; b. digital image

Functional fabric FF2 composed from polyester coated with copper is supplied by tt. Less EMF Inc. USA, characterized by the mass per unit area of 85 g/m^2. The

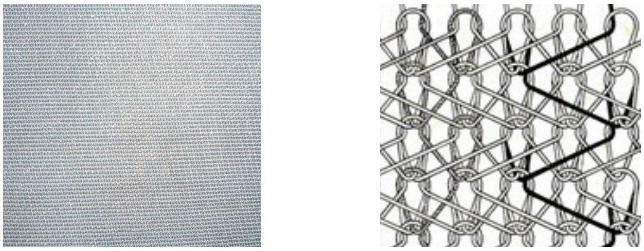
fabric is aimed for interlining with electrically conductive properties against EM microwave radiation. The fabric in plain weave (P1/1) colored like copper is shown in Fig. 2.



a. b.

Figure 2: Polyester fabric with Cu (FF2): a. photo; b. digital image

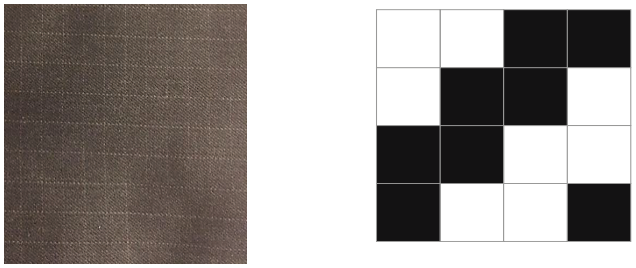
Functional polyamide knitted fabric FF3 is very light, by the mass per unit area of 35.85 g/m^2 with silver-plated threads, knitted in charmeuse colored like silver is shown in Fig. 3. It is supplied by tt. Less EMF Inc., USA and intended for protection against EM microwave radiation and other electrical and electronic devices. Due to the antimicrobial properties of silver it can be used for medical and protective applications.



a. b.

Figure 3: Polyamide knitted fabric with Ag (FF3): a. photo; b. knit unit

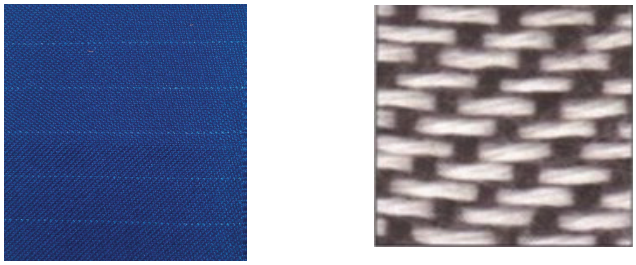
Protective fabric FF4 composed from polyester and and cotton (49% PES, 48% Co) with Ag (w=3%) threads is produced in tt. Čateks d.d., Croatia, Fig. 4. Silver threads were integrated each 1 cm in the direction of the warp and the weft. The fabric is woven in a twill (K2/2), the mass per unit area of 240 g/m^2. This grey colored fabric is aimed for protective clothing for workers who are exposured to EM radiation.



a. b.

Figure 4: Functional protective fabric with Ag (FF4): a. photo; b. weave unit

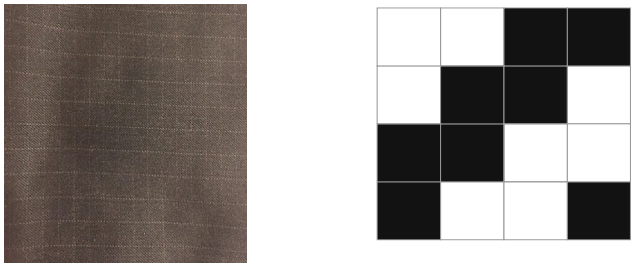
Functional protective fabric cmposed from modacryl and cotton (54% MAC, 44% CO) with stainless steel (2%), FF5 is produced in tt. Čateks d.d., Croatia. The fabric is dark blue with stainless steel thread woven every 1 cm in the weft direction. The functional protective fabric is woven in an atlas weave (A1/4), the mass per unit area 258 g/m^2, with specific resistance of 105Ω, Fig. 5. The application of a fabric FF5 is the same as FF4.



a. b.

Figure 5: Functional fabric from MAC/CO with Ag (FF5): a. photo; b. digital image

The protective fabric composed from polyester and cotton (49% PES, 48% Co) with stainless steel (3%) threads (FF6) is produced in tt. Čateks d.d., Croatia. Stainless steel threads are woven every 1 cm in the direction of the warp and in the direction of the weft.



a. b.

Figure 6: Functional fabric from PES/CO with stainless steel threads (FF6): a. photo; b. weave unit

The functional fabric FF6 is woven in a twill (K2/2), the mass per unit area 240 g/m^2 is shown in Fig. 6. The application of a fabric FF6 is the same as FF4 and FF5.

2.2. Wet cleaning

The wet cleaning (WC) procedure was carried out according to HRN EN ISO 3175-3: 2018, according to the program for very sensitive fabrics in several stages:

- pre-treatment,
- treatment – wet cleaning,
- finishing
- drying.

Wet cleaning process was repeted 10 times under the same conditions.

2.3. Measurement of shield effectiveness (SE)

The shield effect (SE) is calculated as the ratio between the intensity of the EM field (E_1) measured without the tested material and the intensity of the EM field (E_2) with the material placed between the radiation source (radiation) and the measuring device according to expression (1).

$$SE = 20\log\frac{E_1}{E_2} \qquad (1)$$

The impact of wet cleaning on the protective properties of the tested samples was measured using a method developed at the University of Zagreb, Faculty of Electrical Engineering and Computing in the Microwave Laboratory of the Institute of Radiocommunication and Space Technologies [10-12]. Measurements were performed under working environment conditions of temperature of 23±1^{0}C and relative humidity of 50±10%, on the measuring setup shown in Fig. 7.

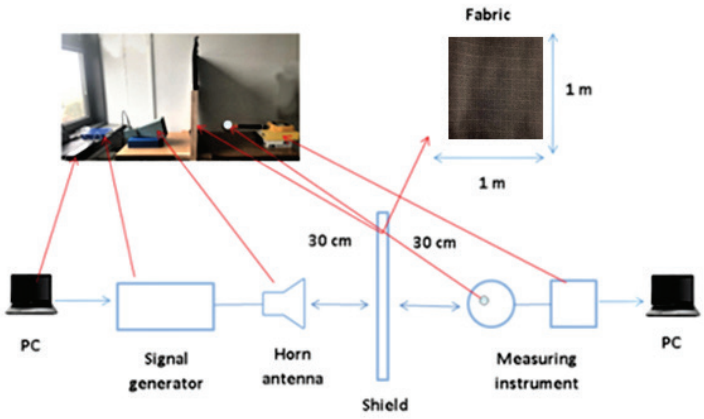


Figure 7: Measuring setup

Figure 7 shows the measuring setup of the metal contained protective samples (FF1 to FF6). It consists signal generator, horn antenna, shield, measuring instrument and PC.

3. Results and discusion

The SE of the tested samples FF1 to FF6 before and after 10 cycles of wet cleaning measured at 1.8 GHz and 2.1 GHz are shown (Fig. 8 and Fig. 9).

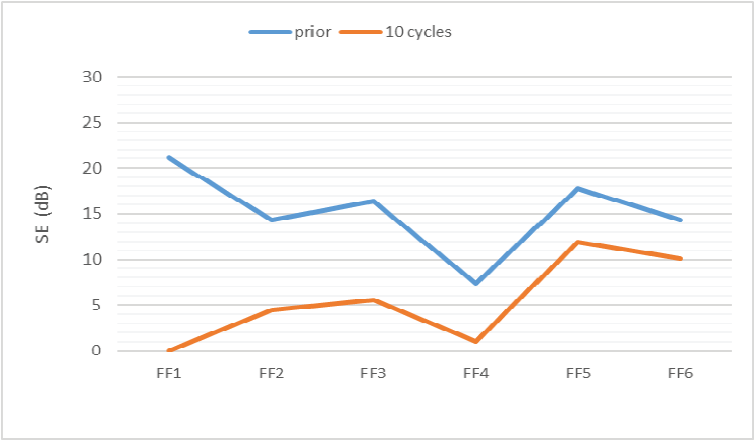


Figure 8: SE of functional textiles, FF1 to FF6, prior and after 10 wet cleaning cycles on frequency 1.8 GHz

Fig. 8 shows results of SE sample, FF1 to FF6 before and after 10 cycles wet cleaning cycles, determined at frequency 1.8 GHz. Initial SE values depend on the type of functional fabric. The most effective fabric is FF1 while FF4 offered the weakest protection within the tested samples, FF1 till FF6.

After 10th wet cleaning cycles sample FF1 showed the lowest values of SE (0.07 dB) followed by the sample of FF4 (1.01 dB). The highest value of SE was retained by samples FF5 (11.91 dB) and FF6 (10.13 dB). Based on the presented results, it can be concluded that the wet cleaning process is favorable for the maintenance of samples of protective fabric with steel stainless whose basic purpose is the production of protective clothing.

Fig. 9 shows the results SE of samples, FF1 to FF6, before and after 10 wet cleaning cycles on frequency 2.1 GHz.

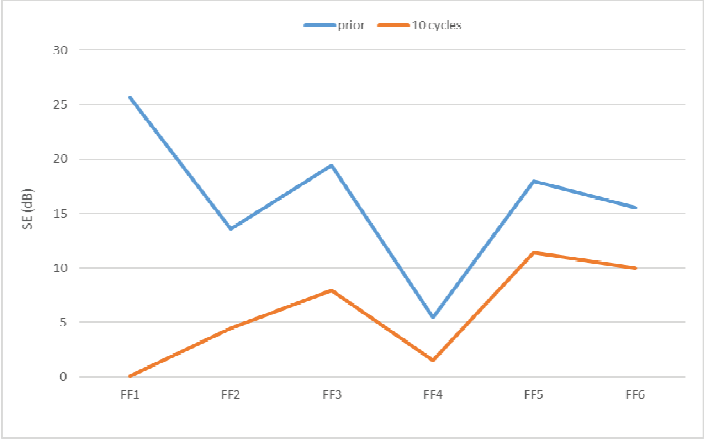


Figure 9: SE of functional textiles, FF1 to FF6, prior and after 10 wet cleaning cycles on frequency 2.1 GHz

Initial SE values depend on the type of functional fabric. The most effective fabric is FF1 while FF4 offered the weakest protection within the tested samples, FF1 till FF6 on frequency 2.1 GHz.

After 10 wet cleaning cycles the highest value of SE at the frequency of 2.1 GHz was also maintained by samples with steel stainless FF5 (11.44 dB) and FF6 (9.98 dB). The lowest values of SE were measured in samples FF1 (0.06 dB) and sample FF4 (1.51 dB). The wet cleaning process is favorable for the maintenance of samples of protective fabric with stainless steel and at a frequency of 2.1 GHz.

3. CONCLUSION

The aim of the work was to compare the SE properties of functional protective textile materials with metal (Cu, Ag and stainless steel). The structural features of all functional textile materials and a technique of functionalization with a metal are different. SE values at frequencies 1.8 GHz and 2.1 GHz were determined before and after 10 of wet cleaning cycles. The results of SE showed that the protective properties of all tested samples are violated after 10 wet cleaning cycles. Based on the obtained results, the wet cleaning process is applicable for maintenance of functional textile materials with stainless steel threads (FF5 and FF6) aimed for protective clothing.

The protective properties of the functional sample with Ag (FF3) after 10th wet cleaning cycles are 7.97 dB at a frequency of 2.1 GHz, while SE values decreased at a frequency of 1.8 GHz (5.62 dB). The SE of the functional fabric FF4 after the 10th wet cleaning cycle is low, 1.01 dB at 1.8 GHz and 1.51 dB at the frequency of 2.1 GHz.

The SE of the functional protective interlining fabric with Cu (FF1) prior to wet cleaning are high. After 10 times of wet cleaning SE almost vanished at the measured frequencies. The SE values of the FF2 samples are 4.42 dB at the frequency 1.8 GHz, and 4.49 dB at the frequency 2.1 GHz.

Acknowledgement

This work is funded by the Croatian Science Foundation under project HRZZ-IP-2018-01-7028.

REFERENCES

[1] Sundaramoorthy P.; Veronika T. & Jiri M.: Fiber-based structures for electromagnetic shielding – comparison of different materials and textile structures, *Textile Research Journal*, **88** (2017) 17, pp. 1992-2012
[2] Erdumlu, N.; Saricam, C.: Electromagnetic shielding effectiveness of woven fabrics containing cotton/metal-wrapped hybrid yarns. *Journal of Industrial Textiles*, **46** (2016), pp.1084–1103, ISSN 1528-0837
[3] Šaravanja B, et al. Shield Effect of Functional Interlining Fabric. *AUTEX Research Journal,* **15** (2015) 2, pp. 93-98. ISSN 1470-9589
[4] Liu Z., et al. Parameter Description of the Surface Metal Fiber Arrangement of Electromagnetic Shielding Fabric, *Fibres Textiles Eastern Europe*, **25** (2017) 2, pp 62-67. ISSN 1230-3666
[5] Ceven E.K., et al. Evaluation of electromagnetic shielding effectiveness of fabrics produced from yarns containing metal wire with a mobile based measurement system. *Industria Textile*, **68** (2017) 4, pp. 289–295. ISSN: 1222-5347.
[6] Sonehara M, et al. Preparation and Characterization of Nanofiber Nonwoven Textile for Electromagnetic Wave Shielding. *IEEE Transactions on Magnetics*, **44** (2008) 11, pp. 3107 – 3110, ISSN 0018- 9464. Electronic ISSN 1941-0069.

[7] Maity S, et al. Textiles in electromagnetic radiation protection, *Journal Safety Engineering,* **2** (2013), pp.11–19, ISSN 2325-0011
[8] Gokarneshan, N.; Naren Srivatsa, G.: Some Significant Trends in Conductive Textiles, Trends Text. Fash. Des. 2018, 3, 179–186.
[9] Rotzler, S.; Schneider-Ramelow, M. Washability of E-Textiles: Failure Modes and Influences on Washing Reliability. *Textiles,* **1** (2021), pp. 37–54, ISSN 2673-7248
[10] MIL-STD-285, Military Standard: Attenuation Measurements for Enclosures, Electromagnetic Shielding, 1956.
[11] IEEE STD 299 Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures, 2006, 299.
[12] ASTM D 4935-99 Standard Test Method for Measuring the Electromagnetic Shielding Effectiveness of Planar Materials, 1999.

Selection of appropriate personal protective equipment after noise measurement

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Abstract
Noise is a physical hazard mandatory to be measured. Upon noise measurement and results obtained, further technical and organisational measures are adopted with the intention to reduce the exposure to noise. However, in this paper the emphasis is placed on noise measurement and selection of personal protective equipment. Recommendations regarding personal protective equipment were given for the worker in the observed business entity whose daily noise exposure is 85 decibels which exceeds the lower exposure action values of 80 db (A). In such instances, the employer is obliged to provide his worker with hearing protection. Daily noise exposure of the observed case is equal to the upper exposure value of 85 db (A) so the worker is obliged to use personal protective equipment. These results are interpreted in order to protect the hearing of workers because they imply which workers are entitled to a health surveillance and selection of appropriate personal protection equipment.
Key words**:** *noise, noise measurement, noise protection measures, personal protective equipment*

1. INTRODUCTION

Occupational safety as a system of rules and established principles and activities, has the main goal to improve the safety and health of individuals, with emphasis on preventing risks, injuries or diseases caused and related to work, but also material and non-material damage. At the same time, there are many technical, health and legal activities within occupational safety which intertwine in order to eliminate and reduce potential hazards in the workplace. Noise is a physical hazard that needs to be measured. Technical and organizational measures must be introduced to reduce daily noise exposure. However, the topic of this paper is noise measurement and selection of personal protective equipment (PPE) for an individual worker. Although the issue of noise can be considered on a global level, i.e. human exposure to noise in urban areas and its impact on health, here will be considered exposure to noise of workers in the observed business entity. The objective of this paper is to analyze noise as a physical hazard and the implementation of noise protection measures in the work environment. In accordance with the objective this paper is focused on the following tasks: analysis of Eurostat statistics as a brief introduction to the issue of worker's health, analysis of the part of the report on the measurement of physical hazards

regarding the measurement of noise, selection of appropriate personal protective equipment for hearing, for the employee in the observed business entity.

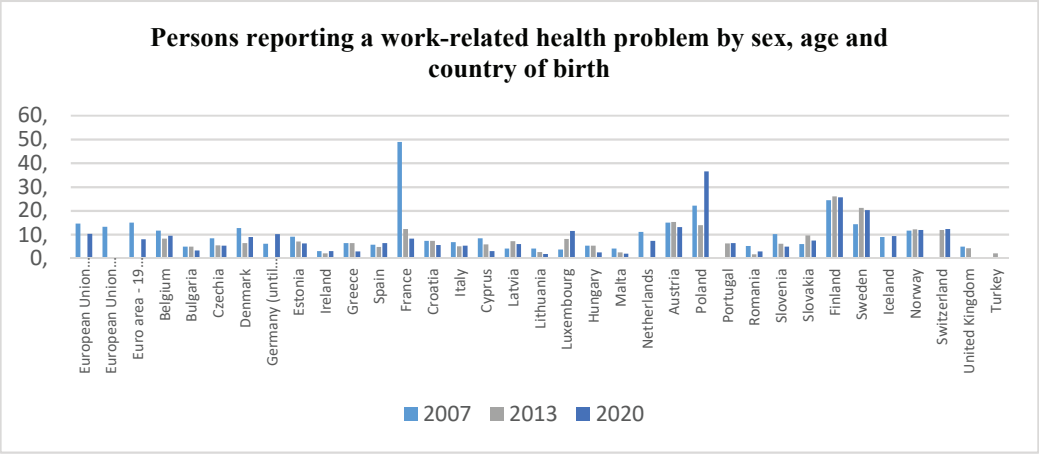
2. METHODOLOGY

In the identification of statistical indicators that indicate work-related health problems, data was collected on the Eurostat website and interpreted by graphs. Measurement of noise was performed using a sound level meter and belonging formulas. The given results were verified by using Daily Noise Exposure Action Value Calculator of British Health and Safety Executive. The data from distributors of personal protective equipment was used for selecting optimal hearing protector.

3. RESULTS AND DISCUSSION

Exposure to noise often leads to health problems, so as a brief introduction to this issue Eurostat survey provides statistics that will show the extent to which individuals in the European Union perceive their workplace as a source of health problems.
Eurostat data is analysed in order to consider the frequency of health problems caused by work. The downloaded data was processed in Microsoft Excel and interpreted by graph. In addition to the quantitative comparison by the observed countries, the author's opinion on individual statistical surveys and their interconnectedness is also given. Graph 1 shows the percentage of people aged 15 to 64, for both sexes, who cited their job as the cause of their health problems. The survey was conducted for year 2007 and 2013 and 2020. However, data was not available for some countries, there was also poor reliability for certain countries or only projections have been made. Stated research shows that the share of people in the European Union (EU-27) who believe that their health problems are related to their workplace, has decreased by almost five percent in 2020 compared to 2007. Comparing the attitudes of workers in the European Union with those in the Republic of Croatia, it is noticed that workers in the Republic of Croatia to a lesser extent connect their health problems with their workplace. For example, in Finland more than twenty percent of workers connect their health problems with their workplace, and significant shares have been observed in Sweden, Austria and Poland. In Croatia, 7.4% of individuals had such an attitude in 2007 and 2013, while in 2020 that percentage was 5.6%.
On the other hand, less than five percent of workers in Romania, Hungary, Ireland and Lithuania believe their health problems are caused by work. This research does not show whether work is really the cause of their health problems, but is an indicator of workers' perception of the workplace as a source of potential risks. Also, differences between countries are due to different working conditions, economic structures, but also differences in the consciousness of workers, treatment, sick leave and prevention of health problems caused by work. This research not only included currently employed persons, but also included those individuals who were employed

in the past. It should also be noted that the emergence of the COVID-19 virus has to some extent certainly led to inconsistent values in 2020.



Graph 1: Persons reporting a work-related health problem in year 2007, 2013. and 2020

3.1. Noise measurement in a carpentry workshop

In this chapter, noise measurements are made in the working environment, i.e. in the carpentry workshop. The selected strategy is measuring noise according to the work task and the worker is interviewed in order to obtain information of the duration of individual work tasks in one working day. These data is given in Table 1

Table 1*:* Noise measurement in the carpentry workshop

Work assignment	Description of work assigment	Duration of work assignmen t Te (h)
1.	Work on manual processing, preparation, installation, daily rest	3,9
2.	Work on a circular saw (Measuring point –M.P. 3)	0,8
3.	Work on a wood combined machine (Measuring point- M.P.4)	1,3
4.	Work on a wood combined machine (Measuring point - M.P.8)	1,4
5.	Work on a chain mortiser machine (Measuring point – M.P. 10)	0,6
	Total working hours T_0 (h)	8

Source: values (duration of work tasks), according to the worker's statement

Within the analysis of work procedure it is established that during the working day, harmful noise is generated on machines located in the observed workshop, where carpenter is exposed to noise. Worker does not use all machines continuously throughout the eight working hours, but occasionally according to the needs of the job. For this reason, noise measurement for each work task followed. Seperate measurment was made three times at intervals of 5 minutes. In Table 2 are shown the listed measurements.

Table 2*:* Measurement results

Work assignment (m)	Measuring point.	Separate measurement of equivalent noise level			
		Measurment No 1. dB(A)	Measurment No 2. dB(A)	Measurment No 3. dB(A)	*Measurement difference smaller than 3 dB?*
1.		65,9	64,2	66,8	*YES*
2.	M.P.- 3	83,4	82,1	83,5	*YES*
3.	M.P.- 4	88,7	88,0	86,2	*YES*
4.	M.P.- 8	90,4	89,8	88,0	*YES*
5.	M.P.- 10	88,1	86,2	86,7	*YES*

Source: author's processing; values measured at the client's premises

The following task is to calculate equivalent noise level $L_{Aeq,T}$, which is later appointed as $L_{Aeq,}$(dB(A)). $L_{Aeq,T}$, i.e. the equivalent noise level divided into n time intervals t_i,and it is calculated from the following formula :

$$L_{Aeq,T} = 10\,log\left(\frac{1}{T}\sum_{i=1}^{n} t_i\, 10^{\frac{L_{Ai}}{10}}\right) \quad (1)$$

Table 3 shows the results obtained, i.e. the equivalent noise level for each work task.

Table 3*:* Equivalent noise level per task

$L_{Aeq,T1}$	65,8	dB(A)
$L_{Aeq,T2}$	83,0	dB(A)
$L_{Aeq,T3}$	87,8	dB(A)
$L_{Aeq,T4}$	89,5	dB(A)
$L_{Aeq,T5}$	87,1	dB(A)

Source: author's processing; calculation according to the formula number 1

In the next stage, the objective is to calculate the contribution of each work task to the level of daily noise exposure according to following formula, also called personal noise exposure per task:

$$L_{Ex,d} = L_{Aeq,Te} + 10\,log\left(\frac{T_e}{T_0}\right) \quad (2)$$

T_e- duration of personal exposure to noise (worker), $L_{Aeq,Te}$ equivalent noise level over the duration of exposure, a T_o is reference time or 8 hours

Table 4:The contribution of each work task to the level of daily exposure

$L_{Ex,d1}$	62,7	dB(A)
$L_{Ex,d2}$	73,0	dB(A)
$L_{Ex,d3}$	79,9	dB(A)
$L_{Ex,d4}$	81,9	dB(A)
$L_{Ex,d5}$	75,8	dB(A)

Source: author's processing; value calculation according to the formula number 2

The results obtained from Table 3 will be used to calculate the daily noise exposure according to the following formula:

$$L_{EP,d} = 10\ \log\frac{1}{8}\left(t_1 * 10^{\frac{L_1}{10}} + t_2 * 10^{\frac{L_2}{10}} + \cdots\right)$$

(3)

$$L_{EP,d} = 85\ dB$$

The level of daily noise exposure can also be verified by using Excel calculator given by British Health and Safety Executive website. Calculation is made by using previously obtained results on equivalent noise per work task and the time of each task:

Table 5: Daily Noise Exposure Action Value Calculator

HSE

Daily Noise Exposure Action Value Calculator

V4-12 March 2021

The *Control of Noise at Work Regulations 2005* define Lower and Upper Exposure Action Values (LEAV and UEAV) of 80 and 85 dB(A).
This calculator estimates the **unprotected daily noise exposures** of workers for comparison with the LEAV and UEAV.

Main Menu | Zoom to fit | *Daily Noise Exposure Action Value* | Daily Noise Exposure Limit Value Calculator | Weekly Noise Exposure Calculator | Instructions

Task[1] name / description	Noise level[1] L_{Aeq} (dB(A))	Points per hour	Time (in hh:mm) to LEAV	Time (in hh:mm) to UEAV	Daily exposure time[1] (hours)	Daily exposure time[1] (mins)	Personal noise exposure per task (dB(A))	Personal exposure points per task
Task 1	66	0	>24hours	≥ 24 hours		234	63	1
Task 2	83	8	4:00	12:40		48	73	6
Task 3	88	25	1:16	4:00		78	80	32
Task 4	90	40	0:48	2:31		84	82	55
Task 5	87	20	1:35	5:02		36	76	12
Task 6								
Task 7								

☐ Lock task names

Reset

Copy values from Noise ELV Calculator

Total daily exposure time (hh:mm)	Daily exposure, $L_{EP,d}$ (dB(A))	Total daily exposure points
8:00	85	106

WARNING: At or above UEAV
Programme of control measures required
Hearing protection must be used
(check suitability with ELV calculator)

Footnotes:

Source: author's processing, according to British Health and Safety Executive

Directive 2003/10/EC of the European parliament and of the Council has been transposed into Croatian legislation by Rulebook on protection of workers from exposure to noise at work *(Croatian: Pravilnik o zaštiti radnika od izloženosti buci na radu*). Both legislations prescribe exposure limit values and exposure action values. For the purposes of this Directive the exposure limit values and exposure action values in respect of the daily noise exposure levels and peak sound pressure are fixed at:

(a) exposure limit values: $L_{(Ex,8h)}$= = 87 dB(A) and $p_{(peak)}$= 200 Pa (140 dB(C)
(b) upper exposure action values: $L_{(Ex,8h)}$=85 dB(A) and $p_{(peak)}$ = 140 Pa (137 dB(C)
(c) lower exposure action values: $L_{(Ex,8h)}$= 80 dB(A) and $p_{(peak)}$ = 112 Pa (135 dB(C)

When applying the exposure limit values, the determination of the worker's effective exposure will take account of the attenuation provided by the PPE worn by the worker. The upper and lower exposure action values do not take account of the effect of hearing protectors. When exposure to noise cannot be prevented by applying basic occupational safety rules or appropriate organizational measures, workers should be provided with appropriate and well-adapted personal hearing protection equipment. In the case of exposure limit values, the employer takes into account the reduction of

noise due to the use of personal protective equipment for hearing protection. On the other hand, this effect should not be taken into account in the case of upper or lower exposure action values. If the exposure to noise exceeds 87 dB(A), these jobs are classified as jobs with special working conditions. The employer shall refer the worker exposed to that specific noise level, to an authorized institution, i.e. a specialist in occupational medicine with a referral containing information on the type of work and other circumstances which affect the assessment of his ability to perform certain tasks. Daily exposure to noise in the observed carpentry workshop is 85 decibels, which exceeds the lower exposure action values of 80 db(A). The employer is obliged to provide workers with personal hearing protection equipment, in this case daily noise exposure is equal to the upper exposure value of 85 db (A), therefore workers are required to use PPE. A worker who is exposed to noise levels above the exposure action values is entitled to a hearing test in occupational medicine, and workers whose exposure exceeds the lower exposure warning values are also entitled to preventive audiometric testing if the assessment and measurement show a health risk. The purpose of these examinations is to diagnose possible loss and preserve hearing function. It is very important to educate the worker on the proper wearing of protective equipment, it should be comfortable so that workers do not remove it. Picture 1 illustrates the consequences of removing hearing protectors. The expected noise reduction of hearing protector is 25 decibels only when worn for a full hour, therefore it is very important to choose a model that suits the workers. The scenario in which worker removed the hearing protector for 10 minutes and wore a hearing protection for the remaining 50 minutes was observed. When the protective equipment is removed 17% of the time (10 minutes 60 minutes), the protection is reduced to only 8 decibels. Likewise, removing PPE for 5 minutes during an operating hour reduces protection to 11 decibels, and removing PPE for 1 minute reduces protection to 17 decibels.

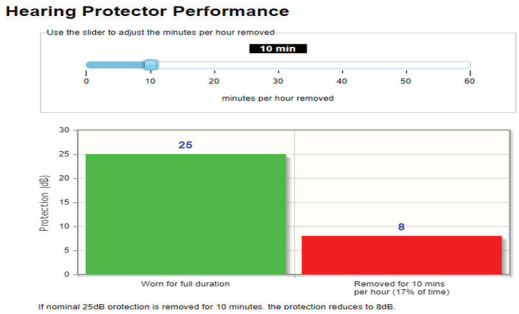


Figure 1 : Illustration of removal of hearing protectors severely reduces protection
Source: British Health and Safety Executive

3.2. Selection of appropriate personal protection equipment

Personal hearing protection is one of the passive measures to protect employers from existing noise that could not be completely eliminated in the work environment. When choosing PPE for hearing, it is necessary to take into account that correct and regular use is decisive for the complete protective effect. It is also very important that hearing protection is accepted by workers. Workers wearing hearing protection should speak as loudly as when they are not using it, and among the various recommended means, they should choose the hearing protector they consider most comfortable. Figure 2 illustrates a danger sign, in this case a noise danger, while Figure 3 illustrates a sign of obligation, which gives instructions or notification on the mandatory wearing of hearing protectors.

Figure 2: Danger Noise Area Sign

Figure 3: Mandatory hearing protection

Appropriate personal protective equipment is selected according to the noise level and frequency range, so the following types of hearing PPE are:
- cotton earplugs, earplugs
- ear protectors (earmuffs)
- semi-aural hearing protectors

When selecting hearing protectors, it is advisable for occupational safety experts to consult with occupational medicine specialist. In accordance with the recommendations of the international labor associations, it is regulated that noise protection devices and equipment reduce noise in the following values:

- Application of cotton earplugs for 20-25 dB, ear plugs for 25-30 dB
- Ear protectors for 30-40 dB, protective caps and helmets over 40 dB

Manufacturers will indicate in their data the assumed values of attenuation or mean values of protection and standard deviations per octave. Hearing protection equipment in the catalogs also contains data calculated from the value of attenuation per octave. These figures are denoted as H, M and L (i.e. attenuation at high, medium and low frequencies) and SNR (Single Number Rating or standard noise attenuation). The following table indicates the suitable hearing protector for different levels of noise (the level during a particular work task, not the daily personal noise exposure). It is based on the single number rating (SNR) and it is intended as a guide for selecting personal protective equipment. Overprotection should be avoided so the worker is not isolated from other workers.

Table 6: Selection of protectors to reduce noise while avoiding overprotection

A-weighted noise level (dB)	Select a protector with the right SNR
85 to 90	20 or less
90 to 95	20 to 30
95 to 100	25 to 35
100 to 105	30 or more

Source: British Health and Safety Executive

In the chapter 3.1.where noise measurment in carpentry workshop is made, Table 2. provided measurment results of A-weighted noise level (dB). The recommendation of Health and Safety Executive of United Kingdom is to select a protector with the right SNR, in this observed case it would be a protector with 20 or less SNR. It is also important to mention Regulation (EU) 2016/425 of the European Parliament and of the Council on PPE, which emphasizes that hearing protectors must be capable of attenuating the latter so that the exposure of the user does not exceed the limit values established by Directive 2003/10/EC. Each segment of PPE must carry labelling which indicates the noise attenuation level provided by the PPE, if not possible the labelling must be fixed to the packaging.

Table 7: Selection of appropriate hearing protector, regarding standards

Industry	Selection of appropriate personal protection equipment, European standards	Croatian name of standard
Carpentry workshop employee	- Hearing protectors -- General requirements -- Part 2: Ear-plugs, EN 352-2:2002	HRN EN 352-2:2004
	Hearing protectors -- General requirements -- Part 1: Ear-Muffs, EN 352-1:2002	HRN EN 352-1:2004

The data in Table 7 will serve as a starting point for selection appropriate hearing protection. Occupational health and safety specialist can choose between earplugs or earmuffs, as long as they meet the stated standards. It is also very important to acquaint the worker with the importance of wearing personal hearing protection as well as to allow him to choose between PPE that will be comfortable for him and will not refuse to wear it. For this reason, the emphasis is not on the brand of personal protective equipment but on its characteristics. This chapter provides an overview of several potential solutions for the observed worker in a carpentry workshop.

Figure 4*:* Honeywell™ Howard Leight™ Clarity™ C1 Earmuffs

Figure 4 shows hearing protection earmuffs with SNR 26 dB which comply with standard EN 352-1. They are considered suitable for a carpenter's workshop worker because they have Sound Management Technology which provides uniform sound insulation while allowing voices and signals to be heard. This feature means that the worker will not be isolated from potentially important sounds or notifications. The next possible solution for hearing protection is individual otoplastic. The observed custom fit earplugs comply with standard EN 352-2. Otoplastic provides a noticeable boost to wearer comfort and improves the perception of sound. They have anti-bacterial-coating and are available in different filter strengths: SNR 20 and 26. Selected hearing protector can be found in Figure 5.

Figure 5: Uvex high-fit u-cut FC otoplastic

4. CONCLUSION

It is necessary to measure noise as a physical hazard, as well as to assess the risks associated with noise, to define jobs in which workers are exposed to noise because they will be entitled to preventive medical examinations. It is also necessary to constantly improve the system of health and safety at work, exceeding the prescribed bare minimum, which will contribute to the improvement of living and working conditions. This approach will create a healthy work environment in which the worker will be aware of how he is an important part of the collective of the business entity. Much of the responsibility for implementing noise protection measures lies with

employers and occupational safety experts. Occupational safety experts, in addition to examinations, should inform the employer of the importance of implementing noise protection measures in their reports. Also, organizational, technical and construction-planning measures are needed in order to reduce noise. An employer who successfully implements these noise protection measures largely controls the risks associated with noise. However, when it is not possible to take these noise protection measures in full, the use of personal protective equipment is mandatory. When choosing personal protective equipment, the employer should consult with occupational safety experts, but also manufacturers of personal protective equipment. Workers exposed to noise should be informed of their rights and obligations, for example they should be informed about the dangers of noise and the obligation to wear personal protective equipment for hearing protection. An adequate level of hearing protection means that the worker is not 'overprotected' and isolated from other workers, but also that he is not 'exposed' to the noise of the work environment. European legislation in the field of occupational safety regulates the PPE market, which has achieved uniformity in quality in the European Union. With the general advancement of technology, there have been better technological achievements of PPE. For example, in practice, otoplastic or individual PPE is increasingly used for hearing protection, then PPE which filtrates noise but it is designed to transmit voice and signal frequencies, which enables better safety of workers. By investing in quality PPE, employers gain the trust of workers, providing optimal hearing protection which will ultimately increase worker productivity. By implementing safety measures at work, and in the narrower sense of noise protection measures, corporate social responsibility is achieved, i.e. business entities contribute in a positive way to the society as a whole.

REFERENCES

[1] Vučinić, J.; Vučinić Z.: *Osobna zaštitna sredstva i oprema*, Veleučilište u Karlovcu, ISBN: 978-953-7343-48-4, Karlovac, (2011)
[2] Sever, S.: *Fizikalne štetnosti,* Iproz, Zagreb, (2007)
[3] Trbojević, N.: *Osnove zaštite od buke i vibracija*, Veleučilište u Karlovcu, ISBN: 9789537343538, Karlovac, (2011)
[4] South, T.:*Managing Noise and Vibration at Work*, Routledge, ISBN: 978 0 75066 342 7,
Abingdon, (2011)
[5] Pravilnik o zaštiti radnika od izloženosti buci na radu, N.N., br.46/08.
[6] DIRECTIVE 2003/10/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)
[7] REGULATION (EU) 2016/425 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC
[8] https://ec.europa.eu/eurostat/data/database Accessed: 2022-31-05
[9] https://www.hse.gov.uk/noise/calculator.htm Accessed: 2022-03-06

[10]http://www.zirs.hr/znakovi-sigurnosti.aspx?category=2&showsign=OB-5A, Accessed: 2022-12-06
[11]https://narodne-novine.nn.hr/clanci/sluzbeni/2009_09_110_2825.html Accessed: 2022-12-06
[12]https://www.carlroth.com/com/en/ear-muffs/earmuffs-clarity-c1f-foldable/p/ct25.1 Accessed: 2022-12-06
[13]https://www.uvex-safety.com/en/products/individual-ppe/otoplastics/7831/uvex-high-fit-u-cut-fc-otoplastic/ Accessed: 2022-12-06

8

PROTECTION FROM FIRE AND EXPLOSION

IMPACT OF FIRE ON FILLING ELEMENTS OF LATTICE WOODEN GIRDERS

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Abstract: *Behavior in fires is one of the criteria for evaluating building materials. Any unwanted inflammation that is not controlled by humans is defined as fire. They are very unpredictable and occur in random locations and are most often caused by a completely random contribution of thermal energy. The most common physico-chemical changes in materials exposed to fire are: combustibility, flammability, flame spread rate, fuel dripping material, the ability to generate smoke of toxic gases and thermal power. The load-bearing elements of buildings must meet, among other requirements, fire resistance such as preventing the spread of fire and smoke inside the building, preventing the spread of fire to neighboring buildings, enabling people to leave the building unharmed, and ensuring their rescue and protection of saviours. The key moment to ensure fire resistance is the time in which the structure can provide the required load-bearing capacity. The paper analysed the yield failure of a lattice wooden girder exposed to average temperatures in house fires. The infill elements of the lattice girder were analysed due to their much smaller dimensions compared to the belt elements. The analysis was done in relation to the duration of the fire.*

Key words*: fire, fire resistance, wooden lattice girder, load-bearing capacity of the structural element.*

1. INTRODUCTION

The use of wood in civil construction is very widespread and therefore there is a need to clarify its behavior in conditions of elevated temperature and fire.

Fire as a phenomenon where there is unwanted and uncontrolled ignition that spreads at high speed is unwanted and uncontrolled. It occurs accidentally at unpredictable locations, and its cause is entirely due to the concentration of thermal energy on the critical area. The probability of a fire outbreak is directly related to the flammability of the material in which the fire starts, so this is precisely the biggest obstacle to the use of wood as a building material in construction, which certainly deserves special consideration.

Therefore, it is very important when dimensioning a wooden structure to know and understand the behaviour of wood in fire and the effect of passive protection measures on increasing the resistance of wood to fire, where the basic idea is to extend the time in which structural elements retain the designed mechanical resistance and stability. When calculating the load-bearing capacity and usability of civil construction structures, it is necessary to take fire as an extraordinary effect in the analysis of load combinations due to its possible destructive behavior on the structure, which can lead to structural collapse in construction material. Therefore, the consideration of wood in the conditions of fire gained importance due to its great application in the constructions.

The calculation also considers the reduction in cross-sectional resistance due to the degradation of the material properties at high temperatures. Appropriate sizing and adequate wood protection increases the resistance to fire and high temperatures of wood. The wooden structures can be brought to the top in terms of fire resistance, as burning loses their mechanical properties, which allows them to reliably calculate fire resistance and opens new areas of application in civil construction.

2. BEHAVIOR OF WOOD IN FIRE

Although a large amount of energy is needed to ignite wood and wood-based building materials, they are still flammable. The flammability of wood as a building material can be mitigated by impregnation, application of a layer of protective agent and passive protection measures as well as by increasing cross-sections during sizing. However, wooden elements cannot be made non-flammable. Moreover, with the right construction procedures, wood can be made as a material with very solid fire resistance properties.

Experimental tests have determined the firing time of wood in structures depending on the temperature and the length of exposure, (see Figure 1 a).

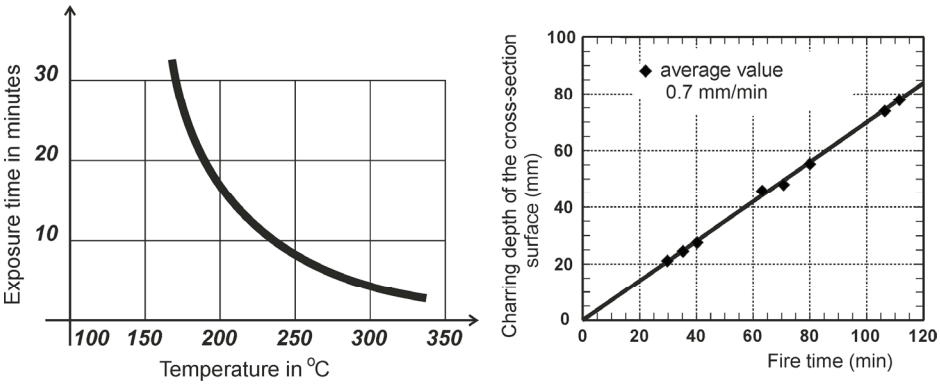
It should be noted that temperatures of 150°C in fires are reached very quickly, especially in the upper zones of the area affected by the fire. Lattice roof and interfloor constructions are most often located in these zones, so they are more exposed to such loads.

This leads to the fact that in a short time, if there is a heat source, the wood material catches fire even at a temperature slightly higher than 300°C. At the temperature of 220- 350°C, the surface is charred and combustible gases develop rapidly, where the surface of the wood heats up and the gases eventually ignite. When burning, a carbonized layer is formed on the surface of the wooden element that prevents or slows down combustion.

At temperatures from 360-510°C, combustible gases ignite rapidly and charcoal is annealed. Temperatures of 550-600°C with a very short action on the surface of the wooden element lead to its self-ignition.

Tests were carried out on wooden elements of various types of wood, both hard and soft, showed that the average charring of wooden elements per cross-sectional

area took place during a fire at a speed of approximately 0.7mm/min. This relationship is shown in the table below.



(a) **(b)**

Figure 1: (a) Wood ignition in relation to the time of exposure to elevated temperatures (b) time dependence of temperature-depth of charring

From the diagram above it can be seen that the charring depth of the cross section exposed to fire can be expressed as:

$$S_u=0.7\cdot t_p \quad \textbf{(1)}$$

S_u [mm] - charring depth of cross section;

t_p [Min] - cross-sectional time spent in fire.

It means that if a wooden element is in the fire for 30 minutes, during that time there will be charring on its surface to a depth of about:

$$S_u\approx 0.7\cdot t_p\approx 0{,}7\cdot 30\approx 21\text{mm} \quad \textbf{(2)}$$

It can be concluded from the above that the critical (smaller) dimension of the structural element needs to be increased by a value of $2S_u$ in order to satisfy the load-bearing capacity of the structural element exposed to fire for 30 min.

$$b=b_0+2\cdot S_u=b_0+42\text{mm} \quad \textbf{(3)}$$

Where:

b - is the required critical dimension of the cross-section of the wooden element, taking into account the influence of fire (charring);

b_0- the required dimension of the cross-section with regard to the calculation of the bearing capacity of the wooden structures;

At elevated temperatures, the load-bearing capacity of the elements in wooden structures decreases.

Figure 2 shows a diagram wooden structural elements strength related to tension, pressure and bending in relation to the increase in temperature in a fire.

It can be seen that the tensile strength of wood at temperatures of 100°C decreases by 10% of its ultimate strength. If the compressive and bending strengths is being observed, it can be seen that their strength in relation to the fire temperature decreases even up to 40% in relation to the ultimate strengths at such elevated temperatures.

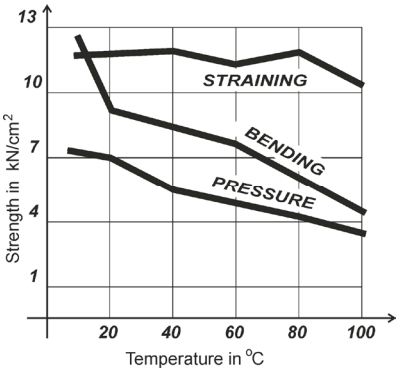


Figure 2: Time dependence of temperature-change of wood mechanical properties

3. ANALYSIS AND EXPERIMENTAL TESTS

Lattice girders in which the diagonal rods have been filled as complex cross-sections were considered. Due to the advantageous design, diagonal rods exposed to tensile stresses differ in the number of elements by 1 from the number of elements of the belt rods. The belt bars and verticals of the lattice structure were made as one-piece, while the diagonal bars were made as two-part elements of the lattice structure.

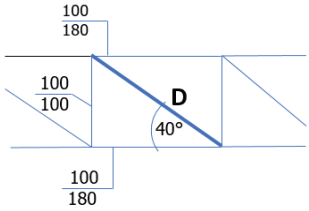


Figure 3: Scheme of the lattice girder of the observed wooden construction

Characteristics:

- Material: conifers S10/M10
- Duration of action: medium
- Humidity of wood: 18%
- Usage class: Uk2

The calculated force in the most loaded diagonal is F_d=17,52kN

For such a loaded bar by calculation, the required cross section of a two-part diagonal rod can be obtained based on the expression:

$$_{potr}A=1,5\cdot F_d/f_{t,o,d} \quad \textbf{(4)}$$

The required area is $_{potr}A$=3048,72mm^2 so that a two-part cross section of dimensions 2·b/h mm 2·24/63,52 mm has been assumed. In this expression b represents width of cross-section and h represents height of assumed cross-section.

Such cross-section satisfies the conditions of load-bearing capacity and usability, while the same as unprotected has very little fire resistance.

The structural element is made of wood with a moisture content of 18%, the wood with this moisture content will catch fire when the temperature reaches 175°C. Such structural elements at this stage lose 10% of their tensile strength, which in terms of load-bearing capacity should still not jeopardize the load-bearing capacity of the structure given the way of sizing and safety coefficients in sizing. At a temperature of 220 to 350°C, the surface of the observed element is charred, which would have the effect on the presented diagonal as it can be seen in Table 1.

Table 1: Depth of charring by critical cross section

Duration of fire	Depth of charring on the surface at a speed of 0.7mm/min [mm]	Depth of charring by critical cross section [mm]	Weakening of the critical cross section due to charring
5	3.5	7	29%

10	7.0	14	58%
15	10.5	21	88%
17	12.0	24	100%
20	14.0	28	
25	17.5	35	
30	21.0	42	

The tensile stresses on the Zwick/roell Z600 ripper were checked by experimental testing performed on wooden elements of characteristics such as the diagonal elements from the example above at a controlled temperature, and the summarized results presented in Table 2.

Table 2: Tensile stresses at increased temperatures

Description	Sample	Tensile strength N/mm^2	Average tensile strength N/mm^3	Description	Sample	Tensile strength N/mm^2	Average tensile strength N/mm^3
Samples exposed to temperature of 200 ° C for 20 min	A1	12.92	12.92	Samples not exposed to increased temperature dimensions 24/80mm	A6	14.68	14.96
	A2	12.78			A7	15.40	
	A3	12.81			A8	14.89	
	A4	12.95			A9	14.72	
	A5	13.14			A10	15.10	

The table above shows that the tensile strength of the observed wooden element decreased by 14% at a temperature of 200°C to which it was exposed for 30 minutes.

4. CONCLUSION

Structural elements of lattice structures made of wood are often found in areas where fires can easily develop high temperatures. As structural elements made of wood with small cross-sections in such constructions are often used, the risk of charring on the wood surface is very highlighted and the structure loses load-bearing capacity much faster due to this phenomenon than due to weakening of mechanical

properties. It should be noted here that already in the calculation of structural elements it is possible and desirable to very easily and effectively increase the critical cross-sections of elements to a dimension that provides sufficient fire protection of the observed cross-section and if it is much larger than the dimension required to meet load-bearing conditions.

REFERENCES

[1] Milan Gojković: *Drvene konstrukcije*, Naučna knjiga Beograd, Beograd (1983)
[2] Davorin-H. Lončarić: *Tehnologija drveta*, Građevinski fakultet Univerziteta u Sarajevu, Sarajevo (2007)
[3] Davorin-H. Lončarić: *Drvene konstrukcije 1*, Građevinski fakultet Univerziteta u Sarajevu, Sarajevo (2007)

SOCIAL INVESTMENT IN THE FIREFIGHTING PROFESSION

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Abstract

The firefighting profession is a complex organization in the Republic of Croatia consisting of a combination of civil society organizations and organizations of state institutions (voluntary fire brigades and professional fire brigades). Despite the great efforts of firefighting organization leaders, from the local to the national level, there are a large number of dissatisfied and frustrated firefighters who feel that society is not investing enough in the firefighting profession. The firefighting profession is one of the fundamental and important for the safety of citizens, regardless of the level of development and organization, and regardless of geographical or any other affiliation. Given the importance of firefighting in the defense of people and property, it is extremely important that social investment in the profession is timely, modern and organized and targeted. Social investment in the profession is considered to be investment in equipment, education, monitoring of modern technological trends, care for the organization and synchronization of work, firefighters' salaries, salary distribution according to the hierarchical scale of the profession, reward system that valorizes risks and responsibilities. This paper shows the satisfaction of firefighters in the field with social investment in their profession. Are firefighters on the ground in a position financially and psychologically trained to take steps themselves to gain additional qualifications? Does the fire department even care about that? This paper presents the attitude and opinion of firefighters on social investment in their profession. The consequences and outcome of social investment leads to quality and satisfied firefighters who contribute to active engagement in their local community, not only during the fire intervention or to frustrated firefighters who will damage the reputation of the fire organization and perform their task poorly. With their attitude towards the firefighting profession, firefighters create the identity of their organization and thus lead to the social perception of the entire firefighting profession.

Keywords: *Firefighters, Fire Organization, The Identity of the Fire Organization, Social investment*

1. INTRODUCTION

The firefighting profession is one of the most important professions in the implementation of the protection and safety of citizens and their property. The structure of the firefighting profession is very different from the functioning of the military, police profession or emergency medical services, although, in terms of importance, it is equally essential and important. The fire department of the Republic of Croatia consists of members of voluntary and professional fire brigades. According to the latest report of the Hrvatska vatrogasna zajednica (November 2021), the fire system of the Republic of Croatia has: 29,345 operational firefighters who are members of voluntary fire brigades, 3,122 firefighters professionally employed in public fire brigades, 365 firefighters employed in voluntary fire brigades and 92,893 other members of volunteer fire brigades. The aforementioned members are assigned to 1,764 volunteer fire brigades, 76 professional fire brigades, 24 professional fire brigades in the economy and 33 voluntary fire brigades in the economy. All fire brigades in the Republic of Croatia with the basic goal of fire protection, rescue in technical interventions and other disasters take organizational, technical and all other preventive measures to protect citizens and their property. Given that the firefighting system largely functions on voluntary firefighting, which is evident from the statistics, a very important segment is the incentive, voluntary engagement, affinity and interest of people towards this humane, voluntary, but extremely professional and professional occupation. As in any profession, the motivation of people is extremely important in firefighting. The motivation of the members of any organization, including the fire department, affects the productivity of work, the quality and quantity of the work done, dedication and desire for advancement. The organizational identity of the firefighting profession depends on human resources: employees of public units, members of voluntary units and their management. In her book Communication Management, Tafra-Vlahović defined organizational identity as the representation of an organization in society, which consists of members of that organization, managers, formal statements to the media, mission and vision, expressions of the organization (logo, symbols...). Given that human resources are the most important, the question arises whether firefighters in the firefighting system of the Republic of Croatia are satisfied with what local, regional and national politics invest in their system, whether they are aware of their professional education, whether they have an affinity and desire for lifelong education etc. The components that represent the social opinion of any, including the firefighting profession, are: investment in equipment, investment in education and training, monitoring of modern technological trends and their application, salaries of firefighters and the distribution of those salaries according to the hierarchical scale... Do firefighting organizations care about acquiring additional qualifications for their firefighters? All of the above affects the social opinion about the firefighting profession, and it also affects the motivation of firefighters.

2. RESEARCH METHODOLOGY

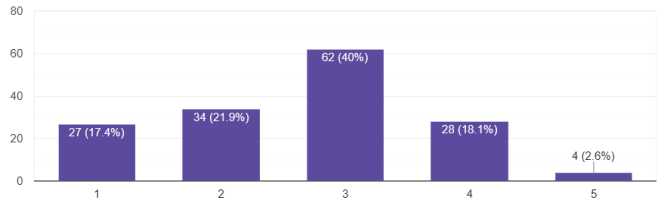
Hypothesis: Social investment in the firefighting profession of the Republic of Croatia is insufficient.

Auxiliary hypothesis: It is necessary to invest in lifelong education of firefighters.

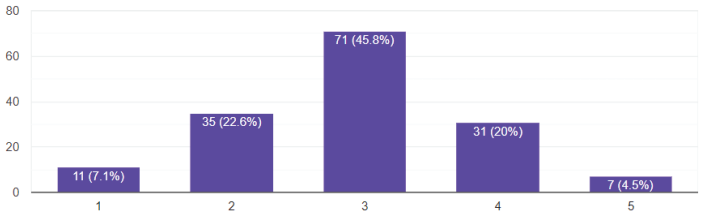
The research was conducted online, and randomly selected members of voluntary and professional fire brigades, from firefighters to fire chiefs. Members of fire brigades from all over the Republic of Croatia participated in the research.

3. RESEARCH RESULTS

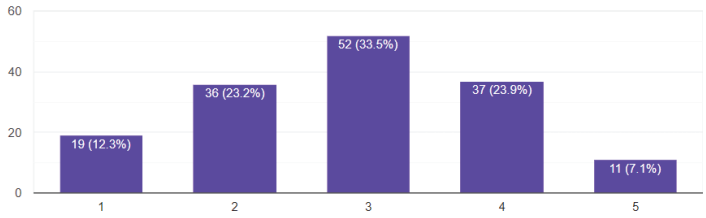
The survey was attended by 74.8% of members of volunteer fire brigades, 11% of professional brigades, and 14.2% of them are members of both. Graphs 1, 2 and 3 show the opinion of firefighters on whether sufficient investment is being made in firefighting equipment at the national, county and local level.



Graph 1: Do you think that enough is invested in firefighting equipment at the state level?

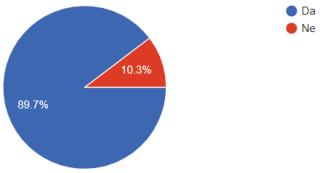


Graph 2: Do you think that enough is invested in firefighting equipment at the county level?

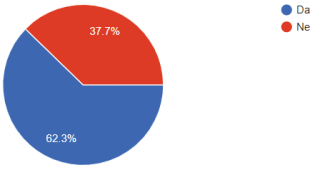


Graph 3: Do you think that enough is invested in firefighting equipment at the local level?

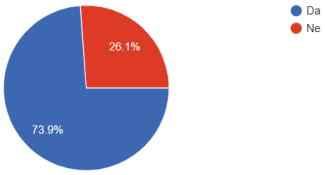
From the above results, it has been proven that firefighters believe that too little is invested in firefighting equipment and vehicles at the national level. At the local level, the results showed that there is a somewhat more positive trend, but it is still a largely poor result of the firefighters' perception of how much the national, regional and local government invests in their firefighting equipment.



Graph 4: Do you want to get additional lifelong education for certain areas in the firefighting profession?

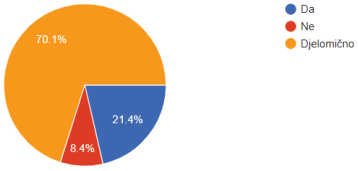


Graph 5: Do you think that the professional firefighting profession invests enough in your education within the fire department?

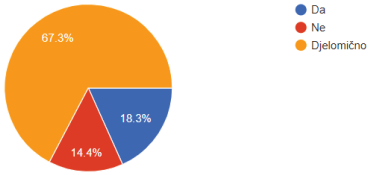


Graph 6: Is your fire department ready to allocate additional financial resources for your professional education?

From graphs number 4, 5 and 6, it can be concluded that there is a large percentage of those firefighters who think that fire departments and their commanders do not invest enough financial and organizational resources in their lifelong education, and a fairly large percentage (10.3%) of firefighters who he has no motivation or desire for lifelong education.

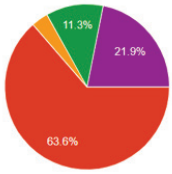


Graph 7: As a firefighter, are you familiar with modern technological trends in the profession?



Graph 8: Are modern technological trends applied in the operational work of your fire department?

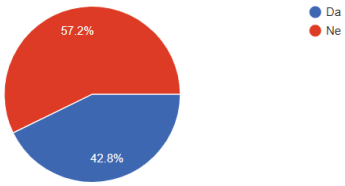
From the data obtained in this part of the research, it has been proven that a large percentage of firefighters are partially or completely unaware of modern global trends and modern methods in firefighting, which is related to the firefighting command staff that should initiate education, training and the introduction of new methods in firefighting operations.



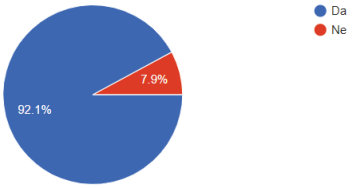
0% =Yes, because I have to; 63,6%= Yes, because I want to; 3,2%= No, because I'm not interested; 11,3%= No, because I don't know who and how to apply; 21,9%= No, because they are not in my unit's area of operation

Graph 9: Do you go to professional seminars and gatherings on the subject of firefighting?

The results of the research showed that more work should be done on the organization of expert meetings and seminars on firefighting topics. Bring them closer to the firefighters and distribute them locally as much as possible, that is, initiate the command staff to organize them.

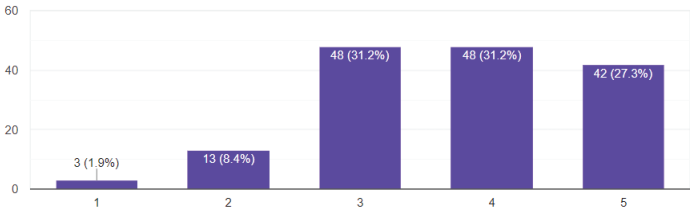


Graph 10: In some situations, do you need advice/a conversation with a communication expert because you don't know how to act or relate in the fire brigade?



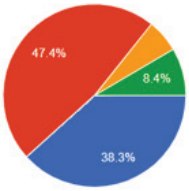
Graph 11: Do you think it is necessary to continuously educate the fire department management about the psychology of interpersonal relations and professional communication?

From the aforementioned research results, it has been proven that firefighters are aware of their needs, as well as the importance of interpersonal relationships in the profession and the influence of these relationships in acting on firefighting interventions. A large percentage of them (42.8%) need an occasional conversation with a communication specialist, and as many as 74.8% of them believe that continuous education of the firefighting command staff on the psychology of interpersonal relations is necessary.



Graph 12: How satisfied are you with the social community's respect for you as a firefighter? (1= I am very dissatisfied, 5= I am very satisfied)

Considering the results of the research, there are more respondents who are more satisfied than dissatisfied with the respect in the local community, which is the result of the large number of members of volunteer fire brigades in the system and good relations with the media, which present the fire department in a positive light.



38,3%= Yes, extremely; 47,4%= Yes, but I could contribute more; 8,4%= No, but I can't anymore because my private obligations don't allow it; 5,9%= No, but I don't want any more because my work is not respected

Graph 13: Are you satisfied with your contribution to the fire department?

Here is a surprisingly high percentage of respondents who answered that they are satisfied with their contribution to the firefighting profession, but could do more. In this area, additional research should be conducted in order to find out what are the barriers that stop them and do not allow them to contribute even more.

In the last part of the research, the respondents were offered the following items: a unique firefighter's uniform, greater education of the commanding staff, relations with the media and the public, equipment and vehicle fleet, and lifelong education. Respondents should, in accordance with their opinion, order in order of importance the items they consider to be the most important and on which additional work should be done in order for the firefighting profession in the Republic of Croatia to be better respected. They singled out the following in order of importance:

1. Equipment; 2. Lifelong education; 3. Unique fireman's uniform; 4. Relations with the media and the public; 5. Greater education of the command

4.CONCLUSION

From the aforementioned research results, the hypothesis was confirmed: social investment in the firefighting profession in the Republic of Croatia is insufficient and, as evidence, it is necessary to invest more in lifelong education. In order for the above to be possible, it is necessary to further educate the commanding staff. On this topic, it is necessary to conduct additional research on the motivation of the command staff, awareness of the political structure, and the perception of the firefighting profession in the social environment of the part of society that is not part of the firefighting system.

5.LITERATURE

1.Aronson, E., Wilson, Thimothy, D., Akert, Robin M.: *Social Psychology*, Fourth Edition. Zagreb School OF Economics and Managment, Zagreb (2005).
2.BMG Reserach, *Public perceptions of fire and rescue services* in England 2019.
3.Law on Fire Service of the Republic of Croatia (NN 125/19)
4.Tafra- Vlahović, M.: *Communication managment. College of business and management* „Baltazar Adam Krčelić“, Zaprešić (2012).

TYPICAL CAUSES AND TRACES OF FIRE OR EXPLOSION OF BATTERIES

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Abstract: *Occasional cases of material damage, and often serious bodily injuries and deaths, caused by overheating and fire or explosion of improperly held, stored or used primary (disposable) or rechargeable (accumulator, secondary) batteries are a cause for concern. Due to the almost complete destruction of movable or immovable property in the fire and the relevant traces in the source of the fire or in the centre of the explosion, for some of these cases the investigation could only assume that, among other things, it is probably a faulty battery. Therefore, their quality and safety of their use is extremely important due to their extremely wide use in many (portable) and fixed devices, appliances, devices and vehicles, from e-cigarettes to all types of electric and classic motor vehicles, vessels and aircraft. The timely notification and rapid extinguishing of a fire that may be caused by the fire or explosion of a faulty battery greatly increases the chances of success of criminal investigation and forensic evidence and the cause of such a nature, and thus the manner of its occurrence. Namely, this can eliminate the suspicion of possible malicious damage or possible arson misuse of the battery. Therefore, this paper seeks to briefly present the typical causes and some circumstantial evidence / possible evidence of malfunction, misuse or possible arson / explosion malicious processing or misuse of batteries. In doing so, a comparative critical analysis of the content of the relevant professional literature sources available to the authors was used, as well as reports / results of several official research and media presentations of such cases.*

Keywords: *primary and rechargeable batteries, fire and explosion hazards, typical fire and explosion causes, typical fire and explosion traces*.

1. INTRODUCTION

It would be difficult to imagine our lives today without the possibility of using various types of electric batteries.[1] It is known that most batteries, both *non-*

[1] **Battery** or **electric battery** (fra. batterie): *In electrical engineering, the connection (usually serial) of two or more direct and identical sources of electricity in which chemical, thermal, solar or nuclear energy is converted into electricity (galvanic and accumulator battery, thermoelectric battery, solar or photoelectric battery, nuclear, atomic or isotopic battery). In ordinary speech, although incorrect, a battery is called only one galvanic cell, even a hand-held electric lamp powered by galvanic cells. In addition, a battery is a connection of number*

rechargeable (primary) and *rechargeable (secondary)*, are chemically unstable products because they constantly undergo relatively slow chemical reactions, with the release of energy, regardless of whether they are powered by a technical means, or not. If for any reason a battery is exposed to conditions that affect the acceleration of these chemical reactions to a specific critical level, then the release of that energy can be so rapid that it can burst, ignite and/or explode. Therefore, they pose a certain risk to their users, the technical means supplied to them and their environment. The level of this risk depends on the types and extent of their potential hazardous effects, which may result from different cases of inappropriate treatment, misuse or abuse. These possible dangerous effects are: *physical* (in a case of initiating fire or explosion of present flammable substances, or spontaneous ignition and/or explosion of the battery); *chemical* (due to toxic and/or corrosive content of chemicals - in case of gradual discharge, especially in case of battery explosion); *damage/destruction of technical means* (pressure, flammable and/or explosive thermal and/or corrosive action) and *harmful impact on the environment* (pollution by toxic and other types of hazardous substances for components of environment and for human health from battery components, mostly from small dimensions from carrying devices, which in the largest quantities usually end up in mixed communal waste) – for more see e.g. [18, pp. 23-38].

An electric battery can cause a fire or explosion by releasing flammable gases from its housing, converting electricity into fire/explosive hazardous thermal ignition energy or into spontaneously overheating, igniting and/or exploding of the released flammable gases from the battery housing or inside an enclosed area of their accumulation.

Thus, for example, lead-acid batteries (Pb-acids), which are mostly commonly used in cars with internal combustion engines, release flammable and explosive gases hydrogen[2] and oxygen when charged with direct current.

Careful expert examination of the narrow location of the centre of the explosion and/or the source of the fire can usually successfully find carbonized debris or heat-damaged remains of batteries (as well as the remains of their possibly pre-fire/pre-explosion used chargers) used in the burned area of a building, as part of a classic motor or electric vehicle, vessels at berth or on a dry dock, electrical device or apparatus. The degree of damage to these remains is usually such that it is not possible to reliably determine whether they were a source of energy to initiate a fire or explosion. Therefore, it is extremely important to forensically reliably determine what

of energy capacitors to compensate for the power factor (capacitor bank). - cit. Battery. Croatian Encyclopedia, online edition. Lexicographic Institute Miroslav Krleža, 2021. *Accessed*: 2022-05-09 http://www.enciklopedija.hr/Natuknica.aspx?ID=6252.

[2] Hydrogen has one of the widest flammability limits (FL) in the mixture with air (FL_{air}: 4-75 vol.%), and especially in the mixture with pure oxygen (FL_{O2}: 4-94 vol.%), one of the highest values of the gas/vapor deflagration index (K_G: 659 bar×m×s^{-1}) and one of the lowest minimum ignition energies (Ei_{min}: 0.018 mJ; and with pure oxygen Ei_{min}: 0.0012 mJ) among all other flammable gases and vapours except acetylene (C_2H_2), so it can be easily ignited by a completely weak/imperceptible spark of static electricity or a mechanical/chemical spark. The chances of it igniting spontaneously on a heated or hot surface are relatively small because its autoignition temperature (T_{ai}) 400 °C [see 19 and NFPA 68].

sort and type of battery it was and, if possible, to identify which manufacturer, and in *what/which*, *how* and in *what place* they were connected as a power source or possibly for attempts to charge with electricity (see [22] for details).

Although such phenomena have not been unknown to the professional public for a long time, the general public is concerned about worrying and preventive useful warnings of occasional media reports on large or regarding the location, facilities or objects and the causes, surprising cases of fires or explosions (as publicly confirmed or presumed in investigation) caused by spontaneous overheating and ignition or battery explosion. For example, in battery factories and warehouses, in a landfill or recycling plant for waste batteries or mixed waste, or batteries within one of the many types of transport, (pre)portable or fixed devices, appliances, devices or (small) means of transport, entertainment or transport (scooters, bicycles, romobils, hoverboards, surfboards, electrically powered wheelchairs), starting with the smallest ones, such as e-cigarettes[3], vape pens and their modifications, children's toys, music cards, (smart or electric) watches, wireless mouses, cordless phones, handheld gaming devices, Bluetooth speakers, wireless headphones, flashlights and GPS devices, to all those structurally complex and most complex types, such as electric, hybrid and classic motor vehicles, (underwater) vessels and aircraft, solar farms and wind farms, data centres and (electrical) energy storage systems (EES or ESS).

In some cases, it was determined that the fire was caused by overheating and ignition of faulty or inadequate chargers of mobile phone batteries or some other, battery-powered portable devices or appliances/tools or electric vehicles, including bicycles, romobils and other sort of small devices intended for sports and personal entertainment.

Thus, many cases have been recorded in the media in the world or in our country, such as, for example:[4]

- huge fire and explosion, investigated as unidentified type and quantity of flammable cargo (suspected to contain Li-ion batteries), fire/explosion hazardous located near the hot engine room of the *Hyundai Fortune* container ship, 2006;
- fire of a Boeing 787 *Dreamliner* aircraft of *Japan Airlines* shortly after the departure of passengers and crew on the runway of Boston's Logan Airport on January 7, 2013, investigation revealed that it was caused by poor Japanese performance of its Li-ion battery system;

[3] Because e-cigarettes are carried in pockets, next to the body, held in the mouth or near the face, the explosion of their (lithium) battery can cause pigmented burns, chemical injuries from alkaline matter (lithium salts), bone fractures, tooth loss, blindness, and sometimes fatal injuries [27, 28 and J.D.: Vape Battery Explosions, *Available from* https://www.vapedanger.com/vaping/battery-explosion/ *Accessed:* 2022-05-11].

[4] An unknown number of incidents with the most fire/explosion-hazardous lithium-ion batteries (LIB) remain unrecorded and officially unreported, and there are no agencies specifically looking for this information. Thanks to U.S. The Fire Administration it is known that the root cause of at least 195 different fire and explosion cases between 2009 and 2017, was that type of battery. The U.S. Federal Aviation Administration also reported several hundreds of cases of incidents of smoke, fire, extreme heating or explosions of lithium-ion or unknown types of batteries among the flight cargo or in the luggage of passengers [30].

- fire in a huge recycling plant in Texas, in December 2016, which lasted for more than 12 hours (believed to be caused by one of the lithium-ion batteries);
- a devastating fire that spread very quickly on September 7, 2018, from the garage of the superyacht *My Kanga*, anchored in the coastal area of Croatia. As the results of investigations published in 2019 showed, it was probably caused by the spontaneous ignition of an electrically powered surfboard with a Li-ion battery;
- fatal powerful explosion and fire for 14 submarines in the compartment of the Li-ion battery system in the bowels of the newest Russian nuclear-powered submarine *Losharik* (type AC-31; Project 10831), in underwater of Barents Sea, July 1, 2019;
- devastating fire of a commercial spearfishing vessel, on September 2, 2019, near Santa Barbara (CA), as an investigation found caused by charging a Li-ion battery, killed 34 of the 39 people on board. The Los Angeles Times called the case "the worst maritime accident in the history of modern California";
- the fire and sinking of the *Felicity Ace* car transport ship on February 16, 2022, with about 4,000 new and expensive cars, including luxury cars such as Porsches, Bentley, Audi and others, in Atlantic Ocean, about 90 nautical miles southwest of the Azores. Electric vehicles, equipped with a Li-ion battery, were part of the load, which created problems for firefighters. As the ship ended up at the bottom of the ocean, it is held that the cause of the fire and the factors that contributed to its spread may never be known. The damage is estimated at over $ 400 million;
- a strong explosion of the batteries of an electric romobil caused severe mechanical damage and a fire in the apartment (fortunately without the presence of the tenant), in Zagreb (Lanište), on April 25, 2022, and
- numerous cases of fires of parked personal vehicles, some of which have not been identified as arson.

2. SOME GENERAL AND SPECIAL CHARACTERISTICS OF BATTERY KINDS, TYPES, STRUCTURES AND PROPERTIES

Batteries are sources of electrical energy in which chemical energy is converted into electrical energy by spontaneous electrochemical reactions. Electricity is stored in batteries, and, if necessary, released quickly enough, with the help of some of the electrochemical reactions suitable for this purpose. These processes occur in each of their electrochemical (galvanic) cells. Reduction and oxidation processes take place in them within two electrode compartments, lined by a solid or liquid electrolyte, and separated by a solid microporous membrane (so-called separator or SEI, i.e., Solid Electrolyte Interface layer), which may be of paper, gel, ceramic/polymer composite or, in the case of lithium-ion cells, most often of a polymer (e.g., polypropylene or polyethylene). Smaller batteries can contain from one to several cells.

Depending on the purpose and needs of users, two types of batteries are produced: ***primary*** (from primary galvanic cells, non-renewable, non-rechargeable) and ***secondary*** (from secondary galvanic cells, rechargeable). Both types can be

completely different in terms of dimensions, shape (round, button-shaped, cylindrical, prismatic, pouch-type[5] or newer proposed flexible type and non-flammable[6]), construction, chemical composition of the material, and thus features of ongoing electrochemical reactions (for more see e.g. [11 and 20, pp. 203-215]). Therefore, each kind has certain advantages and disadvantages (see [2, pp. 44-89]), both in terms of use and in terms of the risk of self-heating and spontaneous ignition or spontaneous explosions.

Battery galvanic cells can be connected in series or in parallel (from ten to a hundred, and in some cases thousands of cells) so that they form larger or smaller battery packs (modules), which can be, also in greater numbers, depending on needs, connected and housed in a suitable housing as a battery system [6, p. 1610].

Depending on the chemical composition, *the **primary*** (non-renewable) battery can be of the type: so-called ordinary [zinc-carbon (ZnC), Leclanché cell], zinc chloride (ZnCl), alkaline manganese (AlMn), zinc-air (ZnAir), mercury (mercury oxide, HgO), silver (silver oxide, AgO), cadmium-mercury oxide (CdHgO), and lithium [lithium metal, lithium-magnesium dioxide ($LiMnO_2$)], Li-iron disulphide ($LiFeS_2$) or lithium alloy.

Thus, for example, lithium primary (i.e. lithium ion non-renewable) batteries are usually made of: anodes (copper and carbon); cathodes (of aluminium and lithium ions); electrolytes [some of the lithium salts: lithium iron phosphate ($LiFePO_4$; LFP), $LiBF_4$ or $LiClO_4$)]; organic solvent [with the addition of methyl ethyl carbonate (EMC), dimethyl carbonate (DMC) or diethyl carbonate (DEC) to improve the properties of the electrolyte solution] and separators in the form of ionic porous polymer membranes (for more details on possible chemical components and their reactions, see e.g. [9, pp. 245-261; 13, pp. 376-377; 20, 26 and16]).

Since they are the cheapest, alkaline batteries are mostly used as disposable (non-renewable) power sources.

Secondary (rechargeable), according to the type of electrolyte system, can be of one of the aqueous types, non-aqueous lithium type or different high temperature types [18, pp. 157-158].

The most widely used secondary (rechargeable) batteries include nickel-cadmium (NiCd), lead-acid (Pb-acid: vented and sealed), sodium-sulphur (NaS), nickel-metal hydride (NiMH), lithium-ion (LIB) and lithium-ion-polymer (Li-Po).[7]

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[5] Lithium-ion-polymer (Li-Po) secondary batteries are sealed in a flexible polymer foil and protected by a thin metal bag. This bag/bag shape allows the production of lighter and thinner articles and their flexible shape, depending on the required capacity and space needs of their installation within different types of vehicles, but create an increased risk of fire due to the possibility of swelling and greater vulnerability in case collision.

[6] See Sharma, S.: Scientists just developed Lithium-ion batteries that can't catch fire, *Available from* https://www.newsbytesapp.com/news/science/lithium-ion-battery-that-won-t-catch-fire/story *Accessed:* 2022-05-11.

[7] Nickel-metal hydride (NiMH) batteries are becoming less common, and it is believed that they will be gradually replaced by lithium-ion battery systems. Due to the high energy density ($mA \times h \times g^{-1}$), the content of flammable substances and the tendency to generate oxygen, lithium-ion and lithium-ion-polymer batteries are particularly prone to spontaneous overheating and ignition, and in certain circumstances to explosion. Numerous cases of withdrawal /

Secondary (rechargeable) lithium (or lithium-ion) batteries consist of: anode (high quality graphite, carbon black or lithium titanate ($Li_4Ti_5O_{12}$; LTO); cathode of lithiated metal oxide [$Li(Ni_xCo_yMn_z)O_2$; NMC], lithium-cobalt oxide ($LiCoO_2$; LCO), lithium-manganese oxide ($LiMn_2O_4$; LMO), lithium-nickel-cobalt-aluminium oxide [$Li(Ni_x,Co_y,Al_z)O_2$; NCA] or lithiated phosphate of a suitable metal, such as lithium-iron phosphate ($LiFePO_4$; LFP)[8] [3, p. 223; 6, p. 1611; 13, pp. 382-383, 394].

They are applied as a coating of a thin copper coating (on the anode) and a thin aluminium coating (on the cathode). These thin coatings are separated by an ion-permeable thin separator (SEI) coating, which prevents direct electrical contact between the anode and cathode. Copper and aluminium foils for collecting current are usually used at the coating sites with a mixture of active cathode and anode materials with a suitable binder, such as polyvinylidene fluoride (PVDF). Ionic conductive electrolytes are organic liquids with lithium fluorine conductive salts, usually lithium hexafluorophosphate ($LiPF_6$) in an organic solvent, located between the anode and cathode (for more details on possible chemical components, see e.g., in [20, 26]).

Another important difference between batteries is their electrolyte status. Namely, in many smaller cells and sealed cells the electrolyte is immobilized by gelling, or its volume is reduced to the extent that it is completely absorbed by the separator and porous electrodes [18, p. 159].[9]

As secondary (rechargeable) lithium-ion batteries have a relatively high energy density ($mA \times h \times g^{-1}$), low maintenance, low self-discharge tendency, fast charging ability, and are relatively very long-lasting and inexpensive, they are widely used as electric batteries in battery electric (BEV), hybrid (HEV), plug-in hybrid (PHEV)[10], range extended electric vehicles (REEV or PHEV) and in fuel cell electric vehicles (FCEV)[11], in the sectors of smart grids and in many, previously mentioned, types of

replacement of lithium-ion batteries by some world-renowned manufacturers of laptops, mobile phones and electric cars are known.

[8] Since LiFePO4 batteries have a lower energy density than other Li-ion batteries, they show greater stability in terms of possible propensity for spontaneous overheating and ignition (see second paragraph of footnote 19).

[9] Primary (nonrechargeable) dry cell batteries (for example, AA, AAA, C, D, lantern and miniature watch sizes) are ZnC (commonly used in torches, clocks, shavers, radios, toys, smoke alarms), ZnCl (commonly used in torches, clocks, shavers, radios, toys, smoke alarms), AlMn (commonly used in personal stereos and radio/CD players), and primary button dry cells (for small electronic devices) are HgO (commonly used in hearing aids, pacemakers, and cameras), ZnAir (commonly used in hearing aids, pagers, cameras), AgO (commonly used in calculators, watches, cameras), and lithium (commonly used in computers, watches, cameras).
Secondary (rechargeable) dry cell batteries, commonly used in mobile phones, cordless power tools, laptop computers, shavers, motorized toys, personal stereos, are NiCd, NiMH, and Li-ion [2, p. 87: Table 6.2].

[10] *Plug-in* hybrid vehicles (PHEVs) work on a similar principle as hybrid vehicles (HEVs), except that they have larger batteries, and hence higher electric driving ranges [4, p. 13].

[11] They are defined as devices that produce energy by the direct conversion of chemical energy (from fuel and oxidizing substances) into electrical and thermal via an electrode-electrolyte system. Unlike batteries (closed systems that chemically store electricity), fuel cells are a kind of open systems that work on the principle of continuous maintenance of the appropriate flow of reactants. Fuel cells can be combined with a Li-ion battery or with a supercapacitor.

(pre)portable battery - powered electronic devices and devices [4, pp. 10-13; 6, pp. 1607].[12]

On each battery cell, depending on the type and design purpose of each of the manufacturers, a relief valve of a certain type (depending on the type of battery) or a rupture disc (safety membrane) can be installed, which enables controlled and directed discharge within the cell of accumulated hot flammable and toxic gases in case of thermal decomposition of electrolytes, to avoid explosive bursting of the cell with scattering of glowing pieces and particles in the environment. The installation of a safety vent solution can reduce the impact of overpressure on the battery separator (SEI) and thus reduce the risk of explosion and fire hazard internal short circuit. When, due to malfunction, an accidentally unacceptable sudden increase in pressure occurs in one of the battery cells with a built-in safety membrane, it will open irreversibly to prevent bursting of such a battery or at least mitigate the scale of this dangerous phenomenon. Thus, it completely falls out of function, but at the same time the fire and/or explosion danger from it does not disappear.

Since small lithium-ion cells are much less dangerous than large lithium cells, until recently they did not include any special solutions for venting overpressure, but are currently required for the production of small and wearable devices or devices such as e-cigarettes, mobile phones, tablet, camera on work clothes, etc.

In the case of sealed batteries, the problem of gas overpressure can be eliminated by recombining the developing gas within its cells [6, p. 1611; 12, pp. 6; 18, pp. 95-96].

Namely, unfortunately, only a couple of types of batteries do not show an explosive tendency to develop gas within their cells, so there is no need for such a technical addition.

For the needs of motor vehicles with internal combustion engines, two types of rechargeable lead-acid batteries are the most widely used as direct current electrical batteries (usually 12-volt or 24-volt, with negative pole grounding).[13] These are traditional Pb-acids, i.e. the so-called wet or flooded liquid electrolyte batteries, in which the lead plates are completely immersed in the electrolyte of water-diluted sulfuric acid (H_2SO_4), and more modern, valve-regulated lead acid (VRLA) sealed batteries with immobilized (gel)[14] electrolyte (so-called dry batteries), from which the excessive development of oxygen and hydrogen gases is discharged outwards by means of vents or valve (more detailed see in 25).

Another form of the VRLA battery is AGM (Absorbent Glass Mat) in which the H_2SO_4 is absorbed by a very fine fiber glass mat which has made the battery as spillproof.

[12] It should be noted here that batteries, capacitors and fuel cells differ significantly from each other in their specific energy (energy/mass) and specific power (power/mass). High specific energies (usually between 120 and 200 $W \times h \times kg^{-1}$) can be stored in batteries and fuel cells, with relatively low specific power (between 0.4 and 3 $kW \times kg^{-1}$). Conventional capacitors can store low specific energy (<0.1 $W \times h \times kg^{-1}$), but their specific power can be high (up to 1000 $kW \times kg^{-1}$). Electrochemical capacitors can store low specific energy (between 4 and 8 $W \times h \times kg^{-1}$) with relatively high specific power (between 5 and 55 $kW \times kg^{-1}$) [9, p. 239].

[13] They consist of flat lead dioxide (PbO_2) anode plates and lead (Pb) cathode plates [24, p. 4].

[14] H_2SO_4 is mixed with a silica-gelling agent that converts liquid H_2SO_4 into a semi-stiff paste.

In traditional larger (prismatic) vented Pb-acid batteries, a built-in safety vent allows the release of evolving and potentially hazardous pressure gases. They have removable plugs to replenish distilled water consumed during the charging process and its spontaneous decomposition into hydrogen and oxygen.

Modern sealed Pb-acid batteries, which do not require maintenance of contents because they regenerate lost water by decomposition, safety vent allows permanent safe venting of overpressure (at each occurrence of pressure rise to a level of about 0.1-0.2 bar [6, p. 1485] or over 0.345 bar [26, p. 390], up to normal operating pressure), throughout its lifespan.[15] In addition, these overpressure vents have built-in flame arresters and antiflashback devices, and small cylindrical batteries have only an overpressure vent installed.

Regardless of the kind, dimensions, type and operating voltage of individual cells (Ni-Cd and NiMH: 1.2 V; alkaline and Leclanché: 1.5 V; Pb-acid: 2.1 V; lithium-ion: 3.6 V), and especially with a kind of rechargeable battery assemblies made of serially connected electrolytic capacitors (electricity stored in an electric field), the so-called. supercapacitors, and electrochemical cells (hybrid supercapacitors of operating voltage up to 600 or 800 V [6, p. 1606] or even 1500 V[16]), their capacity - depending on the type and dimensions (from mAh to Ah) and their power (from W to kW) - may be quite sufficient to, under appropriate favourable ignition conditions, easily cause the ignition of certain types of *normally highly flammable*, but also some of *normally non-combustible*[17] materials. Particularly easily and very quickly (instantaneously), by chemical changes of possibly generated very toxic and pyrophoric substances (chemically unstable lithium-based compounds or in contact with it) [18], in the case of the use of lithium batteries. Or that the heat of their own overheating encourages the beginning of the process of self-heating and self-ignition of such a process of normally prone deposits of substances [17], if they happen to be in direct contact, mixed or covered with them. Even though most complex or fire/explosion hazardous electrical systems with battery power supply are designed, constructed and tested (certified) so as to avoid any accumulation of their energy at any point in such a system, in order to avoid local overheating and the possibility of ignition or explosion.

3. POSSIBLE CAUSES AND EFFECTS OF OVERHEATING AND IGNITION OR EXPLOSION OF THE BATTERY

[15] Interestingly, according to some literature on the results of 2018 research (but doubtfully sufficiently discriminatory, i.e., only based on reports of fire cases and some experiments), modern dry (VRLA) batteries have proven to be more prone to fire/explosion dangerous process of spontaneous overheating and the emergence of so-called thermal runaway from those of traditional wet Pb-acids due to the inability to replenish water lost through exposure to high temperatures and/or overcharging [24, pp. 5-14].

[16] See: ABB: Why Battery Energy Storage Is Moving To Higher DC Voltages, *Available from* https://spectrum.ieee.org/its-big-and-longlived-and-it-wont-catch-fire-the-vanadium-redoxflow-battery Accessed: 2022-05-09. Due to the risk of high-voltage electric shock in all cases of such battery systems, it is necessary to be careful before starting a fire/explosion investigation, i.e., it is necessary to disconnect them safely.

[17] See the meaning of the above-mentioned conceptual phrases in the diagram [15, slide 7].

According to a 1997 study by the National Highway Traffic Safety Administration (NHTSA), the most common causes of possible battery explosions in motor vehicles, accompanied by personal injuries, are: battery charging; replacement, securing or fixing cables; attempts jump starting, if the connecting cables in terms of different poles are incorrectly connected from one battery to another, resulting in a short circuit between two batteries; checking the liquid level of the electrolyte in the battery and adding distilled water and some undetermined ones [1, p. 742].

Traditional, vented lead-acid batteries develop very flammable and (in a mixture with oxygen or air) fiercely destructively explosive hydrogen gas (H_2; see footnote 2) when charged with electricity or engine operation, in addition to oxygen (O_2). Small amounts of H_2 and O_2 also develop inside the housing of sealed lead-acid batteries, which do not need to occasionally add distilled water to the electrolyte. There may be a release and ignition/explosion of H_2 and from such, the so-called, dry, batteries, in case of their damage in a strong collision or impact of the vehicle in solid obstacles.

Except as a result of a vehicle collision, an explosion of a lead-acid battery can be caused by an attempt to charge the battery with dead cells or an attempt to charge a fully discharged battery at excessive speed, due to excessive electrolysis of hydrogen and oxygen in both cases. This can cause the temperature inside the battery case to rise to the point that some of the lead plates bend and come into contact with each other and cause sparks to form between them. Internal sparking can also occur between lead plates if the user allows the electrolyte level to fall below the level of the lower edges of the plates (see possible cause of initiating detonation in footnote 27).

Fire of wooden shelves for storage of batteries of this type can be caused by contamination of wood with battery acid, which can become electrically conductive so that in case of contact with electrodes can initiate the ignition of such wood (for several interesting and instructive cases see e.g. [1]).

Fire and explosion hazards from primary (non-rechargeable) batteries generally arise from the possibility of a short circuit caused outside or inside the battery, from high or low temperatures, and from their overcharging or sudden discharge. These mechanisms can cause the development of exothermic reactions within the battery. When their temperature rises enough, or if a source of ignition energy is found near it, ignition of flammable gases released from the battery occurs (such as methane, ethane, ethylene, hydrogen and carbon monoxide in contact with oxygen from the air) [4, p. 32; 12, pp. 2-3].

Regarding the characteristics of fire and explosion hazards of the most used secondary (rechargeable) lithium-ion batteries (LIB), it was found that if the temperature in any of its cells, depending on the technology or method of their use, exceeds the limit temperature (usually around 100 °C)[18] begins an irreversible, self-accelerating (self-catalysing) exothermic process of chain chemical reactions in the

[18] If Li-ion batteries are charged or discharged too quickly, they can heat up to 30 ºC and if they are also exposed to the sun or the hot atmosphere of its environment, the risk of their spontaneous ignition or explosion increases greatly.

cell, the so-called thermal runaway - a phenomenon of self-heating of the cell,[19] which can no longer be stopped by any external influence.

This will result in the ignition of its highly flammable electrolyte[20] or the explosion of that cell, accompanied by the release of smoke (particles of soot and nickel, aluminium, lithium, copper and cobalt oxides), hot (T_g> 600 ºC) CO_2 and a group of highly toxic gases [such as hydrogen fluoride (HF): 20–200 mg×$(Wh)^{-1}$, phosphoryl fluoride (POF_3): 15–22 mg×$(Wh)^{-1}$, phosphorus pentafluoride (PF_5) and carbon monoxide (CO)], by ejecting and instantaneously igniting the electrolyte and spreading the ignition/explosion to the remaining cells of the battery system assembly [5, pp. 10-11].[21]

It should be noted here that the process of thermal runaway of chemical reactions in the battery cell can occur, not only within lithium but also within all other kinds and types of batteries, which can be caused by many different factors.

Some common causes of initiating the occurrence of such thermal runaway are known. These are: impact, bursting or crushing of the battery body (causes a change in the internal position of the components of the contents of the cell or puncture of the ionic porous membrane of the separator, causing an internal short circuit between the anode and cathode layers); mechanical breakdown of the battery housing (causes breakdown of the ionic porous membrane of the separator, which also causes a short circuit between the electrode layers); occurrence of internal short circuit;[22] externally

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[19] Investigative very indicative may be, possibly, the battery management system (BMS) registered a significant occurrence of a sudden drop in battery voltage 15-40 seconds before the start of the process of thermal runaway due to delamination), i.e., the loss of the stratification property of the battery electrodes, which occurs approximately at the melting temperature of the separator (SEI), indicating a loss of battery integrity and the formation of an internal short circuit. The temperature of thermal runaway depends not only on the battery open circuit voltage (OCV), but also on the type of cathode material.

Although Li-ion batteries come on the market with many different possible chemical compositions, three types dominate: lithium nickel manganese cobalt oxide [($LiNiMnCoO_2$), NMC; $T_{decomp.}$ ~ 210 ºC with $Q_{released}$ ~ 600 J×g^{-1}], lithium nickel cobalt aluminum oxide [($LiNiCoAlO_2$), NCA; $T_{decomp.}$ ~ 150 ºC with $Q_{released}$ ~ 940 J×g^{-1}] and lithium iron phosphate [($LiFePO_4$), LFP; $T_{decomp.}$ ~ 270 ºC with $Q_{released}$ ~ 200 J×g^{-1}]. It is why $LiFePO_4$ batteries are the safest (according to https://www.flashbattery.tech/en/safety-and-risks-of-lithium-battery/; see footnote 8).

[20] The highly flammable organic electrolyte is the least thermally stable compared to all the other components of the cell, which is why it develops flammable gases during the thermal runaway process, while the cathode material generates oxygen.

[21] As soon as the battery case breaks and air penetrates, lithium can ignite even in contact with moisture from the air.

In the case of lithium primary (i.e., lithium ion non-renewable) batteries there is a release of molten, violently burning lithium at temperatures of about 2,000 ºC. For a summary of the process of thermal runaway and the development of ignition in a single Li-ion cell, as well as in a battery with many such cells, see, for example, in [29].

[22] This type of short circuit in lithium-ion batteries (LIB) can be the result of a many possible defects in their production, internal mechanical damage/breakdown of the separator (SEI) due to gradual precipitation and gradual growth of branched solid chains of sharp lithium metal crystals (dendrites) on the anode (due to insufficient negative electrode capacity) in case of battery overcharging or charging at low temperatures (below 0 ºC, because in this case lithium

caused short circuit (contacts with low electrical resistance conductors); overcharging (causes lithium cathode wear, resulting in several exothermic chemical reactions such as electrolyte oxidation and cathode material decomposition) and external battery overheating. Each of these processes initiates mechanisms that result in an increase in the temperature of the battery cell, which can, depending on the type of electrolyte (usually $LiPF_6$), cause the onset of decomposition (70 - 90 °C) and melting of its separator (depending on its type and possible number of layers: 1-3) at temperatures between approximately at least 125 °C and above 155 °C, or 150-160 °C,[23] if no breakthrough has occurred before [3, p. 168; 4, pp. 30-44; 21, pp. 16-17, 47-71]. If a short circuit occurs between the anode and the cathode, this will result in an instantaneous sudden shock discharge of high strength current.[24]

In order to avoid the possible occurrence of initiating such a fire/explosion hazard due to improper use of the battery, it is necessary to take appropriate prevention measures, such as monitoring the voltage and current intensity and ensuring efficient cooling [6, p. 1611].

As practice has shown, if safety solutions have been implemented, such as battery cooling, overpressure vent or safety membrane, developing gas recombination system and separator (depending on the kind, type and location of the battery), but without temperature controller or thermal fuse, without a shutdown separator,[25] without sufficient space between each of the cells of battery pack,[26] with a housing of poorly/limited fire-resistance, or without a technical solution to prevent unlimited charging, in such a case, they become completely ineffective in preventing the occurrence of such a dangerous process. It occurs because the battery overheats so abruptly to a temperature between 100 and 130 °C when it is short-circuited, and when it can instantly ignite or explode. As $Li(Ni_xCo_yMn_z)O_2$ compounds are chemically significantly more reactive and less stable to heat than other chemical compounds

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ions cause accelerated formation of lithium metal and dendritic growth), or due to mechanical battery deformation. There is no danger of the formation of lithium metal and the growth of dendrites within the cells of batteries that have solid electrolytes instead of liquid (about solid electrolytes see [10]).

[23] Ceramic/polymer composite separators have higher melting temperatures, so they are more thermally stable than polymer ones.

[24] See, for example, the flowchart of possible causes of thermal runaway of chemical reactions and a detailed account of the course of this fire/explosion hazardous process in a lithium-ion battery cell in [20, p. 35] and a tabular description of self-heating and decomposition reactions of lithium-ion batteries in [4, pp. 31-32].

It has always been very difficult for us to pinpoint the exact root cause of fires in electric vehicles (vessels, etc.), due to the extremely difficult re-enactment of such a fire under the same conditions. - cit. Kim Pil-soo, Professor of Automotive Engineering at Daelim University (according to: Yang, H.: Explainer: Are lithium-ion batteries in EVs a fire hazard? *Available from* http://irasus.com/top-reasons-why-lithium-ion-batteries-catch-fire/?sort=rating&order=DESC *Accessed:* 2022-05-11).

[25] A type of separator in which its microporous polymer membrane softens at elevated temperatures (usually between 130 and 150 °C) and thus closes its micropores, thus stopping the process of charging or discharging the battery cell to prevent ion transport between anode and cathode.

[26] The electrical connections on the battery assemblies can also act as heat transfer paths.

used in other types of rechargeable batteries, they are significantly more prone to spontaneous ignition (see second paragraph of footnote 19).

Most of the above mechanisms responsible for initiating and spreading the thermal runaway process, as well as their effect, largely depend on the type of battery cell and the size and performance of the battery system [3, p. 172].

Given the enormous extent of their widespread use, some authors hold that the number of reports in the literature on spontaneous ignition of lithium-ion batteries in various electronic devices, such as mobile phones, or in pockets along with keys and coins, that has resulted in the occurrence of severe injuries and deaths, is relatively small [1].

4. SIGNIFICANT TRACES OF BATTERY SPONTANEOUS IGNITION OR EXPLOSION

The initial causes described and the initial effects of sudden overheating of the battery content directly result in several further dangerous effects on the battery housing, and in the conditions of its flammable environment (mostly cellulosic materials), easily, immediately on its immediate and wider environment (see introductory examples of recent cases).

These effects are: sudden increase in pressure and venting of the previously mentioned flammable and some other gases (such as inert CO_2) through the safety vent or the safety membrane of the cell; spillage of formwork debris[27] and smouldering particles of the contents of the cell, which ignite the emitted flammable gases as soon as they come into contact with oxygen from the air; (possibly instrumentally registered) voltage drop of the cell that causes the cessation of functioning of the devices or appliances powered by it (possibly safety or security critical); bursting of electric arcs (plasma temperatures of up to several thousand degrees that melt most battery material) and sparks; the occurrence of ignition of this and the remaining cells of the battery system (due to the complete or partial destruction of electrical insulation components under the influence of the released heat and overpressure of gases); burst of flames that ignite the surrounding (co)combustible substances, or an explosion is possible (if flammable gases accumulate indoors when discharged from the battery housing, mixed into an explosive mixture with sufficient oxygen from the air) [3, pp. 171-172].

Carbonated and melt-damaged remains of the battery[28] and/or its charger can be found at the fire/explosion scene, at the probable or determined source of the fire, or at the determined centre of the explosion. This, of course, primarily depends on the

[27] In a course of a very rare case of a severe detonation of internally generated gases in non-properly maintained traditional wet type Pb-acid battery, vent caps, electrolyte, and fragments of the battery case and cover may be thrown in generally upward and outward trajectories. Initial velocities of such debris have been measured at 24-30 $m \times s^{-1}$ [7, p. 43].

[28] For more detailed descriptions of the possible causes of failures of Li-ion batteries, the resulting traces of energy and non-energy effects, and examples of the possible appearance of some of these residues, see for example in papers [8, pp. 223, 367-369, 427, 449; 21, pp. 46-55; 22, pp. 107, 262, 273, 276-277, 288, 297-298, 319, 323, 325, 329].

type, location, extent and degree of damage / destruction of the burned or explosively damaged object or building,[29] the severity and duration of the fire, or the type and intensity of the explosion, but also on the characteristics of the place/all places of their possible location and on the characteristics of possible extent of fire/explosive damaging effects, and on the electrochemical functioning and materials of the battery. The degree of their damage / destruction may be so great that it will not be possible (immediately) forensically to determine whether they were damaged/destroyed by a previous fire or explosion of another cause or were a key energy component (i.e., electrical ignition source) of the cause of fire or explosion, or only their spontaneous heating and ignition or possible explosion caused possible subsequent fire.

In this case, only the state (degree of damage or destruction) of the structure of the found remains of (non)electrical components of the (non)technical system with which the forensically potentially disputable (group) battery was surely or very likely connected, or in fire/explosive potentially hazardous contact (e.g. in a landfill for used batteries, e-waste or unsorted municipal waste; in a landfill or recycling facility for used batteries; in a poorly managed and maintained commercial or home warehouse; as part of some kind of arson or explosive device, etc.), can be of importance in forensic or criminal terms.

For the needs of forensic laboratory examination by professionally relevant and experienced forensic scientists,[30] it is especially important to properly (in accordance with the rules of forensic profession) find, recognize, document, carefully take out, pack, mark and deliver, preferably all, at the crime scene found and identified possible remnants of the battery and that (part) of the electrical system which may have been directly supplied or charged with electricity, before the outbreak of fire or explosion (see footnotes 27 and 28, and [22, pp. 107, 262, 273, 276-277, 288, 297-298, 319, 323, 325, 329]). Pay particular attention to the kind and manner of safety packaging, securing and labelling of corrosive battery residues.

5. SOME EVIDENCE AND CIRCUMSTANTIAL EVIDENCE THAT MAY INDICATE THE POSSIBLE MANNER, CAUSE, CONDITIONS AND CIRCUMSTANCES OF BATTERY IGNITION OR EXPLOSION OCCURRENCE

[29] A particularly complex case for investigators, or an almost impossible or extremely expensive mission (sometimes at the expense of the insurer, in case of suspicion of sabotage by the insured due to fraud of the insurer [14; 15 slide 30-33; 16] or suspicion of a terrorist act), may be the crash site of a transport or passenger aircraft) or fire of a transport ship with many new and/or used electric, hybrid and ordinary motor and/or other small electric vehicles, or packaging of new batteries, or delivery of used batteries for recycling, especially in case of unsuccessful extinguishing of fire and sinking of the ship; storage facilities for waste batteries (or plants) for recycling, etc. (see some notable examples from the introductory part of the text).

[30] Electrical (technical) and chemical professions, well acquainted with possible components of forensically potentially controversial battery-powered electrical (technical) system, its (electro)technical characteristics, functional characteristics and possible types/causes of their failures, as well as construction, materials and characteristics electrochemical reactions within a multitude of diverse kinds and types of battery cells, in current use/on the market.

Patient, attentive and professional team research work can reveal many investigative and forensic available *evidence*, as well as much possible *circumstantial evidence*, which may indicate a possible cause, conditions and circumstances, and hence, finally, the only probable possible manner (see [15, slide 20]) of the occurrence of any case of fire and/or explosion. Thus, also the one that may be caused by a gradual, rapid or instantaneous process of spontaneous or externally initiated overheating, ignition or explosion (both small and large types) of primary or secondary batteries.

Sometimes such cases may be with such dangerous effects, horrible/severe and/or tragic consequences with very disturbing public features, that a crime scene investigation (CSI) and the corresponding necessary (extensive) reconnaissance and other evidentiary actions[31] will have to be urgent, taken *ex officio* to detect and locate the potentially responsible person(s) or perpetrator of a possible act of arson or intentionally caused an explosion by possible misuse or sabotage of the battery.

These evidence or circumstantial evidence may be:[32]

- traces of carbonized remains of the battery at the source of the fire or its fragments scattered around the centre of the explosion;
- a battery or battery charger of unregistered or suspicious origin/manufacturer, or a cheap counterfeit brand of a reputable manufacturer (excluding all prescribed or possibly counterfeit contents of the product label and quality certificate);
- product with (already noticed frequent) factory defect or poor quality of production design;
- use of mechanically, chemically or thermally damaged batteries;
- *dead* battery indicates the cause of the fire of an electrical nature, and leaked to a short circuit;
- the consequence of a strong collision or impact of the vehicle into solid obstacles (especially easily possible in the case of electric and hybrid vehicles);
- poorly analysed, judged, selected and/or implemented technical and other conditions and circumstances of the intended operational use of the battery;
- sufficient long-term exposure to: summer sun in an uncooled (unventilated) enclosed space; surfaces of sufficiently high temperature; overheated atmosphere of (semi) enclosed space; flame, hot gases or thermal EMF of a combustion process (direct or indirect) or very low temperatures;
- traces of short circuit due to contact of the battery cable with the hot metal branch of the exhaust gases at the outlet of the engine block (due to melting of its electrical protective insulation and contact of the conductor with that pipe);
- missing, broken, unsuitable types or inefficient cooling system(s) of batteries during their use (by natural or forced cooling by means of a fan, radiator or hoses);

[31] In accordance with the Criminal Procedure Act, the Law on Police Affairs and Powers and the Ordinance on the Manner of Conduct of Police Officers.

[32] Without prejudice to possible investigative importance and possible probabilities of any of the following possible evidence or circumstantial evidence as to the possible cause, condition, circumstance or manner of occurrence in any case of a battery fire or explosion.

- model of the battery, i.e. the battery power/charging system, without (or with a malfunction) of: a BMS system of monitoring and control of battery voltage, current and temperature; technical solution to prevent the possibility of unlimited charging; built-in temperature regulator, i.e. without thermal fuse; built-in safety vent or safety membrane; built-in spontaneously closing separator in the structure of the cell; the content of fire retardant in the composition of the electrolyte of the cell (see [12, pp. 4-5]); protective dividers between battery system members/modules; and/or sufficient fire resistance of the battery housing (module);
- keeping batteries in metal boxes (instead of non-conductive packaging/boxes);
- container or other method of transport of improperly packaged used and damaged batteries in the warehouses of the company's plants for their recycling;
- inadequate arrangement/disorderly mixing of groups or piles of small batteries or those of smaller dimensions of any kind, or inadequate fastening in the socket of each of the larger specimens of accumulator batteries in the battery storage;
- excessive voltage and excessive current of the secondary battery (use of ultra-fast,[33] inappropriate/uncertified or technically modified charger);
- neglected, possibly observed or instrumentally recorded, strong heating of the rechargeable battery (and/or its charger) during charging or use;
- possibly personally observed or instrumentally recorded significant occurrence of a sudden drop in battery voltage 15-40 seconds before the start of the process of its thermal runaway;
- possibly personally noticed or recorded by audio-video surveillance hissing, leakage and smoking (cell) of the battery;
- charging car batteries in small unventilated (closed) spaces and/or in the presence and continuous operation or occasional activations of one of the possible sources of ignition energy;
- traces (attempts) of use, according to the technical specifications, the inappropriate battery assembly for powering the battery-powered tool;
- charging the battery for longer than the charging time limited by the manufacturer's instructions (for those kinds or types of batteries where it is necessary to interrupt the charging process when they are fully charged);
- traces of covering the charger (and portable device)[34] with clothing or other thermal insulating material, or clogging the ventilation openings of the charger with impurities or with other clogging substances during charging process;
- charging the battery at ambient temperatures outside the temperature range allowed for this type of battery;
- failure to disconnect the battery charger from the power supply when not in use;
- failure to allow the charger to cool sufficiently between battery charging cycles;
- wrong connection of cables of different poles of discharged car battery when trying to charge from another car battery (or accidental contact of clamps or part of uninsulated cable, or cable of thermally damaged electrical insulation, under

[33] Only nickel-cadmium rechargeable batteries can withstand ultra-fast charging with minimal heating effect.
[34] Even the lack of removal of plastic protective foils from the screens of new mobile phones and tablets makes it difficult to cool them properly.

voltage of positive battery pole with metal chassis part, or less possible hazardous wrong sequence of connecting and disconnecting the same poles from both batteries);
- attempt to charge a lead-acid battery with dead cells or a completely discharged battery at too high speed (causes the sudden development of an explosive mixture of H_2 and O_2);
- possible long-term absence of battery use (according to some opinions, when the vehicle has not been in use for a longer time) [1, p. 742];[35]
- attempt to charge the primary (non-renewable) battery (usually resulting in its explosion, and sometimes the appearance of inflating the volume of the battery and releasing it on the skin and on metals corrosive electrolyte);
- humidity or exposure of the battery to water, especially salty (electrically conductive sea salt or road salt);
- traces of holding/carrying batteries mixed with other batteries and/or among metal objects,[36] such as keys, coins, staples, metal jewellery, nails, screws, nuts, hand tools, bare electrical conductor waste, or waste when processing metals (dust and sawdust of metals);
- traces of mechanical penetration into the battery or opening of the battery body and skilful mechanical or chemical sabotage of the internal structure of the battery contents [can be found only in those batteries that accidentally did not initiate fire/explosion (to the end) according to saboteur expectations];
- traces of explosive (mechanical) injuries by the shock wave of hot gases and debris, pigmented heat burns (with imprint of the pattern and colour of clothing) and chemical burns on the victim's skin in the area around the clothing pocket (see e.g., images presented in [28]);
- traces of wire or other metal melting in accidental or (un)intentional (?) case caused by short circuit of positive and negative pole of battery or battery system terminal (i.e., external short circuit) - due to negligence, ignorance, children's curiosity/play or in attempt to ignite a flammable material in contact [23], or in an attempt to commit arson [31];
- traces of arson or explosion experiments with batteries in the home or workshop, or at tools, clothing, footwear, and skin (usually on hands and face) of a presumptive suspect for causing a suspected case of fire or explosion;
- other possible, forensically relevant, traces of battery misuse in the possible staging of an "accidental" fire of a vehicle, vessel, building or machine with the help of a battery-powered engine, device or apparatus inside their usual construction or in (subsequently?) added some technical appliance or device to conceal the act of arson or criminal intent to cause an explosion for any reason) and
- other possible investigative important facts or indications.[37]

[35] In the case of fires in the Li-ion battery pack of e-bikes, it was observed that a very large number of such cases occurred even when they were not connected to the charger, or in use, but during the period of their dormancy.
[36] Especially if both poles are located on the same side of the battery, such as 9 V batteries.
[37] They can be found by studying the latest regulations / technical instructions prescribing rules for their safe performance and use or transport, published by the competent UN, EU, NFPA

6. CONCLUSION

Despite the fact that there is currently a lack of reliable globally unifying statistics (see footnote 4), and taking into account the immeasurable extent of daily use of many different kinds, types, sizes and brands of electric batteries, in a variety of devices, vehicles, vessels, machinery, appliances and cordless tools, it could be said that cases of fires and/or explosions caused by improper use or malfunction of their operation are nevertheless extremely rare or even extremely rare.[38] However, when they do occur, as many examples around the world and in our country (such as the ones mentioned above) show, they can have dire or very severe consequences for the lives, health, property and environment of such events. All this, mostly due to neglect of manufacturer's instructions and occasional public warnings (usually only after such events) about the necessary measures for their safe use.

The paper presents possible kinds and types of batteries and briefly describes their usual structure and their specific, more or less dangerous properties of the ability of possible fire and/or explosion hazard response. The main possible causes,

(e.g. NFPA 1, 70, 75, 76, 111, 855), IEC and other international and national organizations, or under international agreements on road (ADR), rail (RID), maritime (IMDG), inland waterway (ADN) and air (TI) transport of dangerous goods and goods, and a detailed comparison with the investigation established facts and indications in a particular case.

Among the investigative and evidentiary possible important facts or indications are all those commonly investigated in the event of any type of harmful event (i.e., criminal offense) described by the Criminal Code. These are, for example, those according to: the time of occurrence of the adverse event (before, during and after it); links or similarities with previous similar types of such adverse events; the circumstances of the harmful event (according to each of the 9 common "golden" questions of any criminal investigation); coverage (i.e. regarding the subjective and objective side of such a harmful event); influence the possible versions of the cause and manner of occurrence of the investigated adverse event (which may be confirmatory or rebuttable) and the strong or weak degree of support for the conclusion of the investigator/forensic scientist.

In the event of *grounds* or *reasonable suspicion* of battery misuse in the act of arson or causing an explosion, among other investigative and evidentiary evidence may be indications or facts regarding: attempts to conceal the actual cause of the fire and/or explosion; the disproportion of the property of the possible perpetrator; characteristic, in previous investigations, possibly already seen MO (modus operandi) committing arson or causing an explosion; training/experiments performed to carry out such attacks; knowledge of the arrangements for carrying out the attack or the threats made to the victim; a flawed or false alibi; inquiries about the most suitable MO for performance; motives/benefits from committing such a crime, etc.

[38] According to the US National Oceanic and Atmospheric Administration (OAA), the odds (chance) of being struck by lightning in a lifetime are about 1:13,000, while the chances of lithium-ion batteries reacting to fire/explosion hazards are less than 1:1 million. The probability of failure in quality Li-ion cells is less than 1:10 million (according to: Mountaineer Insurance Services: Lithium Battery Explosions – facts you need to know! *Available from* https://mountaineerins.com/2019/12/01/lithium-battery-explosions-facts-you-need-to-know/ *Accessed:* 2022-05-11.

mechanisms and effects of their spontaneous ignition or explosion of special interest for prevention are pointed out, as well as the possible significant traces of the occurrence and action of spontaneous or externally initiated ignition or explosion of the battery. Finally, an overview of some possible evidence and circumstantial evidence that may indicate the possible cause, conditions and circumstances of ignition or explosion of the battery is presented. They can be crucial for reliable forensic and criminal identification and proving the manner of occurrence of a fire or explosion possibly caused by some kind and type of battery, especially in the case of certain *grounds* or *reasonable suspicion* of malicious intent.

As the use of rechargeable Li-ion batteries has already become dominant in various types of carrying and portable devices, devices and cordless tools, as well as in use for various needs in industry, transport and energy storage, with still quite widely used Pb-acid batteries, the greatest attention is paid to the main and contributing factors and investigative and evidence-based traces and indications of possible causes and mechanisms of the development and occurrence of dangerous spontaneous overheating and possible ignition or explosion in these two, most prone to battery type.

REFERENCES

[1] Babrauskas V.: *Ignition Handbook: Principles and Applications to Fire Safety Engineering, Fire Investigation, Risk Management and Forensic Science*, Fire Science Publishers, ISBN 0-9728111-3-3, Issaquah (WA), (2003, 2014), pp. 742-743, 804.

[2] Bird, J.: Batteries and alternative sources of energy, Sec. 2, Ch. 6, In *Bird's Electrical Circuit Theory and Technology*, 7th Ed., Routledge, ISBN: 978-0-367-67222-5, New York (NY), (2022), pp. 44-89.

[3] Birke, K.P. (ed.): *Modern Battery Engineering: A Comprehensive Introduction*, World Scientific Publishing, ISBN 9789813272156, Hackensack (NJ), (2019), p. 167-172, 223-224.

[4] Bisschop, R., Willstrand, O., Amon, F., Rosengren, M.: Fire Safety of Lithium-Ion Batteries in Road Vehicles (RISE Report 2019:50), RISE Research Institutes of Sweden AB, ISBN: 978-91-88907-78-3, Borås, (2019), pp. 10-13, 30-44.

[5] Blum, A., Long, Jr. R.T.: *Fire Hazard Assessment of Lithium Ion Battery Energy Storage Systems (Final Report)*, Fire Protection Research Foundation, Quincy (MA), (February 2016).

[6] Bosch GmbH: *Automotive Handbook*, 11th Ed., Robert Bosch GmbH, ISBN 978-1-119-91190-6, Karlsruhe, (2022), pp. 1483-1486, 1488, 1607, 1610-1611.

[7] Cole, L.S.: *Investigation of Motor Vehicle Fires*, 4th Ed., Lee Books, ISBN 0-939818-29-9, San Anselmo (CA), (2001), p. 40-45.

[8] DeHaan, J.D., Icove, D.J.: *Kirk's fire investigation*, 7th Ed., Pearson, ISBN-10: 0-13-508263-3, Upper Saddle River (NJ), (2012), pp. 223, 367-369, 427, 449.

[9] Doménech-Carbó, A.: Supercapacitors, Batteries, Fuel Cells, and Related Applications, Ch. 14, In *Electrochemistry of Porous Materials*, 2nd Ed., CRC Press, ISBN: 978-0-367-75253-8, Boca Raton (FL), (2021), pp. 239, 245-261.

[10]Dudney, N.J., West, W.C., Nanda, J.: *Handbook of Solid State Batteries, 2nd Ed. (World Scientific Series in Materials and Energy - Vol. 6)*, World Scientific, ISBN 978-981-4651-89-9, London, (2016).
[11]Gonçalves, R., Tozzi, K.A., Pereira, E.C.: Electroactive Polymers for Batteries, In *Electroactive Polymeric Materials*, CRC Press, ISBN 9781032002842, Boca Raton (FL), (2022), pp. 203-215.
[12]Kong, L. et al. (2018): Li-Ion Battery Fire Hazards and Safety Strategies, *Available from* https://mdpi-res.com/d_attachment/applsci/applsci-07-01314/article_deploy/applsci-07-01314.pdf?version=1513607220 *Accessed:* 2022-05-11.
[13]Koti Reddy, B.: Storage Batteries, Ch. 12, *In Electrical Equipment: A Field Guide*, Scrivener Publishing, ISBN 9781119768944, Beverly (MA), (2021), pp. 375-403.
[14]Kulišić, D., Artuković, M.: Tipični scenariji i znakovite indicije paleži osigurane imovine radi prijevare osiguravatelja, *Zbornik radova „7. međunarodnog stručno-znanstvenog skupa Zaštita na radu i zaštita zdravlja*", Kirin, S. (ur.), str. 695-707., Zadar (Borik), 12.-15. rujna 2018., Karlovac: Veleučilište u Karlovcu, ISBN 2623-6435.
[15]Kulišić, D.: Motivi, scenariji, tragovi i dokazivanje akata paleži ili namjerno uzrokovanih eksplozija, *Available from* https://www.researchgate.net/publication/324966360 slide 7, 20, 30-33 *Accessed:* 2022-05-11.
[16]Kulišić, D.: Motivi paleži, *Zbornik radova „5. međunarodnog stručno-znanstvenog skupa Zaštita na radu i zaštita zdravlja*", Kirin, S. (ed.), str. 660.-669., Zadar (Borik), 17.-20. rujna 2014., Karlovac: Veleučilište u Karlovcu, (2014).
[17]Kulišić, D.: Opće značajke pojava samozagrijavanja i samozapaljenja tvari (III. dio), *Sigurnost*, **48** (2006) 4, pp. 360-371.
[18]Levy, S.C., Per Bro: *Battery Hazards and Accident Prevention*, Springer Science+Business Media, ISBN 978-1-4899-1461-3, New York (NY), (1994), pp. 23-38, 43-131, 135-186.
[19]Lewis, R.J.: *Sax's Dangerous Properties of Industrial Materials*, 11th ed., John Wiley & Sons, ISBN 0-471-47662-5, Hoboken (NJ), (2004), pp. 1502, 1985-1986, 2237-2238, 2241-2243.
[20]Ma, J. (ed.): *Battery Technologies: Materials and Components*, WILEY-VCH, ISBN: 978-3-527-34858-9, Weinheim, (2021).
[21]Mikolajczak, C. et al.: *Lithium-Ion Batteries Hazard and Use Assessment (Final Report)*, Fire Protection Research Foundation, Doc. no. 1100034.000 A0F0 0711 CM01, Quincy (MA), (July 2011), pp. 16-17, 47-71.
[22]NFPA 921: *Guide for Fire and Explosion Investigations*, National Fire Protection Association (NFPA), ISBN: 978-1455908509, Quincy (MA), (2014), pp. 107, 262, 273, 276-277, 288, 297-298, 319, 323, 325, 329.
[23]Nyerges, C.: *Guide to Making Fire without Matches: Tips, Tactics, and Techniques for Starting a Fire in Any Situation*, Skyhorse Publishing, ISBN: 978-1-5107-4991-7, New York, (2020), p. 78, 80, 83.

[24]Parker, T. et al.: *Fire Hazard Assessment of Lead-Acid Battery Chemistries (Final Report FPRF-2020-08-REV)*, Fire Protection Research Foundation, Quincy (MA), (June 2020), pp. 4-14.
[25]Pavlov, D.: *Lead-Acid Batteries: Science and Technology - A handbook of Lead-Acid Battery Technology and Its Influence on the Product*, 2nd Ed., Elsevier, ISBN: 978-0-444-59552-2, Amsterdam, (2017).
[26]Reddy, T.B. (ed.): *Linden's Handbook of Batteries*, 4th Ed., McGraw-Hill, ISBN 978-0-07-162421-3, New York (NY), (2011).
[27]Quiroga, L. et al.: E-Cigarette Battery Explosions: Review of the Acute Management of the Burns and the Impact on Our Population, *Available from* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4785490/ *Accessed:* 2022-05-09.
[28]Walsh, K. et al.: Rare case of accidental fire and burns caused by e-cigarette batteries, *Available from* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4785490/ *Accessed:* 2022-05-09.
[29]Wang, Q. et al.: A review of lithium ion battery failure mechanisms and fire prevention strategies, *Progress in Energy and Combustion Science*, **73** (2019) July, pp. 95-131.
[30]Warraich, H., Martin, K.: When Your Amazon Purchase Explodes, *Available from* http://irasus.com/top-reasons-why-lithium-ion-batteries-catch-fire/?sort=rating&order=DESC *Accessed:* 2022-05-09.
[31]Whitney, L.: *Black Book of Arson*, Desert Publications, ISBN 0-87947-183-2, EI Dorado (AR), (1997), pp. 103-107.

CONDUCTION OF NUCLEAR SAFETY CULTURE IN NUCLEAR POWER PLANTS

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***Abstract*:** *Nuclear power plants use fissile materials to produce energy in the form of heat, which is then converted to electricity in turbine generators. Radioactive materials are produced as a by-product of this process. Despite the fact that radioactive material can be beneficially used, such as in cancer therapy, they are generally harmful to health. Use of radioactive materials and control of the processes by which they are produced, must be strictly regulated to ensure nuclear safety. The major aim of nuclear safety culture is the achievement of proper operating conditions, reducing the risks that can lead to accidents and the prevention or mitigation of accident consequences. Combination of these activities should result in protection of workers, the public and the environment from unwanted radiation hazards. The basic scope of nuclear safety culture, including requirements and regulations, will be presented in this article.*

Keywords: *nuclear safety culture, nuclear power plant, radioactive material, safety objectives*.

1. INTRODUCTION

International Atomic Energy Agency (IAEA) defines nuclear safety as combination of all technical provisions and organizational measures relating to the design, construction, operation, shut down and decommissioning of basic nuclear installations and to the transport of radioactive substances, taken with a view to preventing accidents or limiting the effects [1]. Presenting of safety objectives, principles and regulations for nuclear power plants is the main goal of this paper. With the emphasis on safety culture, and its conduction, as one of fundamental safety principle.

2. NUCLEAR SAFETY OBJECTIVES AND PRINCIPLES

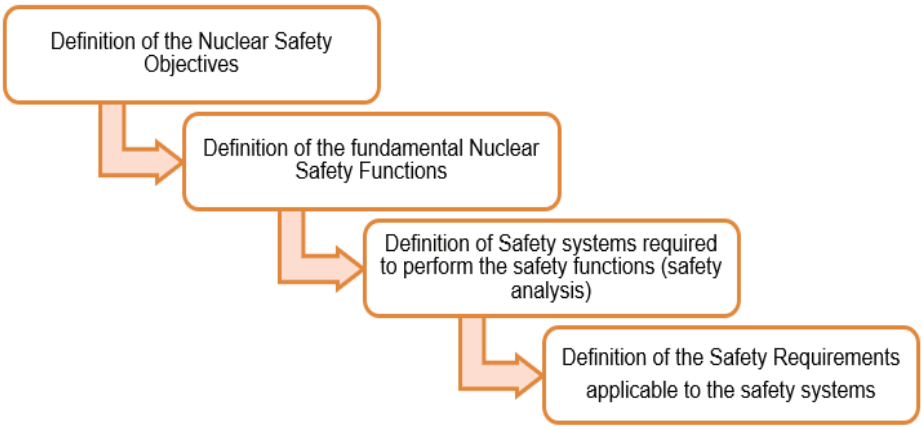
The major safety objectives and principles are presented in Table 1. There are three safety objectives and six fundamental safety principles which are related to safety management and to defense in depth [1, 2].

Table 1: Major safety objectives and principles for nuclear power plants

Objectives	General nuclear safety objective	Radiation protection objective	Technical safety objective
Fundamental safety management principles	Safety culture	Responsibility of operating organization	Regulatory control and verification
Fundamental defence in depth principles	Defence in depth	Accident prevention	Accident mitigation

Safety objectives are set to ensure that all personnel, public and environment are protected against radioactive material releases by establishing and maintaining an effective defense against radiological hazard. As it can be seen on Figure 1, setting up the safety objectives is the first step in procedure of definition of safety requirements and safety functions [3, 4]. Definition of safety requirements and functions include all measures to be taken in facilities in order to ensure the normal course of operations and to avoid accidents and minimize their effects. Measures are applied at all stages of design, construction, operation, dismantling and transportation.

Figure 1: Flow chart indicating process of definition of nuclear safety requirements and safety functions



3. NUCLEAR SAFETY CULTURE

Nuclear safety culture is one of fundamental safety management principles. The term "safety culture" refers to set of characteristics and attitudes in organizations and individuals that ensures that safety issues at all facilities receive the priority attention which they deserve because of their importance [2, 5]. Safety culture appears on collective action and individual action. In other words, it is not only a matter of individual behavior, but also of collective behavior.

Figure 2: The concept of nuclear safety culture based on commitment at three levels [2]

a) Commitment at the level of policy makers

Legislative level is the highest level at which the national standards for nuclear safety culture are set. Each organization, which conducts activities related to nuclear plant safety, provides safety policy statement according to national standards. This statement is provided as a requirement to managers and employees, and to declare the organization's objectives for nuclear plant safety.

b) Management Commitment

Safety standards are only effective if they are properly applied in practice. It is the responsibility of managers to organize application of standards to achieve the commitment of the individuals to the highest possible level of safety and on a continuing basis.

c) Individual Commitment

The safety of a nuclear power plant also depends on the values and safety culture of the individuals in the organization. The desired results are achieved only if the attitudes of individuals at all levels are in accordance with the safety culture framework established by management.

In general, nuclear safety culture is not only a matter of professionalism and rigor. Promoting a strong and effective safety culture is characterized by following actions and interactions at all three levels of commitment [2, 4].

a) Knowledge of the risks, risk identification and assessment
   - It is recommended to ask oneself about potential accidents, actual risks and how to manage those risks.

b) Interrogative attitude
   - Did I properly understand the task to be performed?
   - Am I implementing an unfamiliar procedure?
   - What could be the consequences of a failure or a mistake?
   - What should I do in such a situation?

c) Rigorous and cautious approach
   - Such approach includes professionalism, discipline, conscientiousness, respect for procedures and questioning attitude towards dangers.

d) Communication
   - Any individual should ask for additional information in case of doubt, avoid acting alone depending on the situation and inform those around you.

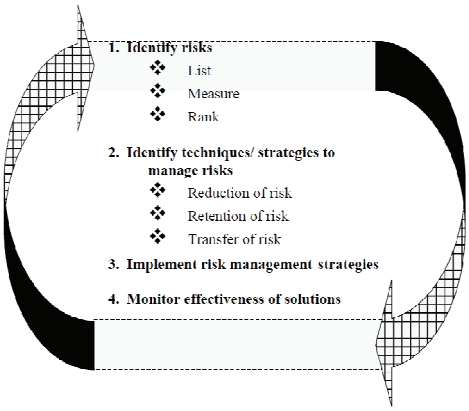
e) Opportunities for improvement
   - Any improvement is allowed only if the safety rules are fulfilled.
   - Derogation from a rule is possible if, and only if, it is authorized by the supervisory staff.

4. SAFETY RISK IDENTIFICATION

Identification and classification of sources of risks in nuclear power plant, determination and implementation of measures for risk prevention and reduction, and continuous controlling and improvement of the processes are fundamental elements of a nuclear safety culture [6, 7].

Figure 3 presents basic steps for the risk identification and management [6]. First step refers to risk identification and determination of potential consequences in case of hazard. Step 2 is to identify the techniques or measures to manage the risk. Step 3 is to implement the selected techniques or measures while step 4 is to provide feedback about risk analysis efficiency.

Figure 3: Basic steps for the risk identification and management



Nuclear power plants are exposed to various sources of risks which might be classified into following categories [7]:

a) Risks of nuclear origin

- Radioactive material spreading
- Internal and external exposition
- Hydrogen emission
- Thermal emission (overheating)

An example of accident caused by risk of nuclear origin happened in Three Mile Island nuclear facility in USA on March 1979. This accident was named as “nuclear meltdown” which is a severe nuclear reactor accident caused by overheating due to failure on cooling system [8].

Figure 4: Three Mile Island nuclear facility

b) Non-nuclear risks of internal origin

- Fire
- Explosion
- Flooding of internal origin
- Failure of pressurized systems

c) Non-nuclear risks of external origin

- Earthquake
- Plane crash
- Fire of external origin
- Flooding of external origin
- Extreme weather or climate conditions

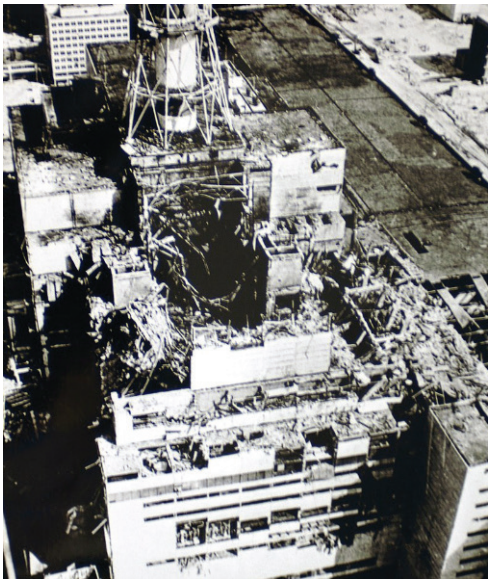
An example of accident caused by non-nuclear risks of internal origin happened in Fukushima Daiichi nuclear power plant in Japan on March 2011. The accident was caused by catastrophic earthquake and tsunami [8].

Figure 5: Fukushima Daiichi Nuclear Power Plant

d) Risks linked to Human and Organizational Factors

Accident in Chernobyl Nuclear Power Plant, Ukraine, in April 1986., was assessed as accident caused by combination in between personnel negligence and incomplete operating instructions [8].

Figure 6: Chernobyl Nuclear Power Plant



5. CONCLUSION

The technology of nuclear power is more complex than other technologies for generating electricity. From that point of view, the safety requirements in nuclear

power plants are significantly different from those in conventional ones. Main difference between industrial safety and nuclear safety requirements is the presence of radioactive material. Radioactive material has many beneficial applications in medicine, industry and agriculture. However, the radiation risks to workers, public and to environment is very significant and have to be foreseen, assessed and controlled. Conduction of nuclear safety culture in nuclear power plants, by applying national safety standards, and fulfilling safety objectives, principles and functions is the major activity for prevention from radiation. As it was presented in this article, contribution to proper and efficient conduction of nuclear safety culture is obligation and responsibility of all participants in the process, from policy makers to management and individuals.

REFERENCES

[1]. International Atomic Energy Agency (IAEA): *Safety of Nuclear Power Plants-Commissioning and Operation* (No.SSR-2/2), Vienna, Austria, (2011.)

[2]. International Nuclear Safety Advisory Group (INSAG): *Basic Safety Principles for Nuclear Power Plants* (75-INSAG-3 Rev. 1), Vienna, Austria, (1999.)

[3]. International Atomic Energy Agency (IAEA): *Safety Classification of Structures, Systems and Components in Nuclear Power Plants*, Specific Safety Guide, (No.SSG-30), Vienna, Austria, (2014.)

[4]. Internationale Länderkommission Kerntechnik(ILK):*Fundamental Safety Requirements for Nuclear Power Plants*, Augsburg, Germany, (2008.)

[5]. International Nuclear Safety Advisory Group (INSAG): *Managing Change in Nuclear Industry - The Effects on Safety* (INSAG-18), Vienna, Austria, (2003.)

[6]. International Atomic Energy Agency (IAEA): *Risk management - A tool for improving nuclear power plant performance* (IAEA-TECDOC-1209, ISSN 1011-4289), Vienna, Austria, (2001.)

[7]. Arup Group Limited (on behalf of EDF Energy): *The safe management of hazards in the nuclear industry - Nuclear Power Plant Hazards Review*, London, UK, (2010.)

[8]. https://en.wikipedia.org/wiki/Nuclear_and_radiation_accidents_and_incidents

Fires of building facades

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Abstract:

The paper describes several real cases of fires that spread through the combustible facades or other combustible elements of the building.

One of the larger fires, which is interesting because it spread over the front of the building, was the fire in the Student Dormitory in Zagreb. In addition to the fire, some other typical examples are described: a vehicle fire in the garage on the ground floor that spread to the front of the building, a fire in the apartment building that spread across the loggia to the upper floors and an auxiliary building fire that was caused by inflammation on the outside.

Some methods of expert work in determining the location and cause of fires are described. Finally, the results of the cause analysis of fire are given and some recommendations for fire protection of building facades.

Keywords: *fires, expertise, cause of fire, building facades, fire protection*

1. INTRODUCTION

Fires in residential buildings are a frequent subject of work of experts for technical expertise of the Forensic Science Centre "Ivan Vučetić", (hereinafter the Centre). Most of them were fires in individual housing, family homes or cottages, but there were also several fires in more residential buildings. One of the larger fires that is interesting because it spread over the front of the building was the fire in the Student dormitory in Zagreb. This fire is interesting for several reasons, according to the place and manner of the fire, and by the speed and magnitude of the spread of the fire on the front of the building.

The methods of expert work in determining the cause of the fire are listed: review of the scene of the fire (inspection), reconstruction and methods of expertise of the excluded material.

Fire protection measures that must be observed when designing new buildings are described, as well as during the energy renovation of the facades of older buildings. Designers must consider that increasing the energy efficiency of buildings by using thicker layers of insulation increases the fire load using combustible materials. In the event of a fire, this increases the risk of transmitting the fire to neighboring areas spaces and higher floors, which can endanger the tenants, and on the other hand the

combustible materials of the facade create large amounts of smoke, which has a very adverse impact on the environment.

The paper gives several real examples of fires in buildings that have spread over the combustible facades of the building or other combustible elements of the building.

Finally, the results of the analysis of the causes of fires and recommendations for fire protection of building facades are given.

2. METHODS OF WORK IN FIRE EXPERTISE

A large part of the fires in Croatia are the subject of the work of inspection teams and fire protection inspectors, who are experts to determine the cause of the fire.

Fire expertise is a combined expertise that is most often conducted by inspecting the scene (inspection) and expertise of the excluded material, which is carried out in the Centre. If it is a technical cause of the fire, expertise is carried out by experts for technical expertise, and if it is a deliberately caused fire (arson) expertise is carried out by fire and explosion experts.

The technical causes of fires are mostly not criminal offenses, so determining the causes of fires is the subject of work court experts to determine liability for damage caused by fire and these are civil proceedings in the courts.

Experts of the Centre also in some cases, as forensic experts from the court file, examine the causes of the fire, and summons to attend court hearings as court experts, where they present their findings orally expertise and give their opinion and answer the questions asked by the judge, lawyer and parties in procedure.

2.1 Overview of the scene of the fire (inspection)

The inspection of the scene of the fire, ie the investigation at the scene of the fire, is performed by the police team for inspection and fire protection inspector in order to determine the place of occurrence of the fire and the cause of the fire and other relevant facts regarding the fire, in order to determine whether it is a criminal offense, and this is mostly the case of arson or other cause [3] and [6]. In larger and more complex cases experts from the Centre, experts in fires and explosions and, if necessary, experts in technical expertise.

2.2 Reconstruction

The method of fire reconstruction in determining the causes of fires in buildings in our practice is not implemented due to lack of resources, time and technical conditions, except for the so-called "thought reconstruction", that is, when the expert witness, based on the information obtained and the traces found at the scene, analyzes established facts seeks to explain to himself and others the origin and course of the fire.

Reconstruction in technical terms in a way to try to reproduce the occurrence of fire is used in the part of the tub it is desired to determine the flammability of a material and thus prove the possibility of fire in a particular case, ie the possibility of fire (ignition) in a certain way.

An expert for technical expertise is present during the expert examination of the fire in the building, when he/she had the court at his disposal file, proposed to the court in the civil case to investigate and reconstruction at the scene of the fire, if the place of the fire (burnt object) has not been completely restored [6].

2.3 Forensic methods in expertise of fire causes

When examining the causes of fires in buildings, it is often the case that due to the high intensity of fires due to high quantities of combustible material, there is an almost complete destruction of the facility and inventory in the facility and thus most useful clues regarding the location and cause of the fire. Then the question arises, and that is the objective circumstance for investigators and experts, how and whether it is possible to determine the exact cause of the fire, and the profession raises the question which methods to use when examining the cause of a fire.

When determining the cause of the fire, experts use various methods of work, from visual inspection of the place events, inspection of electrical installations and electrical devices in the burned building and determination of the type of failur (defects), and inspection and testing of excluded parts of the installation and devices if it is a technical cause fire, whose expertise is carried out in the Centre.

The technical cause of the fire (failure of the electrical installation or device) may be due to a short circuit, overload, high transient resistance and others. Experts use their own to determine faults professional knowledge and extensive experience gained in their work, and when it comes to the technical cause of fires, in some expertises that require specialist knowledge and equipment, it cooperates with experts for individual areas from FER /Faculty of Electrical Engineering/ and other institutions in the form of joint combined expertise by Lawyer's Order or court.

During forensic examinations, fire and explosion experts use various forensic methods to determine types of flammable liquids.

3. REAL EXAMPLES OF FIRE IN BUILDINGS

When transmitting fire across the facade, three typical scenarios are most often mentioned: external fire transmission radiation from the adjacent building to the fuel facade, transmission of external fire to the fuel facade from the fire source located next to the facade itself (for example from burning containers, parked vehicles, etc.), which are consequence of radiation or direct exposure to flame and transmission of

an internal fire that occurs in a space buildings and is transmitted through openings in the facade (windows, doors, balconies, loggias, etc.) to the upper floors [2].

Some real cases of fires in buildings are presented, which were subject of expert work [1], which illustrate the above scenarios.

3.1 Dormitory fire

The student dormitory fire occurred shortly after the dormitory was renovated, which included an energy one renovation of the facade of buildings. The fire broke out in the afternoon, when the home was relatively poorly filled, so fortunately there was no need for a larger evacuation of residents.

By reviewing the scene of the fire, based on the traces found, and based on photographs and videos of fire, it was determined that the fire started from the flat roof of the connecting building (Figures 1 and 2).

Figures 1 and 2: Fire and damage of front in student dormitory

In the next phase, the fire, aided by the wind, spread quickly by burning the material from which the roof was made to the front of the pavilion, the windows of the student rooms and kitchenettes, and to the flat roof of the adjoining pavilion. The facade of the pavilion made of a layer of styrofoam covered with external mesh and protective paint is burned completely to the brick in the floor area next to the roof of the connecting building and on two other upper floors.

3.2 Vehicle fire in the garage of a residential building

A fire that almost completely destroyed the front of the building above the garages where the initial fire occurred caused by the burning of one of the vehicles in an open garage space on the ground floor of the building (Figure 3). Spread fire inside the building was prevented by firefighting.

Figure 3: Damage on the front of the building because of a vehicle fire in the garage

3.3 Fire in an apartment on the fifth floor of a building

The fire in the apartment was caused by a technical malfunction on one electrical device, and destroyed the inventory in several rooms, but there was a transmission of fire over the loggia closed with plastic joinery and combustible material deposited on a loggia on the upper floor and the burning of the apartment above the apartment where the fire occurred (Figures 4 and 5).

Figures 4 and 5: Transmission of fire over the loggia on the upper floor

The fire almost completely destroyed the apartment on the fifth floor of the building, and partially damaged neighboring apartments and the apartment on the sixth floor above the burned apartment.

3.4 Auxiliary building fire

The fire of the auxiliary ground floor building, which burned almost completely together with the roof structure, occurred is after the burning of plastic bins for the disposal of used lanterns in the yard next to the outer wall of the building (Figures 6 and 7).


Figures 6 and 7: Auxiliary building fire and the place of the occurrence of a fire

3.5 Analysis of fire causes of building facades

By analyzing the causes of fires, we came to the conclusion that most often the immediate cause of fires, which according to ours experience may be either intentional or unintentional human action or a technical cause, are not the real cause of the fire, and especially not the cause of the development and spread of fires which consequently led to great material damage, and could lead to the suffering of people because they were residential and public buildings.

The cause of the Student dormitory fire is most likely unintentional human action, but the spread of the fire on the facade of the building came about due to the combustible material (styrofoam), which was used for thermal insulation during the renovation buildings.

Vehicle fires are most often caused by intentional human action, when in addition to great material damage due almost completely destroyed vehicle, there is material damage to other vehicles parked in the immediate vicinity as well damage due to thermal damage to the facade of the building in which or next to which the vehicle was parked, and not to mention the potential danger of human suffering.

In case of fire in the apartments of apartment buildings, regardless of whether the cause of the fire is a technical malfunction or human action, the transfer of fire to neighboring apartments can occur through combustible material that closes loggias, ie combustible furniture and other items that are often found in the loggia space.

The fire of the auxiliary building, caused by the burning of plastic bins in the yard next to the building, shows that it is possible to cause great material damage due to negligence and due to the possible transmission of fire.

4. CONCLUSIONS

Several real cases of fire that were the subject of Centre experts are presented (student dormitory fire, fire vehicles in the garage and the spread of fire over the fuel facade, fire in the apartment and external fire that spread to fuels elements of the auxiliary building) and an analysis of the cause of the fire and its spread over the facades of buildings.

Finally, some recommendations for fire protection of building facades are given with regard to possible causes and ways of spreading fires.

The task of fire protection on the facades of buildings is to prevent the rapid spread of fire over more than two floors above or below the scene of the fire before the intervention of firefighters (on average 15-20 minutes), and prevent falls large parts of the facade.

Requirements for increased energy efficiency of buildings result in a higher risk of fire spread by the front of the buildings, as shown by the analysis of the causes and spread of the real case of the student dormitory fire. When installing combustible thermal insulation materials on the building facades, it is necessary to undertake the fire protection measures that will minimize the risk of fire spreading along the facade [2]. In case of using combustible insulation materials facades, belts must be made of non-combustible materials that prevent the rapid spread of fire on the facade.

Transmission of external fire to the fuel facade or other combustible material of the building from the fire source located next to the building itself (for example from burning plastic containers or bins, parked vehicles, etc.) is possible reduce by changing the culture of behavior and preserving the public good.

The methods of work of the Centre's experts in the expertise of the causes of fires in residential and public facilities areas are described.

LITERATURE

[1] FSC “Ivan Vučetić”: Expert records and photographs from the inspection, 2016. – 2020.

[2] Jelčić Rukavina, M.; Carević, M., Banjad Pečur, I.: “ *Protection of building facades from fire-Manual for design and construction”,* Faculty of civil engineering, University of Zagreb, 2017.

[3] Papić, N.: „*Fires in buildings and plants“,* VII. International professional-scientific conference Occupational safety and health protection, Zadar, 12.-15.-9.2018.

[4] Papić, N.: *“Fires in buildings during constructions”, Safety 2/2018*

[5] Papić, N.: *“Fires in homes for elderly”, Safety 2/2020*

[6] Papić, N.: *„Fire investigation, reconstruction and expertise“, Safety 3/2021*

POTENTIAL HAZARDS IN BREWERY - FROM PRODUCTION LINE TO LABORATORY

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Abstract: *The main aim of the study was to assess the prevalence of occupational health related injuries and use of safety measures among employees and employers in the brewery. Some of the given examples are real-world examples obtained from several Croatian breweries. Safety in the brewing industry is key to reducing accidents and injuries on the job. In this paper, the most significant risks in brewery will be addressed, as well as the steps employers can take to provide a safe workplace.*

Key words*: health, safety, potential injuries and hazards, employees, brewing industry*

1. INTRODUCTION

Beer is the fifth most consumed beverage in the world behind tea, carbonated beverages, milk and coffee, and brewery is a growing industry which plays an important economic role in many countries [1]. Although the quality of the finished product is of exceptional importance, the safety of all employees is a prerequisite for continuous business growth and development regardless it is a craft or a large industrial brewery. Occupational health and safety at work is an important aspect of public health that requires employees and employers to adhere to safety standards and guidelines important in protecting and enhancing safety of the work environment [2]. The risk of injury at a brewery ranges from improper use of personal protective equipment, routine slips and falls, ergonomic hazards to caustic chemicals used in a confined space, as well as risks which are typically attributed to heavy manual lifting and carrying crates of bottles and other raw materials. Besides that, common health and safety hazards also include hazards from faulty equipment and machinery, problems with packaging, unsafe work conditions, hot surfaces, steam and boiling liquids and hazardous or flammable chemicals [2-5]. The one more nuisance impact is related to emission of noise, odour and dust. Along with all the afore mentioned risk, there is also the significant risk of exposure to high concentration of carbon dioxide during the fermentation and maturation process, leading to dizziness, headaches, confusion or even loss of consciousness.[4-6].

2. POTENTIAL HAZARDS IN THE BREWERY

2.1. Beer brewing process

Beer brewing process can be divided into four main parts: production of wort, fermentation and maturation, finishing the beer and filling. Energy production and CO_2 recuperation plants have to be added, although they are not part of the main beer production line. These steps are quite different with each of them having its own specifics and characteristics. Even though the general health and safety rules apply for the whole factory, each individual production step requires specific rules and regulations. In the following text, some of the main health hazards and safety risks will be listed, with the proposed ways on their minimization and/or elimination.

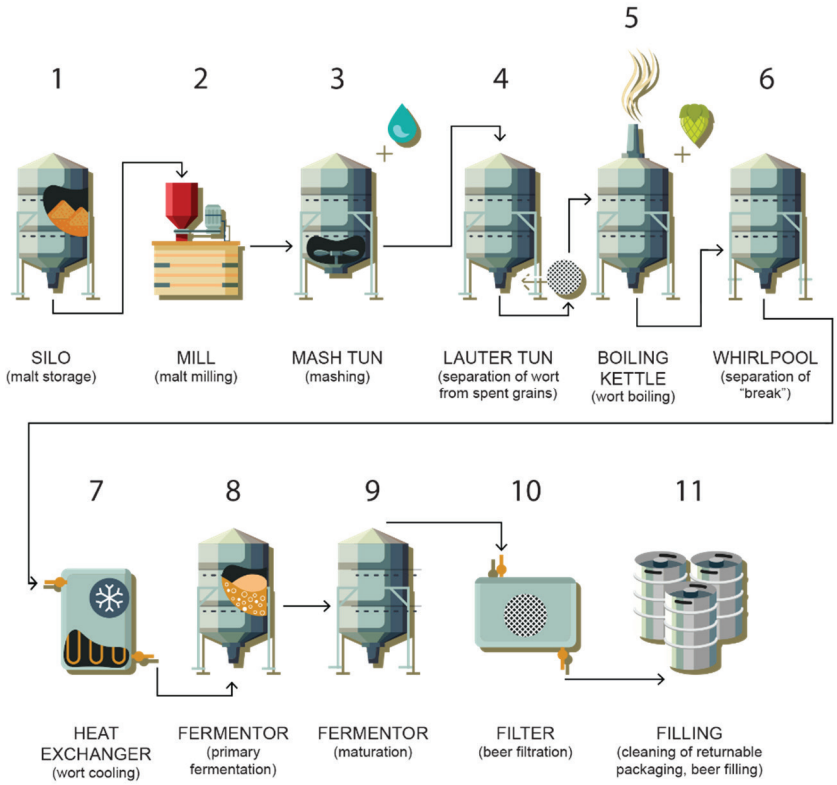

Figure 1. Beer brewing production scheme (Author Goran Šarić)

2.1.1. Brewhouse (production of wort)

During malt transfer to a silo or a malt milling process (steps 1 and 2 in Picture 1) (especially in small breweries which use simple two-roller mills), there is a high probability of dust formation which increases the risk of explosion, but could also cause respiratory problems in workers. Serious injuries can happen if the mill is not operated according to instructions. Due to high noise level during the milling process, hearing loss may occur.

To prevent afore mentioned from happening, following has to be done:

- malt transfer has to be carried out using closed pneumatic systems
- aspirators with dust filters have to be installed
- milling has to be done in a closed mill
- when using small, open two-roller mills, a good practice is to install a screw conveyer which transports milled malt directly to mash tun
- educate workers on how to safely operate the mill
- workers have to wear ear-plugs or some other type of hearing protection aid
- in general, small breweries use malt packed in 25 kg bags so workers have to be instructed on how to lift a load properly

Mashing (steps 3 to 6 in Figure 1) is a process which requires relatively high temperatures (up to 100ºC in boiling kettle (5)) so all the preventing measures have to be implemented (high temperature warning signs, thermal insulation of the pipes). In special situations (etc. during repair of inspection of the tank), to prevent head and eye injuries, workers have to wear helmets and goggles. When opening kettles full of hot liquid, protective gloves must be worn to prevent burns caused by hot steam.

2.1.2. Fermentation and maturation cellar

After the wort is produced, it is cooled down, aerated and the yeast is inoculated during its transfer to fermentation vessels (steps 7 to 9 in Figure 1). During fermentation, carbon dioxide is produced in high amounts as one of the main by-products of the beer brewing process. Even though this gas is not toxic there is a possibility of suffocation if one finds oneself in an CO_2 rich atmosphere. As this gas has no color, odor or taste it is very difficult of even impossible to detect it without a proper equipment. Also, as it is heavier than air, it collets on the ground what increases the chance of an accident. From 1hl of wort (12°Plato), 2,2 - 2,4 kg of CO_2 is formed, what approximately corresponds to the brewery own needs. Many big breweries with CCV tanks have therefore converted to ensure that their own requirements are met by their own CO_2 recovery plant. Smaller breweries don't generally have the necessary equipment for CO_2 recuperation so they need to have adequate ventilation in the fermentation cellar to ensure the proper evacuation of this gas.

2.1.3. Finishing the beer (step 10 in Figure 1)

During this process, beer is being filtered, carbonized and certain additives are added (to adjust the colour, bitterness etc.). As this is completely enclosed system, the potential risks in this department are minimal but nevertheless, certain safety guidelines have to be met - workers have to wear protective equipment, CO_2 detectors have to be installed to send a warning in case of leakage etc.

2.1.4. Filling the beer (step 11 in Figure 1)

Beer is usually filled in glass bottles, aluminium cans, stainless steel kegs or PET bottles. Industrial breweries also use returnable glass bottles which have to be cleaned before reuse for what hot alkaline solutions in combination with other disinfection agents are used. Therefore, special care has to be made when handling these chemicals.

Glass bottles can brake during filling process and can cause injuries why workers are required to wear hand and eye protection. Also, the filling machines are quite loud so hearing protection is necessary during the stay in this department.

2.1.5. CO_2 recuperation and energy production

As before mentioned, carbon dioxide can be potentially dangerous. This is the reason why the recuperation plant has to be equipped with the special sensors which can detect increased levels of this gas. In case of detection, signal light and alarms are turned on at at all plant entrances. As additional safety measure, workers have to wear mobile detectors when entering the plant. All detectors have to be regularly checked to ensure they function properly.

Some of the big, industrial breweries have wastewater treatment plant where biogas is produced, which is subsequently used as a fuel to power boilers. Biogas is a mixture mainly comprised of methane and carbon dioxide which are both dangerous gasses. To ensure safety of the workers, wastewater plants also have to be equipped with gas sensors. Workers also carry mobile gas sensors when working inside the plant.

2.1.6. Laboratory for physicochemical and microbiological analysis

The most important safety concerns in laboratory are potential injuries caused by hazardous chemicals. Therefore, when dealing with toxic volatile chemicals, all the analyses has to be done in digester; when working with corrosive chemicals, protective gloves and goggles have to be worn. At all times, staff working in the laboratory have to wear lab coats, long hair has to be tied back to prevent accidental ignition by the burner.

2.1.7. General requirements

A lot of water is used during production of beer throughout the whole production process, some of it consequently ends up on the floor, which can therefore become slippery. To avoid falls and consequent injuries, it is important to have a non-slip surface on all of the floors inside a brewery.

Strong caustic and acidic substances are used for cleaning and disinfection of the equipment, so special care must be taken when handling these chemicals. Hand (rubber gloves) and eye (protective goggles) protection has to be worn during dispensing, pouring or dosing of the sanitizing chemicals. Also, in some cases respirators have to be worn to protect from harmful vapours.

Except in the brewery's buildings and production lines itself, great importance must be given to safety in the outside spaces between the buildings. Therefore, in big industrial breweries the roads and walkways between the building are clearly marked.

2.2. Background of the common health and safety hazards in brewing industry

Ergonomic hazards: brewery's employees often engage in repetitive motions, lift heavy objects, or stand in awkward poses for extended periods of time, all which can lead to muscle strains and injury. Most of injuries in breweries result from lifting, pushing, pulling or carrying items that are heavy or awkward [4,5].

Unsafe working conditions: Injuries due to slips and falls on wet floors or tripping over items in workers' paths, burns from hot surfaces or steam emitted during the brewing process, and dangers from chemicals are all common causes of injury [4,5].

Hot surfaces, steam and boiling liquids: thermal burns are one of the often injuries in breweries. Workers may touch hot metal surfaces like tanks or steam pipes or suffer a burn through contact with boiling water [4,5].

Hazardous or flammable chemicals and explosion: The cleaning solvents and sanitizing chemicals used in breweries can lead to minor skin irritation to serious injuries. Plus, fire and explosion are also major hazards for breweries. Breweries often have large refrigeration systems, typically using ammonia refrigerant which is toxic and can form explosive mixtures in air [4-6].

Problems with packaging: the bottles the beer is distributed in are often subject to certain issues. Bottles can break when moving through conveyance equipment or when operator manually handle them in a wet environment. Bottles can also burst if filled with too much CO_2 pressure. Broken glass can cause cuts which can be so dangerous and causes serious consequences [4,5,7].

Machinery hazards: serious injuries can occur from contact with the moving parts of machinery like grain hoppers, mills, augers, keg fillers and more. Exposure to equipment's energy source during the cleanup, setup or maintenance work or troubleshooting issues can also lead to an accident. Many breweries also utilize mobile equipment like forklifts, which can tip over, roll forward or collide with items or even

workers. Additionally, breweries use compressed gas cylinders, which can explode if not handled properly [4,5,7].

2.3. Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards. Monitoring should be designed and implemented by authorized employees for internal audits and accredited professionals for external audits as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents, diseases, and dangerous occurrences and accidents [4,5].

Both of aforementioned controls, internal and external controls include audits of employees and monitoring of their behavior during the working. Along with visual inspection, there are many questions used during a visiting inspection with some of them listed in Table 1.

Table 1. Questions used by the auditing of enterprises [8].

Area	*Question*
Risk perception	Does the each department in an enterprise have well-founded risk perception?
Injury awareness	What is the most dangerous incident in the enterprise from the last audit and have any preventive measures been implemented?
Knowledge of security regulations	Does the enterprise have a copy of the most important regulations?
Attitude towards the use of health and safety personnel	Does the enterprise have a deliberate policy for the use of health and safety personnel?
Programme for action	Does the enterprise have a plan for risk reduction?
Risk-reducing action	Does the enterprise follow-up the written plan for action?
Employee participation	Does the enterprise have regular meetings to discuss risks with the employees?
Training	

	Are training needs considered in connection with new employment, new equipment or other changes?
Special arrangements in times of extra work load	Does the enterprise initiate accident prevention measures in periods of extra workload or activity?
Protective arrangements on machines and equipment	Does all production equipment have the concomitant protective arrangements?
Use of personal safety devices	Do employees use the necessary personal safety devices?
First-aid equipment	Does each department has first-aid equipment?

3. CONCLUSION

Brewery is a complex industry with very different production lines all of which have their own health hazards and safety risks. Therefore, for each of them there should be somewhat different and specific rules and regulations regarding safety at work and injury prevention. In this paper, all main processes and technical aspects of beer production with related potential health and injury hazards are explained. It has to be noted that approach to occupational safety and related regulations considerably differ between industrial and craft breweries. Big breweries are paying a lot of attention to this topic and have implemented different standards and measures to prevent accidents from happening, while small breweries often only rely to personal awareness.

4. REFERENCES

[1] Hosseinlou, D.: Application of an efficient, cost-effective and newly developed single-process SAO/PND technology for treating brewery industry effluent, *South African Journal of Chemical Engineering*, **41** (2022), pp. 34-42, ISSN: 1026-9185

[2] Mbonigaba, E.: *To Assess the Prevalence of Occupational Health Related Risks and Use of Safety Measures among Employees in Bralirwa Processing Industries in Rwanda*, **3 (2015) 5,** pp.2-5, ISSN: 2329-6879

[3] Rosecrance, J: *Dissertation: Occupational Injuries Among Craft Brewery Workers in Colorado*, Colorado (2021)

[4] International Finance Corporation (IFC) of World Bank Group, Environmental Health and Safety Guidelines for Breweries, *Available from* https://www.ifc.org/wps/wcm/connect/8afeb6b7-6602-4394-8584-7643035eeb50/Final%2B-%2BBreweries.pdf?MOD=AJPERES&CVID=nPtf7l5 *Accessed:* 2022-06-02.

[5] *Health and Safety for Craft breweries and Distilleries*, Work Safe BC, 978-0-7726-7253-7, Canada, (2018)

[6] Olajire, A. A.: The brewing industry and environmental challenges, *Journal of Cleaner Production*, xxx (2012), pp. 1-21, ISSN: 0959-6526

[7] Li, (X) D.: Cut and slash hazards, In *Cut Protective Textiles*, Woodhead Publishing, 978-0-12-820039-1, (2020), pp.1-13

[8] Bull, N.: Work-related injuries and occupational helath and safety factors in smaller enterprises-a prospective study, *Occupational Medicine*, **52** (2002), pp. 70-74, ISSN: 0962-7480

THE EFFECT OF THE NEW STRUCTURE OF THE CROATIAN FIRE FIGHTING COMMUNITY AS A CENTRAL STATE OFFICE ON THE ORGANIZATION OF FIRE FIGHTING IN THE REPUBLIC OF CROATIA

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Abstract

With the entry into force of the new Fire Act (Official Gazette 125/19), the structure of the Croatian Fire Brigade was significantly changed. By the decision of the Croatian Parliament, the former roof organization united by the total fire brigade in the Republic of Croatia with voluntary fire brigades and their communities, voluntary fire brigades in the economy, and professional fire brigades in municipalities, cities, and economy was assigned to the state administration. The Fire Chief Commander is thus given the status of Secretary of State. Thus, the fire brigade got its own independent competent administrative body, and the changes aimed to improve the overall firefighting system and enable more efficient implementation of firefighting activities in the Republic of Croatia. The topic of the paper is how the functioning of the Croatian Fire Brigade is regulated by the Decree on the Internal Organization of the Croatian Fire Brigade, with an assessment of how and to what extent the new organization of the Croatian Fire Brigade affects the legal regulation of firefighting.
Key words: *state administration, Croatian Fire Brigade, fire brigade*

1. HISTORY OF THE CROATIAN FIRE BRIGADE ASSOCIATION

The history of modern organized Croatian firefighting begins with the establishment of voluntary firefighting societies and professional firefighting units. Thus, as the first unit, the First Croatian Volunteer Fire Brigade was founded in Varaždin in 1864. The first professional fire department was founded in 1863 in Rijeka. Then fire companies were founded in Sisak in 1865, Otočac in 1868, Ludbreg in 1869, Zagreb in 1870, Karlovac in 1871. By 1900, total of165 companies (voluntary and professional) had been founded. With the increase in the number of firefighting companies, arose the issue of establishing an organization that would connect the

existing companies. There was a need to establish an organization that would connect existing companies and work on better organizing firefighting. Thus, in 1876, the Croatian Slavonian Fire Brigade was founded, headed by the first president, Gjur Stjepan Deželić (1838 – 1907), who is also called the father of Croatian firefighting. The goal of the Community was to strengthen the firefighting organization, increase the number of companies, take care of the equipment and training of firefighters, record interventions, and other tasks to promote firefighting. [1]

Although the Law on Firefighting was not passed, in 1897 the Royal Land Government appointed the Croatian-Slavonian Firefighting Association as a professional body in matters of firefighting on Croatian soil. It performed this function until 1933 when it lost it due to a new territorial division of the country.

In 1945, after the Second World War, the Ministry of the Interior of the Democratic Federal Republic of Yugoslavia issued a Decision on the proclamation of the commission of internal affairs at the federal units, which has the task of encouraging the "initiative to help, establish and develop" not only the state but also the voluntary fire brigade to organize and connect fire brigades for the formation of the fire brigade union. In 1948, the Parliament of the People's Republic of Croatia passed the Law on Voluntary Firefighting Societies of the People's Republic of Croatia, which ceased to be valid with the adoption of the Federal Law of Yugoslavia in 1956.

In 1949, the Provisional Administration of the Association of Voluntary Fire Brigades of the Republic of Croatia began its work. During the commemoration of the 90th anniversary of the existence of the First Croatian Voluntary Fire Brigade at the Congress of the Association of Croatian Voluntary Fire Brigades in Varaždin in 1955, the unity of professional and voluntary structures was confirmed, and the former name of the Association of Voluntary Fire Brigades of the People's Republic of Croatia was changed to the new name of the Fire Brigade of Croatia, in which professionals and volunteers joined together.

The Fire Protection Act of the Socialist Republic of Croatia was adopted on December 19th, 1977. The law has finally defined fire protection as a particularly socially important activity. The fire department, from the previously subordinate position of a citizen's association was elevated to the status of a social organization, with mandatory financing from the budget or pooling of funds.

Following the Croatian defense plan, the Civil Protection Headquarters of the Republic issued on July 19th, 1991, the Decision on the transition of the voluntary fire brigade and professional fire brigades to work and act in wartime conditions, as well as instructions for action in the immediate danger of war. Professional and volunteer firefighting units became special firefighting units of Civil Protection.

In 1993, the Parliament of the Republic of Croatia adopted the Law on Firefighting (Official Gazette 58/1993 - hereinafter: Law on Firefighting 1993). With the adoption of that Act, the departmental body for firefighting became the Ministry of the Interior Affairs, and cities and municipalities had the obligation to finance the regular activities of volunteer firefighting units. [2]

The question of how to organize the firefighting activity was always and still is, open, taking into consideration that it is defined as professional and humanitarian, and of interest to the Republic of Croatia. Each municipality and city must have a fire brigade, and there has to be a regional and chief fire commander. The total fire service is connected and cannot be operationally divided into volunteer and professional fire departments. However, a voluntary firefighting organization must have its autonomy, organizationally as well as financially.

The Firefighting Act 1993 provided in Article 18 the possibility for associations of voluntary firefighters and voluntary firefighting units at the economic entity to join firefighting communities for the areas of local self-government and administration units and the territory of the Republic of Croatia. Firefighting associations are registered in the register of citizens' associations with the competent state administration body and are non-profit legal entities. [3]

The Parliament of the Croatian Firefighting Association established the Statute of the Association, according to which the bodies of the association are the Croatian Firefighting Association Parliament, which is held once every four years, the Croatian Firefighting Association Main Board, the Command, and the Supervisory Board. The command has a commander and a chief as an expert person for operational affairs.

After the passing of the Law on Firefighting, operational work and command fell exclusively under the jurisdiction of the Ministry of the Interior Affairs, so the Croatian Firefighting Association and its members were mainly to deal with preventive protection, informational and propaganda activities, and training of members, competitions, etc.

Furthermore, the Law on Firefighting (Official Gazette 106/1999 - hereinafter: Law on Firefighting 1999) stipulates that professional fire brigades from the Ministry of the Interior Affairs, i.e., police administrations, transfer to the jurisdiction of the cities in which they operate, and county fire chiefs from the Ministry of Interior Affairs transfer to fire departments communities of counties. In the Ministry of Internal Affairs, the inspection service, the main firefighting command at the state level, and the intervention firefighting units remain. [2]

However, even by this law, the Croatian Fire Association is not defined as a competent and responsible state institution for the implementation of firefighting activities. Nevertheless, the Croatian Firefighting Association is established as a core organization that unites the entire firefighting in the Republic of Croatia:

voluntary firefighting societies and their communities, voluntary firefighting societies at the economic entity, and professional firefighting units in municipalities, cities, and at the economic entity. Based on the Act on Firefighting 1999, the Croatian Fire Service takes care and responsibility for the organization and effective operation of the entire fire service. At the same time, care and responsibility for fire protection and the development of firefighting should have been taken over by local self-government units, which is also their constitutional task according to Article 129 of the Constitution of the Republic of Croatia (Official Gazette 56/90, 135/97, 08/98, 113 /00, 124/00, 28/01, 41/01, 55/01, 76/10, 85/10, 05/14) added to the Amendments to the Constitution of the Republic of Croatia published in the Official Gazette 113/00, which entered into force on 9 . November 2000.

Based on the Firefighting Act 1999, the decentralization of professional firefighting began on January 1, 2000, in such a way that professional firefighting is organized as public institutions founded by municipalities and cities. The law establishes a transitional period, during which the funding of professional firefighting is gradually decentralized from the state to local self-government.

The Croatian Fire Association lost the status of the competent authority for firefighting at the state level, which it had from 1891 until 1994 when the public fire brigades came under the jurisdiction of the Ministry of the Interior Affairs. In next years, intensive efforts were made to make the Croatian Fire Association the main competent authority for firefighting at the state level and for the chief fire commander to transfer from the State Administration for Protection and Rescue to the Croatian Fire Association.

At the session of the Croatian Fire Association held on May 18, 2010, the position regarding the issue from the Proposal of the Law on Amendments to the Law on Firefighting was agreed upon, and it advocates that the Croatian Fire Association become the competent authority for firefighting at the state level, and performs professional and administrative tasks in the field of firefighting and that the Chief Firefighter Commander transfers from the State Administration for Protection and Rescue to the Croatian Firefighting Community with all existing powers and responsibilities.

2. ORGANIZATION OF THE CROATIAN FIRE BRIGADE ASSOCIATION FROM 1 JANUARY 2020.

According to the Law on Firefighting (Official Gazette 125/2019 - hereinafter Law on Firefighting), the Croatian Firefighting Association is organized as a central state office responsible for firefighting, headed by the chief firefighter.

The chief fire commander is responsible to the Government of the Republic of Croatia for the legality of the work of the Croatian Fire Brigade and the equipment,

organization, training, and intervention readiness of firefighting organizations, firefighting units, and firefighters in the territory of the Republic of Croatia.

The fire brigades of the counties and the fire brigade of the City of Zagreb are under the jurisdiction of the Croatian fire brigade in operational and implementation terms.

The Croatian Fire Brigade is a budgetary beneficiary of the state budget, and budgetary regulations are applied to budgetary processes.

Croatian Fire Brigade Association:
- prepares a proposal for the National Firefighting Development Strategy
- shapes the firefighting system of the Republic of Croatia
- encourages activities regarding the improvement of the state of fire protection and the implementation of firefighting activities
- prepares the Program of activities in the implementation of special fire protection measures of interest to the Republic of Croatia and submits it to the adoption procedure
- implements and coordinates the implementation of the Program of activities in the implementation of special fire protection measures of interest to the Republic of Croatia
- prepares a report on the implementation of the Program of Activities in the Implementation of Special Fire Protection Measures for the Republic of Croatia
- coordinates activities related to the inclusion of fire brigades in the civil protection system
- is organized by the state fire operations center 193
- directs the activities of firefighting organizations and firefighting units in the performance of firefighting activities and supervises their professional work
- participates in the work of international firefighting organizations, represents the interests of firefighting on the territory of the Republic of Croatia, and maintains and regularly updates databases, registers, and other data collected by the Croatian Firefighting Association following the provisions of this Act and the regulations adopted based on this Act
- carries out international cooperation in the field of firefighting and participates in the work of the working bodies of competent European and international firefighting organizations
- issues instructions for the implementation of elections in firefighting communities of counties, firefighting communities of the City of Zagreb, firefighting communities of cities, municipalities, regions, voluntary firefighting societies, and public firefighting units
- organizes firefighting activities
- provides the central information and communication system
- prepares analyzes of firefighting interventions and proposes improvements to deficiencies identified in the analysis
- prepares plans for the procurement of firefighting equipment and techniques
- performs other tasks that are assigned to it by law. [6]

3. AUTHORITIES OF THE CROATIAN FIRE BRIGADE AND THE CHIEF FIRE COMMANDER

The Law on Amendments to the Law on the Organization and Scope of Ministries and Other Central Bodies of State Administration, which was debated at the end of 2018 (Official Gazette 116/18), prescribes the establishment of the Croatian Fire Association as a body of state administration - the central state office and established its commencement of work on January 1, 2020.

It was decided that the firefighting activity, as an activity of interest to the Republic of Croatia, will be fully regulated by a special law that will be passed no later than one year from the date of entry into force of that law.

Changes in the law and the adoption of the Firefighting Act, which entered into force on 1 January 2020. it resolved, after an extensive public debate, the issues that voluntary and professional firefighting societies had been warning about for a long time.

By abolishing the previously divided jurisdiction between the State Administration for Protection and Rescue and the Croatian Fire Brigade, it was possible to pass by-laws, which are very necessary for the coordinated work of all participants in the firefighting system and simplified the process of adopting strategic documents (Fire Protection Strategy, National Security Strategy, and fig.).

The work of volunteer fire brigades has also been facilitated, and parallel command has been excluded, which made work in the field difficult, especially in cases where the Airborne Fire Fighting Forces and Specially Organized Forces of the Armed Forces of the Republic of Croatia would be involved.

Coordination has been strengthened at all levels of the firefighting system, and the conditions for performing firefighting activities and participating in firefighting interventions have been uniform.

Easier withdrawal of funds from the European Union has been made possible, and the rights and obligations of local and regional self-government units have been regulated.

The issues of the duration of the mandate of all responsible persons and their competencies, conditions for performing firefighting duties, regulated insurance tenure with increased duration, rights of professional firefighters when going on a disability pension and old-age and early retirement, rights of a firefighter's family if he loses his life in an intervention, and others have been regulated. [7]

The chief fire commander is the head of the Croatian Fire Association, the central state office, and commands the fire system in case of large fires when the Air Fire

Fighting Forces and Specially Organized Forces of the Armed Forces of the Republic of Croatia are involved in extinguishing the fire. The chief fire commander is considered the head of the body and is obliged to enact regulations on the internal order of the Croatian Fire Service. [8]

The Croatian Fire Association performs administrative and professional tasks related to firefighting; carries out training of members of fire brigades; provides technical assistance in accidents and dangerous situations and performs other tasks related to firefighting. The Croatian Fire Brigade Association also performs other tasks that are assigned to it by a special law.

4. CONCLUSION

With the entry into force of the Firefighting Act on 1 January 2020., the Croatian Fire Association became the central state office for firefighting, headed by the chief fire commander with the status of state secretary.

In this way, the fire department got its own independent competent state body. At the same time, greater importance is given to county fire chiefs and to chiefs of cities and municipalities, whereby fire chiefs will be able to directly replace and appoint lower-ranking chiefs, and in professional units, the previous administrative councils, as political bodies, have been replaced by fire councils in which there are firefighters, not politicians.

The financing of firefighting is also better regulated because the state, in addition to professional firefighting, also finances volunteer firefighting through it.

When it comes to salaries, the system is decentralized and a minimum firefighting standard is determined by the Collective Agreement of Civil Servants and State Employees, but the law also foresees the possibility of concluding a branch collective agreement through which it will enable certain local self-government units that have more money to add it above minimum contracted.

From entry into force of the Firefighting Act on 1 January 2020 until today, in terms of normative activities, the Croatian Fire Department, i.e. the Chief Fire Department, initiated and completed the adoption of regulations regulating the following issues:

- official badges, identity cards, minimum work and protective equipment, clothes and shoes of fire inspectors
- fire inspector's reports on the event that caused the death of the worker
- programs and methods of implementation of theoretical classes and practical exercises in fire brigades
- rulebook on the program and method of passing the professional exam for firefighters with special powers and responsibilities

- log book on inspections and measures taken by fire inspectors
- selection procedure for county, city, regional and municipal fire chiefs and their deputies
- price list of firefighting interventions
- information systems and firefighters' personal data protection
- standard operating procedures
- classification of the positions of professional firefighters and the criteria for determining the aforementioned
- firefighting technology.

By changing the way of decision-making and by raising the status of the Commander-in-Chief of the Croatian fire brigade to the level of the state secretary, the system that normatively regulates the issue of firefighting in Croatia has been made more efficient, and the rules of conduct concerning volunteer and professional firefighters have been made uniform, which was especially evident during the public debate on the classification of working places and coefficients.

Based on this, but also other examples of regulations adopted so far, this change of status of the Croatian Fire Brigade achieved the given target of equalization of status for all fire brigades and better efficiency. So far it seems that the reorganization of the Croatian Fire Brigade into a state authority instead of the earlier association of fire brigades and organizations was a wise decision.

REFERENCES

[1] https://mhv.hr/povijest-hrvatskog-vatrogastva/ accessed 10.7.2022.

[2] Puljak, R.: Vatrogastvo na tlu Hrvatske, Karlovac, 2021. https://urn.nsk.hr/urn:nbn:hr:128:801457, accessed 3.7.2022.

[3] Zakon o vatrogastvu (Official Gazette 58/1993)

[5] Zakonom o vatrogastvu (Official Gazette 106/1999)

[6 https://hvz.gov.hr/o-nama/9, accessed 6.7.2022.

[7]https://www.sabor.hr/hr/radna-tijela/odbori-i-povjerenstva/izvjesce-odbora-za-unutarnju-politiku-i-nacionalnu-sigurnost-303 , accessed 6.7.2022.

[8] https://hvz.gov.hr/print.aspx?id=241&url=print , accessed 6.7.2022.

9

SOCIAL AND LEGAL ASPECTS

INTERPRETATION OF THE PROPERTY INSURANCE CONTRACTS IN BOSNIA AND HERZEGOVINA AND EUROPEAN UNION

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Abstract: *The paper will present the regulations of Bosnia and Herzegovina and the European Union regarding the interpretation of property insurance contracts in accordance with the positive legal framework, pointing out the specifics of the regulation of this issue. During the duration of the contract on insurance of property in legal transactions, various changed circumstances and facts may occur that the contracting parties do not understand the same, or understand the same, but representing their interest, act differently and contrary to good business practices. Therefore, it is necessary to point out the institute of interpretation of property insurance contracts, with the emphasis on the law of insurance the interpretation of only disputable provisions of contract is approached, while undisputed, until clear provisions are applied as they read.*

Keywords: *interpretation of property insurance contracts, Law of Obligations, Principles of European Contract Law, UNIDROIT, Consumer Protection Act*

1. INTRODUCTION

A property insurance contract is a model of property protection against various risks that could potentially endanger it. Today, the mentioned contract is concluded en masse, because several goals are realized through it (property protection from various threats, social security, accumulation of funds, etc.) Considering the frequency of its conclusion, as well as the length of its duration, the need for its interpretation is very often indicated, which is due to the different understanding of certain provisions of the contract by the contracting parties, which is due to the existence of disputed provisions in the contract, which is due to the occurrence of certain changed circumstances and facts in legal transactions, etc. Due to all of the above, a very important part of contract law is the rules according to which it will be approached interpretation of property insurance contracts.

2. INTERPRETATION OF THE PROPERTY INSURANCE CONTRACTS ACCORDING TO THE GENERAL RULES OF THE LAW OF OBLIGATIONS IN THE INTERPRETATION OF CONTRACTS

The interpretation of property insurance contracts is approached in a specific way. Namely, any interpretation should be carried out according to the general rules of the law of obligations on the interpretation of contracts (Art. 99, paragraph 1 of the Law of Obligations of the Federation of Bosnia and Herzegovina[1] states that the provisions of the contract are applied as they read).[2] However, as the insurance contract is considered a contract by access, and in accordance with the provisions of Art. 100 of the ZOO stipulates that if the contract was concluded according to pre-printed content or if the contract was otherwise prepared and proposed by one contracting party, unclear provisions will be interpreted in favor of the other contracting party. This regulation is in accordance with the general rule dating back to Roman law "*in dubio contra stipulatorem, contra preferentem*", which can be adapted and interpreted as "*in dubio contra assecuratorem*", which means that the ambiguities and ambiguities (contradictions) of the insurance conditions and the policies should be interpreted to the detriment of the person who made these conditions, which means the insurer, i.e. in favor of the insured.[3] In the event of a discrepancy between

[1] *Law of Obligations of the Federation of Bosnia and Herzegovina*, Official Gazette of the Federation of Bosnia and Herzegovina, no. 29/03. and 41/11. (In the following text: ZOO.)

[2] "The provisions of the contract are applied as they read." (Higher Commercial Court of Croatia, Pž-1430/78 of 27/02/1979) Taken from: Stojanović, Dragoljub D., *Interpretation of contracts of self-governing agreements and social agreements*, Books, Belgrade, 1982, p. 194.; Ivo Andrić also beautifully said: "If we do not know the meaning of a word or it is not clear to us, it does not mean that it does not exist; just as one word can mean another and say more than what we know about it." The interpreter must not assume that the word or phrase used has no meaning. Taken from: Morait, Branko, *Obligatory law*, Faculty of Law Banja Luka, Banja Luka, 2007, p. 235. However, one judgment held that a contract should never be interpreted abstractly and literally without considering the context or actual scope (*Judge Mance in Charter Re vs. Fagan, 1995*). Cited according to: Pavić, Drago, *Legal sources of insurance contracts*, Svijet osiguranje, Zagreb, no. 2., 2003, p. 35-49.

[3] The following Latin sentence is significant: "*Ambiguitas contra stipulatorem est*." ("Unclear provisions should be interpreted to the detriment of the creditor.") "Any possible ambiguity in the text of the contract is to the detriment of the one who drew up the contract." (*Supreme Commercial Court, Sl. - 2587/69 of 19 October 1970*) and "When the will of the tenant is vaguely expressed in the contract and cannot be understood, the clauses of the contract should be interpreted in favor of the debtor because, considering the way the emergence of a contractual obligation, it assumes that the debtor wanted to assume as little obligation as possible" (*Supreme Commercial Court, Official Journal - 508/65 dated 11.06.1965*) Cited according to: Stojanović, D. D., *op. cit.*, p. 185.; Thus: "*In dubiis benigniora praeferenda sunt.*" ("When in doubt, one should first decide on what is more favorable." - for the parties, the debtor, etc.) "If, finally, the stated clause of the policy text would not be clear enough, in the sense of the legal rules of civil law, it should be interpreted to the detriment of its drafter, i.e. the claimant (insurer), therefore, in the direction that cases that remain doubtful should be considered insured." and maritime sales, 1961/12) Cited according to: Šulejić, Predrag, *Insurance law*, Dosije, Belgrade, 2005, p. 201.

a provision of the general or special conditions and a provision of the policy the provision of the policy will be applied, and in the event of a discrepancy between a printed provision of the policy and its handwritten provision, the latter will be applied (Art. 902, paragraph 5 of the ZOO). And provisions can be handwritten, printed, typed, etc., which today contributes to the possibility of disputes.[4] The meaning of individual terms should be evaluated in the context of the entire contract, i.e insurance policies, not outside of them. In other words, they should be interpreted in connection with the others the words used. Phrases, sentences, sections, part of the policy, the entire policy, and beyond the policy should be observed: the parties' relations in the past, the business context, the goal wanted to achieve with the shelf. Therefore, when interpreting the disputed provisions, one should not stick to the literal meaning of the terms used, but should investigate the common intention of the contracting parties and understand the provision in such a way that it corresponds to the principles of the law of obligations established by this law as prescribed by the provision of Art. 99, paragraph 2 of the ZOO.[5]

3. INTERPRETATION OF THE PROPERTY INSURANCE CONTRACTS IN ACCORDANCE WITH THE PRINCIPLES OF EUROPEAN CONTRACT LAW (LANDO PRINCIPLES)

The entire fifth chapter of the principles of European contract law[6] or Lando principles are dedicated to the interpretation of all types of contracts, and thus the provisions also refer to the Insurance contract. General rules of interpretation under the provision of Art. 5:101. they anticipate that the contract should be interpreted according to the joint intentions of the contracting parties, even if it is different from the literal meaning of the expression used. If it was determined that one party had the intention of gaining a certain meaning, and at the time of the conclusion of the contract, the other party had to know about the intention, the contract should be interpreted in a manner that is in accordance with the intent of the first party. And if the intention of the contracting parties cannot be determined, the contract should be interpreted as the reasonable persons of the same properties in the same circumstances as the contracting parties should be understood. In the provision of Art. 5:102. the provisions of relevant circumstances were also treated in the interpretation of the contract, stating that when interpreting the contract, special attention should be paid to: the circumstances in which it was concluded, including previous negotiations; the behaviour of the contracting parties, even after the conclusion of the contract; the nature and purpose of

[4] See: Ćurković, Marijan, *Life insurance contract*, Zagreb, 2005, p. 21.; Here it should be mentioned that the provisions of Art. 101. of the ZOO cannot be applied to insurance contracts as a "supplementary rule", which prescribes that unclear provisions in the contract of cargo should be interpreted in the sense of achieving a fair relationship of mutual benefits, for the reason that the insurance contract belongs to aleatory contracts.

[5] See: Clarke, Malcolm, *The Law of Insurance Contract*, London, 2002, p. 411.; "When interpreting disputed provisions, one should not stick to the literal meanings of the expressions used, but rather investigate the common intention of the parties and understand the provision in a way that corresponds to the principles of mandatory law.") Published in: *Judicial practice*, Our legality, Zagreb, no. 195, 1981, p. 99.

[6] *Principles of European Contract Law – PECL established by Commission on European Contract Law - CECL*

the contract; interpretation that the contracting parties have already applied to similar provisions and the practice that they have established with each other; Meaning usually attached to the provisions and expressions in the given profession or branch and interpretation that has been already applied to similar provisions and conscientiousness and honesty. Also, *the Contra Preference* rule is found in Art. 5:103. The principles of European contract law states when there is suspicion of the meaning of contracting provisions that have not been used individually, the advantage should be given to the interpretation that is less favorable for the side that proposed that provision.[7] It is significant to point out the provision of Art. 5:104. according to which provisions that were the subject of special negotiations, they also have an advantage in the application in relation to those provisions that were not negotiated, as well as the provision of Art. 5:105. that the provisions should be interpreted in the light of the entire contract in which they are located. The provision of Art. 5:106. regulates the manner or ultimate purpose of interpretation in such a way that prescribes an interpretation that maintains the provisions of the contract in force, that is, the advantage of interpretation on the basis of which the contractual provisions would be legal or would have an effect, in relation to what they would be illegal or without the effects. In the case of linguistic disobedience, that is, when the contract is drawn up in two or more languages, and it is not stated which version of the text has a prevailing, in the case of linguistic disobedience, it should be given the advantage of an interpretation that stems from that version of the text in which the contract is originally composed (Art. 5:107.). With such solutions, all practical questions were answered that could be the subject of any disputes between the contracting parties, which depends on the successful realization of the contract.

4. INTERPRETATION OF THE PROPERTY INSURANCE CONTRACTS IN ACCORDANCE WITH UNIDROIT (PRINCIPLES FOR INTERNATIONAL TRADE CONTRACTS)

International Institute for Unification of Private Law[8] adopted the Principles for international trade contracts in which the issue of interpretation of the contract was regulated in Chapter 4. All provisions from Art. 4.1. - 4.8. in the same way, as the Principles of European contract law, governed the issue of interpretation of the contract.

5. THE PROPERTY INSURANCE CONTRACTS IN THE CONTEXT OF CONSUMER PROTECTION RIGHT

Consumer Protection Act in BiH[9] in the XII head called "Insurance" in Art. 68. prescribes that the insurance contracts that are concluded or offered to consumers must be in accordance with regulations that regulate oblique relations in BiH as well as with special

[7] Petrić, Silvija, *Introduction in the Principles of European Contract Law (LANDO PRINCIPLE)*, Proceedings of the Faculty of Law, University of Rijeka (1991), v. 29, Rijeka, no. 1st, 2008, p. 335-370.
[8] *International Institute for Unification of Private Law – UNIDROIT*
[9] *Consumer Protection Act in BiH*, Official Gazette of BiH, no. 25/06. and 88/15.

insurance regulations. The consumer has the right, without stating special reasons of any kind, to terminate the contract, but that the insurer notification in written form within 15 days from the date of conclusion of the contract (Art. 69). In the sixteenth head of "Unjust provisions in consumer contracts" there is a complete picture of the protection of the customer of insurance services, i.e. the contractor or, the insured. Thus, in the provision of Art. 93 it is prescribed that the contractual provisions are obliged to be obliged to consumer only if he was familiar with the contents of the contract before the contract concluding, or if his contractual conditions should be known at the time of the conclusion of the contract (paragraph 1 of the said member). Contracting provisions should also be understood in connection with other provisions in the same or other contract between the same parties, considering the nature of the service and all other participants regarding the conclusion of the contract (paragraph 2 of the said member). In the case of doubt about the meaning of individual provisions in the contract, it will be valid for the meaning that is more favorable for the consumer (paragraph 3 of the said member). The consumer is considered to be aware of the contractual provisions if the merchant warned him and if they were available to him (paragraph 4 of the said member). The provision of Art. 94 it said law stipulates that the merchant, in this case, the insurer may not require contractual provisions that are unjust or that would cause damage to the consumer. Such contractual provisions are null and void. Unjust provisions are all those contractual provisions that the consumer did not personally contracted, in contrast to the principle of conscientiousness and honesty and good business customs (Art. 95 paragraph 3 of the said regulation).[10] The provisions of the Consumer Protection Act in BiH act as Lex Generals in relation to the Insurance Act of the Federation of BiH[11]. The term consumer within the meaning of the provisions of this latter implies every natural person who has the rights and obligations under the insurance contract. According to this law, protection in the form of the right to inform the insurance contractor in the conclusion of the Insurance Agreement, as well as during its duration (Art. 200 and 201). The Survelation Agency is established an independent organizational unit within which one or more ombudsman operates in insurance in order to promote and protect the rights and interests of the beneficiaries of the insurance services, i.e. natural persons as a user of insurance services. Ombudsman, as one of the consumer rights holders in the Federation of BiH, allows for disagreements and disputes between societies and insurance users can be properly and quickly resolved by independent persons, with a minimum of formalities through aging, mediation or other peaceful ways.[12] The attached can be concluded that the legal order of BiH is committed to modern flows in the insurance area,

[10] In the context of the above, the guideline 93/13/EEC (OJ 1993 L 95/29) is purposefully mentioned on dishonest provisions in consumer contracts that explicitly state that written provisions of the contract must be written in a simple and intelligible language, and the content will be interpreted in favor of consumer, i.e. the insured. See more: Baretic, Marko, *Consumer Protection in the European Community* (Gavella, Nikola - Alincic, Mira - Hrabar, Dubravka - Gliha, Igor - Josipovic, Tatjana - Korac, Aleksandra - Baretic, Marko - Nikic, Sasa), *European private law*, legal right Faculty of University of Zagreb, Zagreb, 2002, p. 167-173.

[11] *Insurance Act*, Official Gazette of the Federation of BiH, no. 23/17.

[12] The same is provided for by the provision of Art. 25. *Law on Insurance Societies*, Official Gazette of Republika Srpska, no. 17/05., 01/06., 64/06. and 74/10.

primarily thinking of an effort to be harmonized with the legal denials of the countries in the environment.

6. CONCLUSION

The interpretation of the Property Insurance Contract in BiH is governed by the provisions of the ZOO, respecting the old Roman rules on the interpretation of the disputed provisions, on which the rules of European contract law on the interpretation of the asset insurance contract also rest. When interpreting unclear and controversial provisions of the contract, a list of rules will be applied: the joint intention of the contractor will be determined, the aim of the contract, the meaning of the terms used will be considered in the context of the entire contract, the advantage of the provisions in the manuscript in relation to the printing provision, etc. Considering the rules on the interpretation the property insurance contracts are interpreted in such a way that the unclear and ambiguous provisions should be understood in the spirit of the protection of the security contractor (insured) and to the detriment of the insurer.

REFERENCES

[1] Babić, Ilija: *Obligatory law-general part*, Official Gazette and Faculty of European Legal and Political Studies of Singidunum University , Belgrade-Sremska Kamenica, 2009
[2] Baretic, Marko: *Consumer Protection in the European Community* (Gavella, Nikola - Alincic, Mira - Hrabar, Dubravka - Gliha, Igor - Josipovic, Tatjana - Korac, Aleksandra - Baretic, Marko - Nikic, Sasa, *European private law*, legal right Faculty of University of Zagreb, Zagreb, 2002
[3] Bikić, Abedin: *Obligatory law-general part*, Law Faculty of the University of Sarajevo, Sarajevo, 2007
[4] Clarke, Malcolm: *The Law of Insurance Contracts*, London, 1997
[5] Clarke, Malcolm, *The Law of Insurance Contract*, London, 2002
[6] *Consumer Protection Act in BiH*, Official Gazette of BiH, no. 25/06. and 88/15.
[7] Ćurković, Marijan: *Life insurance contract*, Zagreb, 2005
[8] Đurović, Radomir; Dragašević, Momir: *Obligatory law with traffic matters*, Contemporary administration, Belgrade, 1980
[9] *German Civil Code*, 1896
[10] Gorenc, Vilim: *Law on Obligatory Relations with Commentary*, RriF, Zagreb, 1998
[11] *Insurance Act*, Official Gazette of the Federation of BiH, no. 23/17.
[12] *International Institute for Unification of Private Law – UNIDROIT*, 2010
[13] *Judicial practice*, Our legality, Zagreb, no. 195, 1981
[14] Kapor, Vladimir: *Agreement on the purchase and sale of goods according to the general regulations for the circulation of goods with the text of general regulations*, Savremena administracija, Belgrade, 1960
[15] *Law on Insurance Societies*, Official Gazette of Republika Srpska, no. 17/05., 01/06., 64/06. and 74/10. and other sources.

JURISDICTION FOR THE EMPLOYMENT CONTRACTS OF EUROPEAN UNION

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Abstract: An increasing number of labor relations within the European Union whose participants are natural persons who are citizens of different countries, or labor relations are being crated, their effects are being realized or otherwise stopped on the territories of different countries, has led to the need to gradually achieve a single space of freedom, security and justice, to establish rules that determine the jurisdiction of the authorities of a particular jurisdiction for a employment contract. Due to this, with regulation of Brussel I bis, as legal sources of secondary law of the European Union, rules about jurisdiction in individual employment contracts have been established. The following paper analyzes the Regulation Brussels-I bis, which determines jurisdiction of the court in the procedure in which the employee is the claimant, in the procedure in which the employer is the claimant and lastly, a possibility for the parties of the contract to agree on courts jurisdiction.

Keywords: working relationship, single employment contracts, jurisdiction, European Union

1. GENERAL

The ever growing openness of borders and freedom of movement of persons has led to an ever growing private-legal relationships with a foreign bypass, independent of its participants being physical persons who are national of different countries or having habitual residence in different countries, their effect are being realized or stopped in the area of different countries, has led to a need to determine rules with gove jurisdiction to institutions of specific jurisdiction.

During the six decades of euro-integrational process, the European Union has built, and is still building its legal system based on, at the same time, harmonization and unification of public and private legal rules.[1] For decades, in the scope of the European Union, these questions have been regulated on the basis of international treaties. It was the Regulation 220 of the Rome contract that created a basis for the Brussel Convention of judicial authority and executing judicial decisions and civil

[1] Bouček, Vilim: Pravno-historijski aspekt europskog međunarodnog privatnog prava, Zbornik radova Međunarodne naučne konferencije Bosna i Hercegovina i euroatlantske integracije – trenutni izazovi i perspektive, Pravni fakultet Univerziteta u Bihaću, Bihać, 2012., str. 116-124., str. 116.

and commercial matters from 27.9.1968.[2] This international treaty will later be reshaped into sources of secondary legislation, Brussel Convention into Regulation of European Council Nr.44/2001 from 22.12.2000.about judicial authority, recognition and enforcement of decisions in civil and commercial matters[3], altered by the Regulation of the European Union Nr. 1215/2012 of the European Parliament and Eruoepan Council from 12.12.2012 about the jurisdiction, recognition and enforcement of decisions regarding civil and commercial matters[4] (later: Regulation Brussels-I bis). When we look at the cases of referral of employees, the regulations are complemented by Guideline 96/71 of the European Parliament and European Council from 16.12.1996 about referral of employees in service matters.[5]

2. BRUSSEL-I BIS REGULATION

Brussel-I bis Regulation is also known as the "*convention double*" because, on the one hand, it contains rules which determine the jurisdiction of specific institutions of an individual jurisdiction, and on the other hand the rules that edit the procedure of recognition and enforcement of decisions in civil and commercial matters given in a one Member State in another Member State of the European Union. The area of application of the Brussels-I bis are civil and commercial matters, regardless of the nature or type of the court (Article 1).[6]

[2] Official Journal L 299, 31. 12. 1972.
[3] Official Journal L 12, 16. 1. 2001.
[4] Official Journal L 351, 20.12.2012
[5] Official Journal L 18, 21.1.1997.
[6] For the purposes of this Regulation: (a) 'judgment' means any judgment given by a court or tribunal of a Member State, whatever the judgment may be called, including a decree, order, decision or writ of execution, as well as a decision on the determination of costs or expenses by an officer of the court. For the purposes of Chapter III, 'judgment' includes provisional, including protective, measures ordered by a court or tribunal which by virtue of this Regulation has jurisdiction as to the substance of the matter. It does not include a provisional, including protective, measure which is ordered by such a court or tribunal without the defendant being summoned to appear, unless the judgment containing the measure is served on the defendant prior to enforcement; (b) 'court settlement' means a settlement which has been approved by a court of a Member State or concluded before a court of a Member State in the course of proceedings; (c) 'authentic instrument' means a document which has been formally drawn up or registered as an authentic instrument in the Member State of origin and the authenticity of which: (i) relates to the signature and the content of the instrument; and (ii) has been established by a public authority or other authority empowered for that purpose; (d) 'Member State of origin' means the Member State in which, as the case may be, the judgment has been given, the court settlement has been approved or concluded, or the authentic instrument has been formally drawn up or registered; (e) 'Member State addressed' means the Member State in which the recognition of the judgment is invoked or in

The main rule that the jurisdiction is based on is *"actor seguitor forum rei,"* meaning, on the basis of the habitual residence of the defendant. The jurisdiction for individual employment contracts is put in specific rules and is ruled on but Articles 20-23. The significance of jurisdiction in individual employment contracts is highlighted in the introductory provisions of point 18, which states: *"In relation to insurance, consumer and employment contracts, the weaker party should be protected by rules of jurisdiction more favorable to his interests than the general rules*." Brussel-I bis does not provide an answer to questions "who is an employee", "who is an employer" and "what is an individual employment contract. Definition of an employment contract was given by the Court of the European Union. The Court of European Union believes that individual employment contracts are determined by the creation of a "permanent relationship, through which an employee is in a certain way included in the business operations of the company or the employer."[7] Such contracts are " in connection with the place where the operations take place, and according to that place, application of binding provisions of law and collective agreements (Subject 266/85, Shenavai: see also: Subject 32/88, Six Constructions)[8] The Regulation Brussel-I bis has, in its provision, rules on the jurisdiction of individual employment contracts, meaning rules on determining jurisdiction in proceedings which are started by the employee as a claimant and rules when the role of claimant is held by the employer. Furthermore, Brussel-I bis Regulation, while giving jurisdiction under certain assumptions, determines anatomy of free will to the parties of the contract.

2.1. Jurisdiction over individual contracts of employment

The very first question that is being asked when we want to exercise or protect the right of relations with an international character is to which institution, more precisely, institutions of which state they can approach. [9]

The complexity of rules of jurisdiction is a result of, firstly, the majority of legal orders, each one of them performing its functions on a certain territory, and in certain cases and depending on their functions, they manifest outside of their

which the enforcement of the judgment, the court settlement or the authentic instrument is sought; (f) 'court of origin' means the court which has given the judgment the recognition of which is invoked or the enforcement of which is sought. (Article 2).

[7]https://eur-lex.europa.eu/legal-content/HR/TXT/PDF/?uri=CELLAR:41547fa8-20a8-11e6-86d0-01aa75ed71a1&from=FR str. 9. (7. 6. 2022.)

[8] Ibid

[9] Varadi, Tibor; Međunarodno privatno pravo, treće izmijenjeno i dopunjeno izdanje, Forum, Novi Sad, 1990. str. 1-448., str. 323.

territory.[10] Each country, taking into the account that they are completely sovereign in determining jurisdictions of their courts in disputes with an international character, is attempting to provide jurisdiction of their court in all of the interested disputes and in that way, expand their courts' jurisdiction on a larger number of such disputes.[11] In simple terms, the international jurisdiction is a jurisdiction of courts in disputes with an international character.

Brussel-I bis Regulation in this provisions of Article 20, par.1, states: "In matters relation to individual contract of employment, jurisdiction shall be determined by this Section, without prejudice to Article 6, paragraph 5 or Article 7, in the case of proceeding brought against an employer, paragraph 1 of Article 8."Where an employee enters into an individual contract of employment with an employer who is not domiciles in a Member State but has a branch, agency or other establishment in one of the Member States, the employer shall, in disputes arising out of the operation of the branch, agency or establishment, be deemed to be domiciles in that Member state (20(2)).

2.1.1. Determining jurisdiction in proceedings commenced by an employee against employer

Regulation Brussel-I bis, while determining jurisdiction in disputes between employees and employers, provides the employee with a possibility of choice when he is in the role of the claimant against the employer as a defendant. Namely, Article 20, paragraph 1 of the Regulation determines that an employee can sue the employer in front of the court of a Member State in which he has habitual residence, or another Member State. Regulation Brussel-I bis through this Article also determines:

(i) in the courts for the place where or from where the employee habitually carries out his work or in the courts for the last place where he did so; or
(ii) if the employee does not or did not habitually carry out his work in any one country, in the courts for the place where the business which engaged the employee is or was situated.

Regulation Brussel-I bis explains, through Article 63, paragraph 1, that statutory seat, central organization or central place of business fall under the definition of habitual residence.[12] An employer not domiciled in a Member State may be sued in a court of a Member State in accordance with point (b) of paragraph 1. (20(2)).

[10] Triva, Siniša; Mihajlo, Dika; Građansko parnično procesno pravo, sedmo izmijenjeno i dopunjeno izdanje, Narodne novine d.d., Zagreb, 2004., str. 1-958., str. 257.

[11] Čalija, Branko; Omanović, Sanjin, Građansko procesno pravo, Pravni fakultet Sarajevo, Sarajevo 2000. str. 1-444., str. 119.

[12] Article 63 1. For the purposes of this Regulation, a company or other legal person or association of natural or legal persons is domiciled at the place where it has its: (a) statutory seat; (b) central administration; or (c) principal place of

2.1.2. Determining jurisdiction in proceedings commenced by an employer against the employee

In contrast to determining jurisdiction in matters in which the proceedings of the court have been commenced by the employee against the employer, the Regulation Brussel-I bis, while determining the jurisdiction in the proceedings of the court where the role of the claimant belong to the employer, leaves it in disposition to the employer one possibility, commencing the proceedings in front of the court of a state where the employee has their habitual residence.[13]

2.1.3. Stipulation of the jurisdiction

The regulation Brussels-I bis provides the parties with a possibility to reach an agreement regarding the jurisdiction of the court by themselves. The freedom of will is however limited to the rules listed out in Article 23, according to which the provisions of this Section may be departed from only by an agreement: (1) which is entered into after the dispute has arisen; or (2) which allows the employee to bring proceedings in courts other than those indicated in this Section.

3. INSTEAD OF A CONCLUSION

On one hand, in order to secure one of the fundamental rights, the freedom of movement of workers, in the framework of the European Union, unique rules which determine jurisdiction of institutions of specific jurisdictions in matters of an employment contract, are determined. The Regulation Brussels-I bis strives, with its provision, to provide for weaker party protection of the workers in the employment contract, and by doing so, it differentiates between situations in which the jurisdiction of proceedings started by the employee against the employer to proceedings started by the employer against the employee. Brussel-I bis also enables the parties with a possibility to reach an agreement about the court's jurisdiction. As mentioned above, such freedom of will is conditioned by limitations. In the end,

business. 2. For the purposes of Ireland, Cyprus and the United Kingdom, 'statutory seat' means the registered office or, where there is no such office anywhere, the place of incorporation or, where there is no such place anywhere, the place under the law of which the formation took place. 3. In order to determine whether a trust is domiciled in the Member State whose courts are seized of the matter, the court shall apply its rules of private international law.

[13] Article 22 1. An employer may bring proceedings only in the courts of the Member State in which the employee is domiciled. 2. The provisions of this Section shall not affect the right to bring a counter-claim in the court in which, in accordance with this Section, the original claim is pending.

Regulation Brussel-I bis, with its provisions, enables weaker party protection for workers.

REFERENCES

[1] Vilim B.: *Pravno-historijski aspekt europskog međunarodnog privatnog prava*, Zbornik radova Međunarodne naučne konferencije Bosna i Hercegovina i euroatlantske integracije – trenutni izazovi i perspektive, Pravni fakultet Univerziteta u Bihaću, Bihać, 2012., str. 116-124.

[2] Čalija, B.; Omanović, Sanjin, Građansko procesno pravo, Pravni fakultet Sarajevo, Sarajevo 2000. str. 1-444., str. 119.

[3] Triva, S. & Dika, M.; *Građansko parnično procesno pravo*, sedmo izmijenjeno i dopunjeno izdanje, Narodne novine d.d., Zagreb, 2004., str. 1-958.

[4] Varadi, T.*; Međunarodno privatno pravo*, treće izmijenjeno i dopunjeno izdanje, Forum, Novi Sad, 1990. str. 1-448., str. 323.

Regulation of the European Union Nr. 1215/2012 of the European Parliament and Eruoepan Council, Official Journal L 351, 20.12.2012

[5] PRAKTIČNI VODIČ *Nadležnost i mjerodavno pravo u međunarodnim sporovima zaposlenika i poslodavaca*, str. 1-30., str. 9. https://eur-lex.europa.eu/legal (7. 6. 2022.)

NOVELS OF LABOR PROTECTION LEGISLATION IN THE FEDERATION OF BOSNIA AND HERZEGOVINA

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Abstract: *In order to create a safe working environment, it is necessary to have an adequate normative labor protection framework by which the employer will adjust the internal acts in that area. As the Law on Occupational Safety from the previous constitutional system was in force in the Federation of Bosnia and Herzegovina from 1990 to 2020 and applied as such for 30 years, it was necessary to adopt a new regulation that would be harmonized with the transformation of the constitutional order of Bosnia and Herzegovina and European legal sources in this area. Thus, at the end of 2020, a completely new Law on Occupational Safety of the Federation of Bosnia and Herzegovina was adopted. The adoption of the new law established the principles on which modern labor protection legislation is based, the incorporation of which into the adopted regulation sought to harmonize with international standards, including standards defined at the level of the European Union in this area.*

Key words: *labor protection legislation, Federation of Bosnia and Herzegovina, European legislation, occupational safety*

1. INTRODUCTION

Within any work environment, it is necessary for the employer to provide every worker as a subject of employment relationship with a safe working environment. In this way, the employer creates a safe business zone for all workers and at the same time enables adequate work without fear of any risk to the life and health of workers. In doing so, the employer is obliged, first of all, to eliminate all factors that could result in the death of the worker, especially if it is a job that carries such a risk due to its nature and manner of performance. Also, the same attention should be paid to the elimination of all factors that can lead to bodily injuries or severe damage to the health of workers.

By creating a safe environment in the workplace and introducing preventive measures, the absence of workers from work is reduced or at least reduced to a minimum, which

is of special interest to the employer in order to achieve maximum productivity and better work results.
The existence of an adequate normative framework is of special importance for creating a safe working environment, which in the case of the Federation of Bosnia and Herzegovina meant the adoption of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina in 2020, as well as adjusting internal acts of employers.

2. REVIEW OF PREVIOUS APPLICABLE LEGISLATION

With regard to occupational safety and health, Article 77 of the Stabilization and Association Agreement obliges Bosnia and Herzegovina to harmonize regulations in the field of occupational safety and health. Namely, the competence for enacting regulations in this area in Bosnia and Herzegovina is at the level of the entities and the Brčko District of Bosnia and Herzegovina.[1] Thus, there are three laws: Law on Occupational Safety of the Federation of Bosnia and Herzegovina, "Official Gazette of the Federation of Bosnia and Herzegovina", No. 79/20, Law on Occupational Safety of the Republika Srpska, "Official Gazette of the Republika Srpska, No. 1/08 and 13 / 10 and the Law on Safety and Health Protection of Workers of the Brčko District of Bosnia and Herzegovina, "Official Gazette of the Brčko District of Bosnia and Herzegovina", No. 20/13. Until the adoption of the above regulations, and especially the Law on Occupational Safety of the Federation of Bosnia and Herzegovina, which was adopted at the latest, occupational safety was regulated by the so-called. a republican regulation taken from the earlier system of organization of state power before Bosnia and Herzegovina became an independent and sovereign state.[2]
The adoption of the above regulations in the field of occupational safety in Bosnia and Herzegovina has largely harmonized their provisions with the Convention of the

[1] In addition to the legislature, the executive authorities, ie the competent ministries, have a significant role in achieving the full capacity of occupational safety in Bosnia and Herzegovina, ie its entities, namely: the Ministry of Labor and Social Policy of the Federation of Bosnia and Herzegovina and the Ministry of Labor and Veterans protection of the Republika Srpska. In comparison with the countries from the region with which Bosnia and Herzegovina formed one state union until independence, especially in comparison with the countries that have meanwhile become full members of the European Union, Croatia and Slovenia, respecting the common legal-historical tradition and dynamics of harmonization regulations from the acquis communautaire, in the field of occupational safety and environmental protection in the legislative sense, Bosnia and Herzegovina shows a significant degree of harmonization of regulations.
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International Labor Organization on Occupational Safety and Health No. 155 of 1981, as well as the Protocol to the Convention on Occupational Safety and Health. No. 155 of 2002 and Recommendation No. 164 of 1981 on Health and Safety at Work, which was accepted and ratified by Bosnia and Herzegovina. Relevant European legislation was largely taken into account when drafting the legislation, respecting the provisions of the 1961 European Social Charter relating to the right of workers to safe and healthy working conditions, as well as the provisions of the Council of Europe Framework Directive on measures to encourage improvement. safety and health of workers at work No. 89/391 / EEC of 1989.

There are no special differences between the regulations of the Entities and the Brčko District of Bosnia and Herzegovina in the field of occupational safety, and in terms of content and structure they generally contain the following: definitions of basic terms, primarily referring to persons entitled to occupational safety; general requirements for safe and healthy working conditions; obligations of employers in achieving safety at work, including effective preventive measures; rights and obligations of workers and their representatives; adequate health surveillance; keeping the prescribed records with the employer; work of authorized organizations for safety at work; shortening working hours under certain conditions; inspection supervision; as well as penal provisions.

The main goal of the three laws on occupational safety in Bosnia and Herzegovina is to prevent and prevent injuries resulting from work, as well as the occurrence of occupational and work-related diseases. Employers are responsible for ensuring the highest level of protection at work, but permanent information and education of workers in this field also plays an important role.

3. EUROPEAN LEGISLATION

3.1. European Union standards

Occupational safety within the European Union is an area of activity of the European Agency for Safety and Health at Work (EU-OSHA). Their goal is to promote the importance of protection through a workplace hazard prevention and elimination approach. The Agency investigates hazards and proposes measures to improve safety at work, while participating in its work with member state governments, workers 'and employees' organizations, regulators and private companies.[3]

Measures and regulations in the field of occupational safety are regulated by the OSHA standard. This standard regulates the requirements that work equipment, the environment, as well as facilities must meet. Requirements concerning the building itself have been defined, such as requirements for work surfaces and walking surfaces, so we have for example the regulation for arranging the height of railings on the staircase or in areas where work is done on the elevated. Other regulations concern proposed evacuation and rescue measures, protection of health and hazards from the

[3] Safety at work in the European Union, text available at: https://www.zastitanaradu.com.hr/novosti/Zastita-na-radu-u-Europskoj-uniji-39 (25.05.2022.)

working environment, hazardous substances, personal protective equipment, first aid obligations (such as first aid kits), fire protection and conditions to be met. fire alarm and extinguishing systems, measures for storage and handling of pressure equipment, protection measures to be met by machines with increased hazards and conditions to be met by hand and portable tools, welding devices, measures to be met by electrical installation (from conductor insulation to performance of the guide), working conditions if it is work below the ground surface.[4]

3.2. Directive 89/391/EEC

The main objective of this Directive is to introduce measures to encourage improvements in the safety and health of workers at work. To this end, it contains general principles on occupational risk prevention, safety and health protection, elimination of risk factors and accidents, information, consultation, equal participation in accordance with national regulations and / or practice and education of workers and their representatives, as well as general guidelines for implementation of the above principles. It applies to all sectors, whether public or private, and covers a wide range of activities, but cannot apply to some specific activities in the public administration sector, such as the armed forces and the police.
The most important thing is that the basic principle in this directive is the principle of prevention, and on the basis of this principle and in accordance with the guidelines established by this Directive, a new Law on Occupational Safety of the Federation of Bosnia and Herzegovina was adopted. The new institutes that have been introduced are a reflection of this principle of prevention and the emphasis is on preventing the risk of health or safety of workers.
Thus, according to this Directive, for the purpose of fulfilling the mentioned principle, the employer's obligations are as follows: risk avoidance, assessment of unavoidable risks, suppression of risk causes, adaptation of work to the individual, especially with regard to job design, selection of work equipment and production methods. with the aim of facilitating monotonous work and work at a previously determined working speed and reducing their impact on health, adapting to technical progress, replacing the dangerous with non-dangerous or less dangerous, developing a coherent comprehensive prevention policy related to technology, work organization, working conditions, social relations and impact factors related to the working environment, giving priority to collective protection measures in relation to individual protection measures, giving appropriate instructions to workers.[5]
The Directive focuses not only on the activities of the employer but also on the manner in which workers themselves or their representatives participate in ensuring protection measures. Thus, there is an obligation of the employer to appoint one or more workers to carry out activities related to the protection and prevention of occupational risks. Such a worker's representative has the right to require the employer to take appropriate measures and to inform him of proposals for mitigating the danger to workers and /

[4] Safety at work in the European Union, text available at: https://www.zastitanaradu.com.hr/novosti/Zastita-na-radu-u-Europskoj-uniji-39 (25.05.2022.)
[5] Council Directive 89/391 / EEC.

or eliminating sources of danger. Thus, the directive indicates the necessary close and efficient cooperation between workers and employers. The entire burden of monitoring working conditions cannot be placed on the employer, nor can it be expected that workers are the ones who will provide themselves with adequate working conditions. Therefore, it is important that workers inform the employer about the real situation in the workplace, and the employer is the one who is obliged to take all measures to combat all possible risks.

4. NOVELS OF LABOR PROTECTION LEGISLATION IN THE FEDERATION OF BOSNIA AND HERZEGOVINA

4.1. The need for a new law

The Parliament of the Federation of Bosnia and Herzegovina is on October 1, 2020. adopted a new Law on Occupational Safety of the Federation of Bosnia and Herzegovina. It was necessary to pass a new law because the old Law on Occupational Safety has been applied since 1990, which means that the law has been applied for 30 years, and in accordance with it, numerous bylaws and internal acts that do not correspond to new circumstances.

Society itself is active and dynamic, and one of the most important segments of an individual's social life is the establishment of an employment relationship, as well as the realization of certain rights and obligations from that employment relationship. For labor law as a fairly young legal discipline as well as the legal branch, 30 years is a fairly long period within which there have been no changes in terms of protection and safety of workers in the workplace.

The protection of workers cannot be neglected because every worker has the right to work and make material gain within both an economically stable community and a community within which he does not have to worry that his health will be impaired. The adoption of the new law establishes the principles on which modern legislation is based and strives for harmonization with international standards, including standards defined at the level of the European Union.

4.2. Law on Occupational Safety of the Federation of Bosnia and Herzegovina from 2020

The new Law on Occupational Safety of the Federation of Bosnia and Herzegovina states that this Law regulates the rights, obligations and responsibilities of employers and workers in relation to the implementation and improvement of safety and health of workers at work, as well as general principles of prevention and safety rules. and protection of health at work, the application of which achieves the prevention of injuries at work, occupational diseases and other diseases related to work, as well as protection of the working environment, and other issues related to safety and health

at work.[6] Therefore, the goal of the Law is stated, as well as what is to be achieved, and the employees and the employer are listed as entities that have rights and obligations.
What should be especially emphasized is the fact that the new Law emphasizes the existence of special protection for young people, women, and protection of persons with disabilities and occupational diseases, as well as preserving the working abilities of older workers within the limits appropriate to their age. Therefore, at the very beginning of the Law, the protection of special categories of workers is emphasized and their special protection is pointed out.

4.2.1. Worker protection measures

The Law on Occupational Safety of the Federation of Bosnia and Herzegovina provides for measures to protect workers at work, which include three basic groups of measures, namely: measures that directly ensure safety at work, measures related to working conditions and measures related to special protection of workers.[7] Furthermore, it regulates in detail what one of the mentioned measures includes. However, although it is stated that there is an obligation to periodically inspect and test the means of work and equipment, it does not specify when such inspections will be carried out, but it is determined that it depends on the collective agreement as a general act. Although these are non-mandatory examinations, the manner of their conduct cannot be adequately determined in the collective agreement, but it is necessary to adopt a special internal act which will define the manner of conducting such examinations, but also to take other actions to prevent bodily injuries. or some other form of damage to the health of workers. That is why the positive trend is that the new law establishes the obligation of the employer that there must be both an internal act on safety at work and an act on risk assessment.

4.2.2. Occupational Safety and Health

Council In relation to the previous law, the new Law on Occupational Safety prescribes: which persons have the right to safety and health at work, the formation of occupational safety councils, the institute of risk assessment at workplaces and workplaces in the work environment for all employers , the institute of "occupational safety workers" is envisaged for those employers who have jobs with increased risk, the institute of "occupational safety commissioner" is established as a representative of workers with special rights, internal acts on occupational safety and risk assessment acts.[8]

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[6] Article 1, Law on Occupational Safety, “Official Gazette newspaper of the Federation of Bosnia and Herzegovina ", no. 79/20.
[7] Article 6, Law on Occupational Safety, “Official Gazette newspaper of the Federation of Bosnia and Herzegovina ", no. 79/20.
[8] "What the new Law on Occupational Safety brings" "text available at: https://www.akta.ba/najave/sta-donosi-novi-zakon-o-zastiti-na-radu-u-odnosu-na-zakon -iz-1990-te-godine- / 125922 (25.05.2022.)

One of the new institutes of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina is the Occupational Safety and Health Council. Representatives of the Government of the Federation, the Association of Employers, trade unions and prominent experts in occupational safety and health work within the said council. Thus, it can be concluded that the Council acts in accordance with one of the basic standards of the International Labor Organization, which is a tripartite system that involves the participation of government representatives, employers and workers in discussing all issues related to labor relations. In this way, cooperation is achieved between the employer and the workers whose interests may be opposed, so the presence of a neutral subject with authority is needed, and that is the representatives of the government. The Council has a total of nine members and is elected for a period of four years. The main task of the Council is to review the policy of safety and security at work and instruct the authorities regarding their harmonization with the applicable regulations and standards. After conducting an analysis in terms of protection and safety policy, it must inform the Government of the Federation and propose certain changes, all in order to improve working conditions, ie primarily to ensure adequate protection at work.[9]

4.2.3. Risk evaluation

Considering that this law was adopted in accordance with Directive 89/391 / EEC, which emphasizes the principle of prevention, the Act itself states that the employer implements occupational safety measures in compliance with the following principles: risk assessment, risk avoidance, risk prevention, risk elimination. source, adaptation of work and place of work to the worker, especially with regard to the choice of work equipment and methods, as well as the choice of technological procedure to avoid uniformity in work in order to reduce their impact on workers' health, adapt to technical progress, replace hazardous technological processes or methods work with harmless or less dangerous, replacement of hazardous substances with harmless, establishing unique preventive measures to interconnect technology, work organization, working conditions, social relations and the impact of factors related to the working environment, giving priority to joint protection measures over individual, appropriate training and informing workers.[10] One of the most important tasks of the employer for the realization of the principle of prevention is the adoption of the internal act on occupational safety and the act on risk assessment. An occupational safety worker and an occupational safety commissioner also participate in the process of adopting such acts.
Risk assessment is the systematic recording and assessment of all factors in the work process that can cause injuries, illnesses or damage to health and determine the possibilities, ie ways to prevent, eliminate or reduce risks, obligations and responsibilities of occupational safety workers and other workers in this areas, as well

[9] Article 7, Law on Occupational Safety, “Official Gazette newspaper of the Federation of Bosnia and Herzegovina ", no. 79/20.
[10] Article 21, Law on Occupational Safety, “Official Gazette newspaper of the Federation of Bosnia and Herzegovina ", No. 79/20.

as other issues of importance for safety and health at work.[11] The Risk Assessment Act contains a description of the work process with an assessment of the risk of injury or damage to health at the workplace in the work environment and measures to eliminate or reduce the risk to a minimum in order to improve safety and health at work. The employer performs risk assessment on the basis of the Rules on Risk Assessment, adopted by the Federal Minister of Labor and Social Policy, in cooperation with the Federal Minister of Health, and which have been applied since March 16, 2021.[12]

4.2.4. Worker and Commissioner for Occupational Safety

The law stipulates that an employer who is obliged to appoint one or more workers for safety at work is one who has jobs with increased risk. This worker will be obliged to take all measures to prevent risk at work and ensure health protection in the workplace. Only a person who has the appropriate professional qualifications and is able to perform all tasks related to safety at work can be appointed to this position. There is an obligation of the competent Minister of Labor to determine which conditions must be met by the professional staff of the employer, including the worker for safety at work. In addition to workers for safety at work, it is necessary to appoint a commissioner for safety at work, and this obligation lies with the employer who employs 30 or more workers. However, it is possible to appoint a commissioner for safety at work, regardless of the number of workers, if required by working conditions (eg work in isolated places). The Commissioner for Occupational Safety and Health has the right to receive information on working conditions, analysis of injuries at work, occupational diseases and work-related illnesses, findings and recommendations of inspection bodies, may request the employer to take appropriate measures and submit proposals for risk mitigation and eliminate sources of danger, inform workers about the implementation of occupational safety measures, request an inspection if it considers that the measures taken by the employer are not appropriate to ensure safe and healthy working conditions and present their observations during the inspection, attend inspections and / or submit their observations during inspections. The commissioner is elected on the proposal of the union or at least 20% of the total number of employees who are employed:

a) a list of all workplaces where the risk assessment has been carried out, indicating the degree of risk identified,
b) a list of jobs identified as high-risk jobs,
c) priorities in eliminating risks,
d) a statement by the employer undertaking to apply all established measures for the safe and healthy work of workers.[13]

[11] Law on Occupational Safety of the FBiH - implementation, text available at: https://rec.ba/zakon-o-zastiti-na-radu-u-fbih-implementacija/31552/ (25.05.2022.)
[12] Law on Occupational Safety of the FBiH - implementation, text available at: https://rec.ba/zakon-o-zastiti-na-radu-u-fbih-implementacija/31552/ (25.05.2022.)
[13] Article 45, Law on Occupational Safety, "Official Gazette newspaper of the Federation of Bosnia and Herzegovina ", No. 79/20.

If the employer does not pass an internal act on safety at work, he will be fined in the amount of 2,000 to 10,000 KM, and this penalty can be imposed if he does not take adequate preventive measures to protect at work.

5. CONCLUSION

The adoption of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina is a significant step in the concrete protection of life and health of workers in the Federation of Bosnia and Herzegovina in relation to the then valid Law dating back to 1990. The new Act sought to achieve the basic principles enshrined in Directive 89/391 / EEC. All new institutes taken from the said Directive are primarily aimed at preventing risks to the safety and health of workers at work.
In order to carry out the adequate implementation of the specific Law, the employer is obliged to ensure the adoption of adequate internal acts, such as the act on risk assessment and the act on safety at work. However, in that process, the role of the workers themselves is very important, which is expressed through the rights and obligations of workers for safety at work and the commissioner for safety at work. The role of the representatives of the government, specifically the line ministry, which should determine certain rules and criteria regarding the selection of the mentioned employed professionals by the employer, is not negligible either.
One of the most important novelties of the new Law on Occupational Safety of the Federation of Bosnia and Herzegovina is the act on risk assessment because this act can accurately predict all potential risks in a particular workplace and accordingly ensure adequate measures to protect workers.
In achieving any segment of the employment relationship, the cooperation of the government, workers and the employer is necessary, as well as in terms of safety at work. Only by joint work of all participants in the employment relationship will it be possible to achieve the goals and tasks that are represented by the legal norms of the Law, and thus the European legislation in this area.

LITERATURE

[1] Directive 89/391 / EEC
[2] Law on Occupational Safety, "*Official Gazette. newspaper of SR BiH* ", No. 22/90.
[3] Law on Occupational Safety *"Official Gazette" newspaper F BIH* ", No. 79/20.
[4] Law on Occupational Safety of the F BiH - implementation, *available text at*: https://rec.ba/zakon-o-zastiti-na-radu-u-fbih-implementacija/31552/
[5] What does the new Law on Occupational Safety bring? "*Text available at*: https://www.akta.ba/najave/sta-donosi-novi-zakon-o-zastiti-na-radu-u-odnosu-na-law-of-1990-that-125922
[6] EU OSHA, *text available at*: https://www.hzzzsr.hr/index.php/eu-osha/
[7] Safety at work in the European Union, *text available at*: https://www.zastitanaradu.com.hr/novosti/Zastita-na-radu-u-Europskoj-uniji-39

CHANGES IN THE EDUCATION PROCESS AND THE ROLE OF STUDENTS DURING THE COVID-19 PANDEMIC IN BOSNIA AND HERZEGOVINA

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Abstract
The Covid-19 pandemic and the lockdown brought significant changes in the educational process so far around the world, including in Bosnia and Herzegovina. The entire population was asked to adapt to the new situation. Educational institutions, their staff and students have more or less adapted to the new situation and made a significant contribution to solving this problem caused by the pandemic. The paper presents some aspects of changes in the education process in BiH and the role of students in this process during the pandemic.

Key words*: Covid-19, changes in the education process, the role of students.*

1. INTRODUCTION

During the pandemic, the education system in Bosnia and Herzegovina, as well as the rest of the world, underwent abrupt and forced changes. As a result, the classical teaching that was represented has been replaced by virtual or online teaching in various forms and applications. The most difficult challenge was quickly adapting to this type of teaching in order to avoid significant losses in the teaching process. One of the most challenging issues was the unknown: "How long will the Covid-19 pandemic last?" This type of education can have a negative impact on the participants' physical, mental, and emotional health of protective masks and high demand caused the production of protective masks made of fabric.

Online classes were established in all levels of education in a short period of time, and while some students worked from home, others followed the classes using digital technologies and various available applications. In addition to the teaching process, students and professors worked tirelessly to combat the pandemic in their respective fields. Making visors with a 3D printer has become the primary occupation of many makers worldwide, including those in Bosnia and Herzegovina. Fabric protective masks were produced due to a scarcity of protective masks and high demand.

A group of students and professors from Bihać's Technical Faculty joined these activities, and only fifteen days after the lockdown began in 2020, they produced the first visors, which they distributed to the most vulnerable population. In addition, students and professors from this faculty's textile department worked on creating protective masks out of fabric. During the Covid-19 pandemic in Bosnia and Herzegovina, changes in the educational process and the role of all participants (students and professors) in this process must be viewed from several different angles (aspects), taking into account: changes in the way of teaching, the contribution of students and professors in activities to prevent the spread of infection, and the impact of the aforementioned measures and activities on the health of students.

2. ONLINE TEACHING DURING THE PANDEMIC

With the emergence of the Covid-19 pandemic, which forced almost the entire world to replace traditional classroom instruction with online instruction, there was a sudden increase in the use of certain types of online communication. Given the availability of the Internet and the widespread use of technology in education, it was easier to adapt to the new situation that would affect the entire world in March 2020. Then it turned out to be an excellent solution not to lose classical teaching, but to replace it online, with over 1.37 billion students worldwide, according to UNESCO data. [4] What could be assumed, but was not so important at the time, is that this type of teaching can have a negative impact on young people's mental, emotional, and physical health.In addition to adapting to this type of teaching, the students and their professors had a number of other problems that they had to face, such as poor internet coverage, outdated equipment or lack of adequate equipment for teaching, as well as a lack of space inside their homes because they all had to some way to work online.

Nowadays, online teaching entails simultaneous communication (audio or video) between students and professors, as well as independent student work with communication between students and professors in a written format, such as e-mail.

This type of online learning is known as synchronous learning in research, as it involves professor-student communication via video link. Many people are uncomfortable with this type of meeting, i.e. classes, and it takes time for them to adjust. In contrast to traditional communication, students can feel uncomfortable because they cannot see who is looking at them or what they see in a part of the work space. This has been demonstrated through video communication research. [2]

Distance learning first appeared in the world in the 18th century, when lessons were sent via postal letters. Later on, the delivery of learning material is done via audio broadcasting. [3] Later, easier and more accessible video technology led to increased use in distance learning types, which produced positive results. As in the rest of the world, but also in Bosnia and Herzegovina (and at our University in Bihać), this is not new, and even before the pandemic, students had the opportunity to follow some of the classes through online class applications. As a result, this request was quickly met, and classes were established in all directions within a week.

Distance education, also known as online education, gives students independence, flexibility, and a better use of their time by allowing them to study materials, watch videos, and complete various tasks. If it is a case of synchronous learning via some of the applications where students and professors interact.

According to research on the effectiveness of distance learning, which includes online courses, student learning is comparable to that of traditional classes. [1] Other research has found that students in online courses had significantly lower retention rates when compared to groups that attended traditional classes. Researchers use the term sense of community to describe the differences between these two types of teaching. There was also a stronger connection with colleagues in traditional classes than in online classes, which is understandable given the group cohesion and the possibility of more interaction and free speech. It is important to note that the members of the online group expressed greater satisfaction with their team, were kinder, more precise, and more specific in their mutual communication, all of which are indicators of improved group cohesion as a result of distance learning. As a result, advantages and disadvantages are a broad topic for debate, depending on the type of group, the learning topic, the duration, and a variety of other factors that can favor one side or the other. [1]

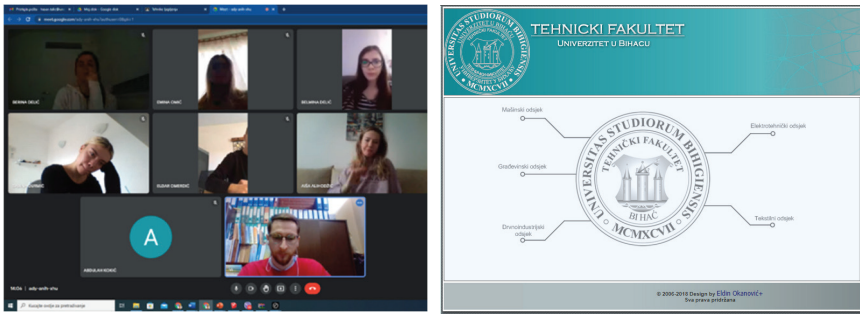

Figure 1: Online teaching, information system of the Technical Faculty in Bihać

The technical faculty, i.e. the University of Bihać, has an information system that has modules for interaction between students and professors, setting teaching materials, checking knowledge in the form of tests or quizzes. It also has its own Adobe connect platform for virtual classroom distance learning, but it also uses other available applications such as ZOOM, SKYPE, Google Classroom, Viber, Whats App, and many others.

On a daily basis, students were communicated with via info service, e-mails, organizing viber, whats app, or messenger groups, necessary materials were delivered, instructions were sent, and their possible suggestions and proposals were accepted. Similarly, other universities in Bosnia and Herzegovina held online classes, with varying degrees of success, utilizing the applications and possibilities mentioned.

3. PARTICIPATION OF STUDENTS IN ACTIVITIES TO PREVENT THE SPREAD OF THE PANDEMIC

It also has its own Adobe connect platform for virtual classroom distance learning, but it also uses other available applications such as ZOOM, SKYPE, Google Classroom, Viber, Whats App, and many others. On a daily basis, students were communicated with via info service, e-mails, organizing viber, whats app, or messenger groups, necessary materials were delivered, instructions were sent, and their possible suggestions and proposals were accepted.

Similarly, other universities in Bosnia and Herzegovina held online classes, using the aforementioned applications and opportunities with varying degrees of success. Ofcourse, this represented a great challenge and adaptation for both students and professors. In addition to adapting and transitioning to online classes in a very short period of time, students and professors put their newly acquired knowledge into practice, helping to prevent the spread of the Covid-19 infection not only at the university, but also in the larger community.

The concept of "makers" producing parts for protective visors on a 3D printer suddenly appeared in the world. This concept influenced all decision-makers, including those in Bosnia and Herzegovina and the region. Several of them began making protective visors in this manner with the Sarajevo-based company DizArt d.o.o. Almost on the same night, students and their assistants from Biha's Technical Faculty begin the first 3D printing in their homes, with the intention of transferring the action to the faculty in the coming days ("Students from Bihać's Technical Faculty, along with their assistants and professors, began producing protective visor masks for healthcare workers in the Una-Sana Canton (USK). Hasan Talić and Dženan Bajrić from Bužim created the first visor masks using a 3D printer, and young people from Cazin, Velika Kladuša, and Bihać are already following in their footsteps." [5]). A laboratory for the production of protective visors using 3D printers was established thanks to the equipment owned by the Faculty of Engineering and the knowledge of their professors and students.

They shared their knowledge with their colleagues in the region, and within a few days, all of the printers in the USK area had only one task: printing protective visas. Printing took place 24 hours a day, both at the university and in the homes of professors and students, to increase productivity and respond faster to the need for visors. After a few days, this group of professors and students were able to deliver the first visors to those in greatest need, the Biha Cantonal Hospital and health centers. [5,6]

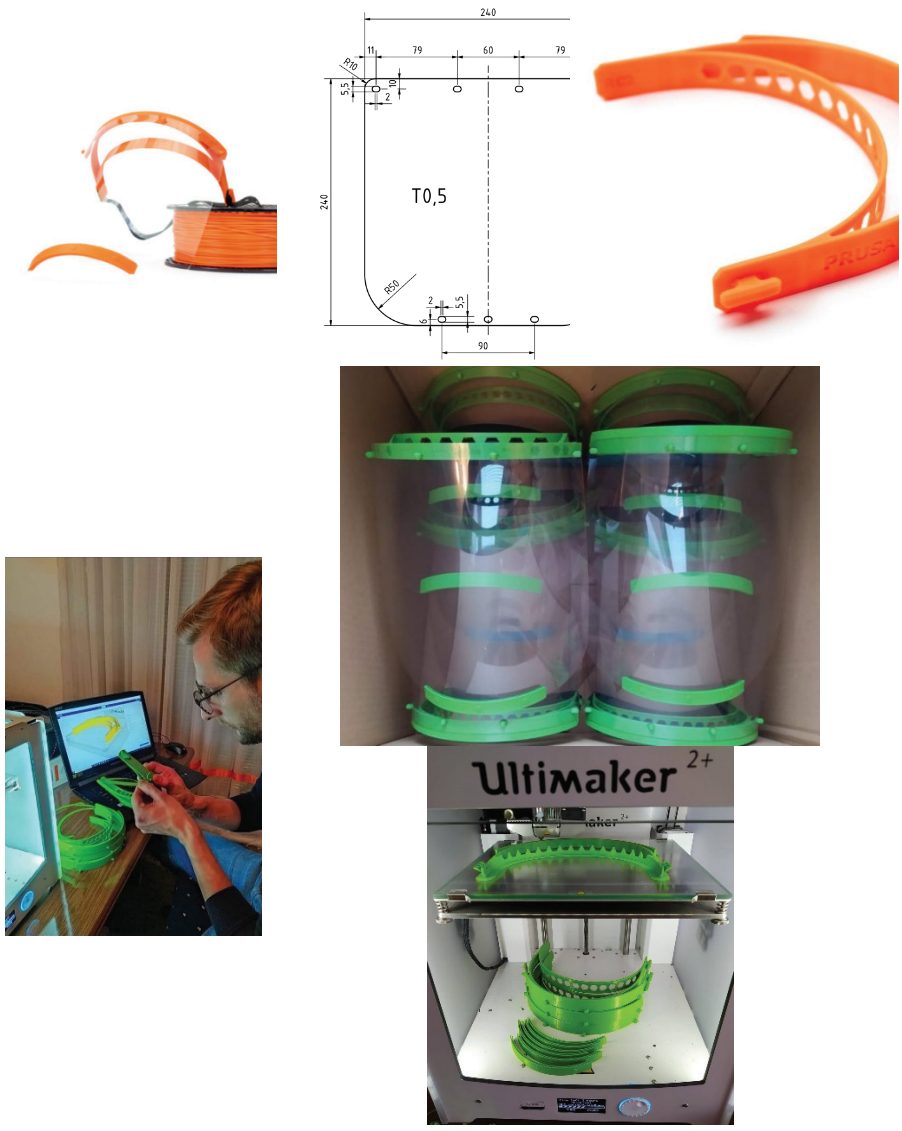

Figure 2: Making a protective visor using a 3D printer [7]

Given that 3D printing technology is relatively slow, increasing productivity has been a challenge. It was necessary to manufacture a large number of visors in a short period of time, which was nearly impossible. The printing process must first be optimized in order to increase production speed. It took 5 to 6 hours to print one set of supports, depending on the printer. Aside from the type of printer, several parameters influence print speed, including layer height, print speed, print quality, nozzle size, and so on. Correcting these parameters reduces printing time by

approximately 50%. The first model printed was PRUSA, and the second step in reducing time was the creation of a new model called KR, which took slightly more than an hour to print. Meanwhile, companies that make plastic products through injection molding worked on developing prototypes and molds for quick assembly of the visor mounts. Of course, this is a time-consuming process, for which printed visors were still being produced, and the first high-speed carriers appeared within a few weeks. This type of production had a daily capacity of several thousand.

Thousands of visors were made using 3D printers and distributed free of charge to the most vulnerable people in Bosnia and Herzegovina, including workers in hospitals, police, the Red Cross, social institutions, volunteers, workers in post offices, schools, banks, and stores. This action was supported by colleagues from Sarajevo, Banja Luka, Zenica, Tuzla, Mostar, Travnik, and many other cities in Bosnia and Herzegovina, in addition to students and professors from the Technical Faculty in Bihać.

The visor is made of two printed PLA plastic parts: the upper part supports the user's head, and the lower part forms the visor's curvature and reinforcement. On the upper part, an elastic band is placed that is adjustable depending on the size of the user's head and other equipment on the user's head. The visor's final component is Polyethylene Terephthalate Glycol, or PETG, a thermoplastic polyester that is transparent and provides significant chemical resistance, durability, and excellent formability for manufacturing. It is laser cut for greater precision and easier mounting on supports; the cutting scheme is depicted in the image (Figure 2).

The start of the world's closure, combined with high demand for masks, resulted in their sudden disappearance from the market and an increase in their prices. The alternative was to make improvised masks out of various fabrics. Students and professors from the textile department of Bihać's Technical Faculty contributed by sewing face masks.

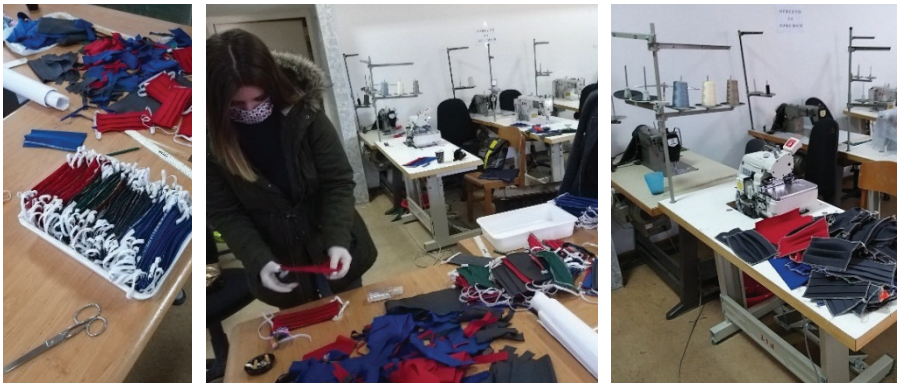

Figure 3: Sewing protective masks at the Technical Faculty in Bihać

Several students and professors came to the university for days preparing material and sewing such masks for the most vulnerable population of people and distributed them for free. It was also an opportunity to provide a certain number of masks for employees and students of the faculty.

4. INFLUENCE OF ONLINE TEACHING ON STUDENTS' HEALTH

During the COVID-19 pandemic, the education system underwent abrupt changes, leaving certain consequences. Knowing that traditional teaching has been replaced by online instruction, a new e-education system is developed. This is how we get terms like e-education, e-learning, distance teaching, distance learning, online teaching, e-teaching, face-to-face teaching, online education, and so on.

Online teaching is a type of learning in which there is no physical presence or contact between professor and student, and the learning process itself takes place in a virtual environment with the assistance of digital technologies. Professors and students face new and different challenges when it comes to online learning. For students, it will first and foremost be self-discipline, independent and high-quality time management, patience, dedication, and persistence. All of these elements require the support of professors to maintain a sufficiently high level of motivation. As with anything else, there are advantages and disadvantages to taking online classes, some of which are listed below. [8]

Table 1: Advantages and disadvantages of online classes [8]

Advantages	Disadvantages
• flexibility of working at your own pace and time, • avoiding travel, • developing personal responsibility for learning, • developing skills in processing available information, • a feeling of security behind the screen in participating in classes, • lectures can be recorded and watched again, • it is cheaper for the social community if education is accessible to all, • sick students can participate in the work.	• live contact is irreplaceable, especially in children, • weak technical support related to material circumstances, • technical difficulties can frustrate and encourage giving up, • weak motivation caused by insufficient IT literacy of professors and students, • the classical educational role of the professor is reduced, • technology costs, • the teacher will have a harder time focusing on the students individually, • a multitude of platforms and the constant need for additional training,

When asked about online classes, many students (at the Technical Faculty in Biha) stated that they have certain advantages and possibilities (as shown in the previous table), but that they gain more knowledge from classical classes, have a greater motivation for learning, and would rather choose classical classes than online classes. If given the option, seven out of ten students said they would prefer classical education.

The negative effects of online classes on students' physical and psychological health can be seen. When discussing physical health, it is critical to emphasize the dangers that can occur in both children and adults. Vision problems are one of the first issues that arise in both children and adults. Because of excessive exposure to harmful computer screens, eye strain and vision problems are frequently referred to as

"computer vision syndrome." One study found that the prevalence of eye strain was higher among students who took online classes compared to the general population, and that online students outperformed teachers and the general population on the digital eye fatigue test. [9] Gammoh (2021) finds a similar prevalence of computer vision syndrome in students aged 18-24 years, with weeping eyes as the most common symptom 59 percent, followed by headache symptom 53 percent, eye itching symptom 51.4%, and 50.7 percent with the symptom of increased sensitivity to light. [10] Following that, physical changes and problems are associated with body postures. Because ergonomic procedures are not followed when using technological devices, this includes pain and tension in the neck, back, and shoulders. Research shows the existence of a link between musculoskeletal disorders and online classes during the COVID-19 pandemic. In that study, 80 percent of students reported symptoms of headache and neck pain; 58 percent of students report symptoms of musculoskeletal disorders in the right shoulder and 56 percent of students in the right hand's fingers; and more than 40 percent of students have experienced at least some symptoms of musculoskeletal disorders since beginning to take online classes. [11]

Other common injuries and pains on the hands, specifically the joints, have a negative impact on sleep quality, and insufficient physical activity causes these and other physical health disorders. Given that the global pandemic of COVID-19 caused a massive transition to online classes, students felt additional pressure and concern for their education. So, for example, there is an increased concern about the repetition of the year. It is possible that social isolation and a lack of interpersonal communication can increase anxiety and, as a result, the intensity of psychological distress. The findings of the qualitative study show an increase in irritability, with many students expressing anger when there is a disruption in the environment or when the Internet is interrupted during online learning. [12] Students who switched to online classes during the COVID-19 pandemic achieved significantly higher results on the scales of exhaustion and cynicism compared to groups of students from other studies, while achieving better results on the scale of professional efficiency. [13] Demotivation, the state without intrinsic and extrinsic motivation, is the factor that most contributes to the failure of online students. For ages between 15 and 16, it was found that high exposure to digital media increases the likelihood of developing symptoms of hyperactivity disorder. We associate the increase in time spent in front of digital screens with depression and suicidal behavior in adolescents. [1]

5. CONCLUSION

The sudden situation caused by the Covid-19 pandemic required the entire population, particularly students and professors, to quickly adapt to a new way of life. The transition from traditional to online education occurred quickly at the University of Bihać, as well as at all other educational institutions in Bosnia and Herzegovina. Thus, classes were held, knowledge was acquired, and all other activities were carried out using various applications (Infosistem, Zoom, Skype, Google Classroom, Viber, Whats App, and so on). Of course, this presented its own set of challenges, such as inadequate technological equipment, a lack of application knowledge, a lack of coverage or a weakness in the Internet, all of which impacted the quality of the

teaching to varying degrees. However, students at Bihać's Technical Faculty chose classical teaching as superior and because it provides them with more opportunities during their education, as some activities are nearly impossible to perform virtually.

Professors and students from this faculty and around the world made significant contributions to the application of acquired knowledge in concrete activities to prevent the spread of infection, such as making visors using 3D printing technology and sewing fabric masks.

The accelerated transition from traditional to online teaching had a significant impact on the health of all educational participants. It is visible in the physical, psychological, and mental health of the process's participants, particularly students. This negative influence has been demonstrated in various studies by other scientists, and some of the results observed in our students are listed in the paper. As a result, switching to online classes has resulted in increased vision problems, frequent headaches, muscle pains, depression, and other direct or indirect consequences.

LITERATURE

[1] Beganović H.: *Consequences of online classes on students' health,* University of Sarajevo, Sarajevo 2021.
[2] Bedenlier S., Wunder I., Michaela G-Z., Kammerl R., Kopp B., Zieglerc A., Handelc M.,: *Higher education students' (non)use of webcams in synchronous online learning,* International Journal of Educational Research Open, 2021, https://doi.org/10.1016/j.ijedro.2021.100068
[3] Siemens, G., Gasevic, D., Dawson, S.: *Preparing for the digital university: a review of the history and current state of distance, blended, and online learning,* Atabasca Univeristy Press, 2015.
[4] UNESCO: Downloaded from: https://en.unesco.org/news/137-billion-students-now-home-covid-19-school-closures-expand-ministers-scale-multimedia Accessed: 2022.06.15
[5] Portal Radiosarajevo: Downloaded from: https://radiosarajevo.ba/metromahala/teme/studenti-iz-bih-3d-printerom-izraduju-zastitne-vizir-maske-za-medicinsko-osoblje/371795 Accessed: 2022.06.15
[6] Trend radio Velika Kladuša: Downloaded from: https://www.trendradio.ba/volonteri-iz-krajine-prozvode-maske-sa-vizirom-pomocu-3-d-printera/ Accessed: 2022.06.13
[7] Prusa: Downloaded from: https://www.prusa3d.com/page/covid-19_379/ Accessed: 2022.06.18
[8] Marina Č.: *Distance learning*, 2021 Downloaded from: https://hrcak.srce.hr/file/370991 Accessed: 2022.06.19
[9] Ganne P., Najeeb S., Chaitanya G., Sharma A., Krishnappa NC.: *Digital Eye Strain Epidemic amid COVID-19 Pandemic - A Cross-sectional Survey*, Ophthalmic Epidemiology:1-8. 2020.
[10] Gammoh Y.: *Digital Eye Strain and Its Risk Factors Among a University Student Population in Jordan: A Cross-Sectional Study*, Cureus 13(2), 2021.

[11] Karingada K.T., Sony M.: *Demonstration of the relationship between MSD and online learning during the COVID-19 pandemic,* Journal of Applied Research in Higher Education, 2021. Downloaded from: https://doi.org/10.1108/JARHE-08-2020-0269
[12] Irawan A., Dwisona D., Lestari M.: *Psychological Impacts of Students on Online Learning During the Pandemic COVID-19*. KONSELI: Jurnal Bimbingan dan Konseling (E-Journal). 2020.
[13] Gonzalez-Ramirez J., Mulqueen K., Zealand R., Silverstein S., Reina C., BuShell S., Ladda S.: *Emergency Online Learning: College Students' Perceptions during the COVID-19 Crisis.* SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3831526 2020.

FINANCIAL INSTITUTIONS AS TARGETS OF ROBBERY

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Abstract

The most common criminal act in the world and there fore also in Croatia are acts of property offenses and through this work we are going to process criminal act „Theft" and „aggravated theft" and also criminal act of property offenses with elements of violence that includes criminal act „Robbery", „Robbery theft", and „extortion". We will primarily be based on criminal offenses „ Robbery", committed by individuals but also as a form of organized crime group activity. Latterly, criminal acts of property offenses with elements of violence are not a rarity, but when they are made by a group then the object of attack in most cases are institutions that can obtain substantial material gain in addition to the above crimes we mentioned earlier. The objects of attack are often a monetary institution (bank, currency exchange office, ... etc.), it is also common that vehicles carrying money or securities are intercepted and thats why they are provided with secirity personal and high grade technical protection. Further in this work we will process and analyze an event of multiple ciminal acts „robbery" by an organized criminal group in which „a prominent member" was the an security personal who was providing physical security in a bank that was also the object of attack.

Key words*: robbery; property offenses; monetary institutions; physical protection,*

1. INTRODUCTION

Monetary institutions are supplied with a significant amount of money, i.e. a larger amount of money circulates through them every day as part of their activities, and as such they need additional protection, which is prescribed by the laws and by-laws of the Republic of Croatia. In accordance with the legal provisions, certain financial institutions must also have "physical protection" as a form of protection, i.e. a licensed security guard to perform private protection. As stated, a larger amount of money and

securities circulates in financial institutions, and as such they are often the targets of attacks by robbers, both individual robbers and organized robber groups.

2. HISTORY OF ROBBERY

War is said to incite violence and often precedes the development of marauding gangs. In the United States, the end of the Civil War in 1865 marked the beginning of a period of banditry unmatched until the 1920s and 1930s. It should not be particularly surprising that wars are often the forerunners of banditry, since in countries like England it was common to recruit criminals into the army in exchange for pardon. Throughout history, the term "noble robber" has developed, which best symbolizes "peasant outlaws" like the American Jesse James, and such social gangs are depicted as a special type of criminals, "peasant outlaws who are considered criminals by the master and the state, but who remain within the peasant society" in who consider them "heroes", "fighters for justice" and people "who should be admired, who should be helped and supported". The noble robber is best depicted in the myth of Robin Hood. In the territory of the Republic of Croatia, in the area of Slavonia, Jovo Stanisavljević, aka Čaruga, initially acted as an independent outlaw, while later he organized an outlaw group that engaged in robberies. [1]

3. LEGAL REGULATION REGARDING THREATS TO MONETARY INSTITUTIONS

A review of the regulations that legally regulate this area revealed a large number of legal acts and norms, and one of the most important laws related to financial institutions is the Law on the Protection of Monetary Institutions. The purpose of this Act is to reduce risk and increase the protection of persons in financial institutions, which is achieved by directly protecting them or indirectly by protecting their assets. Monetary institutions that are obliged to apply the Act on the Protection of Monetary Institutions are: 1. Croatian National Bank 2. Croatian Monetary Institute 3. Financial Agency (FINA) with associated day and night vaults 4. Banks and savings banks with associated internal and external ATMs, daily - night vaults and safety deposit boxes and internal and external ATMs of other legal entities 5. housing savings banks 6. post offices 7. branches of the Croatian Lottery 8. exchange offices and currency exchange offices 9. betting shops 10. credit unions 11. slot machines-clubs 12. jewelry stores, silversmiths, filigree shops, offices for the purchase of precious metals and valuables, and legal entities and trades for the processing of precious metals 13. casinos 14. legal entities and trades that perform monetary business through cash payment transactions. [2]

Spatial-technical protection measures mean general minimum conditions that define the appropriate arrangement and equipment of the branch in order to enable the smooth and safe movement and stay of parties and employed staff, as well as smooth operations during the manipulation and distribution of cash and valuables. Every financial institution for the implementation of spatial-technical and organizational measures as well as physical, technical and other protection measures in branches must appoint a person in charge of implementation of protection measures in the branch office in accordance with the prescribed security procedures in a "general act". [2]

3.1. Body protection in financial institutions

Physical protection - protection of persons and property that is performed by the personal presence of the person performing protection tasks and his protective activity, without the dominant use of technical means and devices (guard, security guard, specialist security guard...). Guards, security guards and specialist security guards carry out physical protection of persons and property in accordance with the conditions, methods and powers prescribed by the Law on Private Protection and the Ordinance on the Implementation of Physical Protection. The security guard, depending on the issued work order, performs private protection duties during the distribution of money and valuables and other shipments and persons as a security guard driver or escort security guard.

Persons performing private security duties are obliged, when performing such duties, in case of detection of a possible criminal offense or misdemeanor with elements of violence, based on their own security assessment, to personally provide intervention by proportionate application of the appropriate authority prescribed by the Law on Private Protection, in order to prevent it or reduce its consequences which would arise due to its commission. If, for security reasons, the private security rooms cannot provide immediate intervention, they are obliged to immediately inform the police of all information that points to the commission of a criminal act or a misdemeanor with elements of violence. Persons who perform physical protection tasks, when performing these tasks, may not simultaneously perform other tasks that hinder or prevent the smooth implementation of physical protection of persons and property, and may not leave the perimeter of the protected object, space or surface while performing these tasks, except in exceptional circumstances immediate danger to life. Also, persons performing physical protection tasks must be alert and concentrated when performing these tasks, must not be under the influence of alcohol and drugs, and must respect the dignity of parties, employees and other persons.

Perimeter – the extent that delimits the space inside and around the protected object, public and other surfaces, or next to the protected person, within which the application of private protection is allowed.

Before borrowing a firearm, the security guard and specialist security guard must check the correctness and readiness of the weapon for use and, in the case of a pistol, make sure that there is no ammunition in the barrel. Weapons are checked in a safe room, and a safe room is any room where there are no other people during the weapon check. [3]

4. PROPERTY OFFENSES

Criminal offenses against property (property crimes) are quite widespread and represent a significant percentage of the total amount of crime, and according to the total number of reported and detected crimes, property crimes sometimes make up 70% of the total crime because many of the forms of other groups of crimes are concealed. , unnoticeable so that they are not detected or registered, in contrast to property crimes that are most often reported by the injured person, but the perpetrators of such crimes are often unknown. Therefore, the basic characteristics of property crimes are massiveness and undisguised nature, as well as the anonymity of their perpetrators. Property crimes include crimes in which the perpetrator takes another person's movable property with the intention of appropriating it. The most common crimes are: "Theft" and "Aggravated Theft", as well as the property crimes of illegal confiscation of someone else's movable property with elements of violence, namely: "Robbery" and "Theft". [4]

Theft: Thefts are the most widespread and massive form of property crime. With the exception of a large number of occasional thefts, a large number of these crimes appear to be the "craft" of professional thieves individually or in organized groups. Most professional thieves have adopted their own, more or less trained and well-established way of committing, which includes not only the act of committing, but also the usual place or time of committing, the type of stolen objects, objects where thefts are committed (pickpocketing). [4]

Aggravated theft: it differs from ordinary theft according to the way it was committed, the circumstances under which it was committed, that is, according to the value and significance of the stolen item. [5]

Robbery: Article 230. CC of the Republic of Croatia, Who, by using force against a person or by threatening to directly attack life or body, seizes another's movable property with the aim of unlawfully appropriating it, if the criminal offense referred to in paragraph one of this article has resulted in the acquisition of substantial financial gain or the use of any weapon or dangerous tool, if the criminal offense referred to in paragraphs 1 and 2 caused the death of a person, the perpetrator will be punished with a prison sentence of at least five years. [6]

Robbery is a complex criminal offense because it always contains the element of force and the element of confiscation of someone else's movable property (money, jewelry and other movable property). The element of violence appears as a means of committing the crime, that is, the robber uses force or a serious threat to directly attack the victim's life and body with the intention of taking from her the things he wants to appropriate. Robbery is one of the most serious property crimes because the robber does not hesitate to injure or kill the victim (severe cases of robbery). [4]

Robbery attacks on financial institutions and other facilities where large amounts of money are handled (banks, post offices, exchange offices, gas stations, etc.) appear as the most dangerous form of gangsterism, which is undertaken by organized and armed groups of criminals. In contrast to the perpetrators of primitive forms of banditry, who are characterized by more audacity and brute force than intelligence, this category of bandits is characterized by brashness, cunning, resourcefulness, the ability to pretend

and mask, great mobility and a sense for planning and preparing bandit attacks. [4] Modern robbers, especially when attacking financial institutions, act according to an elaborate plan, develop imagination when carrying out their act and cold-bloodedly calculate their own risk. [7]

Robbery theft: The difference between robbery and robbery theft is that the perpetrator of robbery, when caught in the act of theft, used force or threat with the intention of keeping the already stolen thing, while the perpetrator of the crime uses robbery, force or threat against a person with the aim of confiscation. things. Accordingly, in robbery, force or threat precedes the unlawful confiscation of someone else's movable property, while in robbery theft, force or threat comes after the unlawful confiscation of property. [4]

5. CRIMINAL OFFENSE "ROBBERY" - EVENT

In 2008, the Office for Suppression of Corruption and Organized Crime (USKOK) published a press release on its website, which further stated the following:

There is a well-founded suspicion that the 29-year-old, as an employee of a security company and employed in a branch of a bank, in Zagreb, according to a previous agreement, took over the walkie-talkie station from T.T. (today deceased) with which he signaled an opportune moment to enter the bank, and which he before that he got acquainted with the way of working, the insurance of the building and the safekeeping of money. After the bank employees locked the vault and headed for the exit together with the first suspect, the 29-year-old, he informed the sixth suspect and T.T., who then, masked and armed, pushed the first suspect and two female employees into the bank premises, where T.T. pointed the gun at the 29-year-old, ordering him to lie on the floor and tie his hands. The sixth suspect and T.T. took the bank employees to the vault where they opened the safe from which they took at least two million kuna and then drove away in a car where the 44-year-old man was waiting for them. On the same day, they left and set the car on fire and divided the money among themselves. A few days later, T.T. handed over HRK 200,000 to the 29-year-old as a reward.The aforementioned group was reported due to the well-founded suspicion that they had committed multiple criminal acts of robbery, assisting in robbery, attempted robbery, theft and serious bodily injury. [8]

6. ANALYSIS OF THE EVENT

An organized bandit group in itself in this form is an obvious example of an organization, i.e. a group of people who joined together to commit multiple crimes and illegally obtain large property benefits. The form of the organization is acquired on the basis of the distribution of shared roles during the preparation or actual execution of the KD, obligations and status values. When talking about status values, it mainly refers to the person "protector" who abused them in the performance of his duties and participated in the commission of KD in a previous agreement with the organizer. It is also evident that the perpetrator or several of them used a gun or a

firearm as a means of committing KD, which leads to the qualifying form of KD "Robbery" from Art. 230 paragraph 2 of the CC, - using weapons. After the crime was committed, the previously stolen car was set on fire due to the impossibility of proving it, i.e. destroying traces that could help the perpetrators be identified more easily, and as another proof of a well-organized group of robbers, one person remained in the immediate vicinity of the vehicle with the aim of fleeing the scene faster events and actions of KD are well planned, planned and realized.

6.1. Responsibility of security guards

The aforementioned statement is an obvious example of how a security guard should not act. It is evident that the security guard committed a number of criminal acts with the aim of obtaining illegal property benefits. Every citizen is obliged to report to the police or the state attorney's office after learning that a criminal act has been committed and is being prosecuted ex officio or is preparing such a criminal act. Thus, the security guard in question was obliged to immediately upon learning that a KD "Robbery" was being prepared, that is, that an unknown person or several of them tried to engage him with the aim of participating in the commission of a KD, he was obliged to report the above.

6.2. Employer's responsibility

A security guard must meet certain conditions in order to be able to perform private security work in financial institutions, so the employer must monitor the condition of the employee and if he notices that the security guard is prone to actions and conditions such as vices of alcohol, gambling, betting, etc., a justified complaint from a former employer, high financial indebtedness , life in unsettled social circumstances, etc. , the same may not perform private protection work in financial institutions. [9]

6.3. Procedure of employees when committing robbery

The staff must carry out the robber's instructions, hand over the money intended for the trap, if possible activate the so-called silent alarm, determine the direction of the robber's departure, the type and description of the vehicle used, registration number, peculiarities, etc., until the arrival of the police, move as little as possible around the MD and communicate with each other

6.4. The security guard's procedure when securing MD

The security guard should make a mental reconstruction of that event and immediately prevent access to unrelated persons, preserve the scene of the event in an unchanged state, keep the secret of the scene of the event, inform the police officers about the actions taken, hand over the temporarily detained persons to the police officers (witnesses), make a written report...[10]

7. CONCLUSION

In the vast majority of cases, security guards perform private protection duties professionally and honorably, and their lives are largely in danger, while to a much lesser extent, security guards who do not perform their work professionally, i.e. abuse their authority, are a status symbol in the workplace, and by issuing official secrets enable criminals, individuals or criminal groups, to commit criminal acts of "Robbery" and other criminal offenses to the detriment of protected persons, premises and objects. According to the above, it is necessary to educate and develop awareness among fellow security guards and other persons to report a person whom they know to have fallen into financial problems, to be prone to vices (gambling, drugs), to be in the company of persons known to that they are perpetrators of criminal offenses as well as other changes in behavior compared to previous behavior. The education of security guards is extremely important for the prevention of robberies, the manner of handling and acting during a robbery in the case of an individual or an organized group, as well as the observation during a robbery, details that can greatly help police officers in finding the perpetrator. Education must be frequent, often repeated, although every robbery is different, the security guard must "routinely" do his job, and this routine is acquired through exercises and repetition.

8. REFERENCES

[1] Roth, M.: Oko za oko, Nacional, br. 972, Zagreb, Croatia, 2016.
[2] Law on the Protection of Financial Institutions ("Official Gazette", 56/2015)
[3] Law on Private Protection (Official Gazette 16/20)
[4] Perić, V.; Forms of operational activity of the public security service, Republički sekretarijat za unutrašnje poslove SR Hrvatske, Zagreb, Croatia, 1987.
[5] Derenčinović, D.; Introduction to criminology and social pathology with the basics of criminal law, Faculty of Law, University of Zagreb, , ISBN:953-6714-68-X, Zagreb, Croatia, 2004.

[6] Criminal Code (Official Gazette 125/11, 144/12, 56/15, 61/15, 101/17, 118/18, 126/19, 84/21), Zagreb, Croatia, 2021.

[7] Zerjav, C.; Criminalistics , Republički sekretarijat za unutrašnje poslove SR Hrvatske , Zagreb, Croatia, 1986.
[8],,Priopćenje za javnost DORH-a“ http://www.dorh.hr/Default.aspx?art=7410&sec=656, 26.03.2020.
[9] Duties and procedures of security guards when securing financial institutions,, http://zastita.info/UserFiles/file/zastita/SIGBANK%202015/PDF%20PREZENTACIJE/ 11.%20Ante%20Percin.pdf, 26.03.2020.

[10] Marohnić, D: Security of the crime scene after the commission of a criminal offense or other security events", Final paper - Specialist graduate professional study Security and protection, Polytechnic in Karlovac, Croatia, 2018

PRACTICAL CHALLENGES IN THE APPLICATION OF OCCUPATIONAL SAFETY REGULATIONS IN CIVIL ENGINEERING

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Abstract: *Since the Law on Safety and Health at Work of the Republic of Serbia came into force in 2005, certain problems in the application of some of its provisions, as well as legal and technical shortcomings, have been observed. According to the data of the Labor Inspectorate of the Republic of Serbia, one of the industries where the highest number of occupational injuries (especially fatal ones) has been recorded is civil engineering. This is the opportunity to improve not only the Law on Safety and Health at Work, but also numerous bylaws regulating occupational safety in civil engineering. The paper analyzes practical problems in the application of current regulations on the occupational safety in civil engineering and suggests some ideas for improving the legal regulations in this area.*

Keywords: *practical aspect, regulation, occupational safety, civil engineering*

1. INTRODUCTION

In addition to being highly expansionary and one of the most employable branches of the economy, construction is also a branch of industry with a high number of work injuries [1]. It is now exposed to risks of different kinds and intensity [2]. The construction sector faces a major problem in terms of protecting workers from hazards and hazards in the workplace, preventing injuries and occupational diseases, and improving safety and health at work. Expert analyses have established that the most common causes of injury at work (all injuries - individual and collective, with fatal consequences, serious injuries and minor bodily injuries) in the construction industry are the failure to apply the basic principles of organizing the non-performance of work, deviation from the prescribed and established process of work, work at an indeterminate height, work with an unsecured edge of an object from which you can fall into the surrounding space, work on improperly mounted scaffolding, work in improperly secured excavations, failure to use prescribed means and equipment for personal protection at work

(primarily work without protective helmets and protective belts), Incompetence of employees for safe and healthy work, inattention and insufficient concentration of employees at work, employment of a significant number of untrained people working on " black ", etc. [3].

The precondition for ensuring the conditions for safe and healthy work is the regulations that define this issue, the measures that the legislator and the employer will apply in order to implement the policy of protection of employees at work, awareness of their necessity and competence for safe and healthy work. The definition of the legal framework for safety and health at work in the construction industry, as well as the definition of the protective measures themselves by the employer, i. e. the person in charge of safety and health at work, is specific in relation to the other branches of the industry and requires a special and comprehensive approach. In order to devise adequate legal regulations for the protection of employees in the construction industry, it is necessary first to record problems in the application of the regulations in force, and then to amend these regulations and monitor their application.

2. LEGAL FRAMEWORK OF OCCUPATIONAL SAFETY IN CIVIL ENGINEERING

Looking at the international legal framework for safety and health at work in construction, the legal sources of the UN, the International Labour Organisation, the Council of Europe and the European Union stand out. Two human rights in general, including the protection of employees, can be deduced from UN regulations - the General Declaration on Human Rights of 1948 [4] and the International Covenant on Economic, Social and Cultural Rights of 1966 [5]. There are far more acts of the International Labour Organisation that Serbia has ratified, which have a legal impact in the area of safety and health in construction work. There are two principal natures - Convention No. 155 on protection at work, health care and the working environment [6] and Convention No. 187 on a safety and health at work promotional framework [7]. In addition to these, the 1937 Convention on Safety and Health at Work, the 1937 Convention and Recommendations on Safety (High Building), the 1937 Recommendation on Cooperation to Prevent Accidents (High Building), the 1937 Convention and the 1963 Recommendation on the Protection of Machinery, Convention and Recommendation on Maximum Weight of 1967, Convention and Recommendation on Cancer arising from Work Conditions in Certain Occupations of 1974, Convention and Recommendation on Working Environment (Air Pollution, Noise and Vibrations) of 1970, Convention and Recommendation on Work Services of 1985, etc. are of particular importance to construction workers [8]. Of the European documents in this area, Serbia, as a member country of the Council of Europe, is bound by the European Convention on Human Rights of 1950 and the European Social Charter of 1961 [9]. Also, as a country at the stage of accession negotiations with the European Union and in the process of aligning its legal system

with that of the European Union, the Republic of Serbia should bring its protective legislation into line with the EU Directive on the application of minimum safety and health conditions on temporary or mobile construction sites [10].

When it comes to the legal system of the Republic of Serbia, it is made up of a meeting of the National Assembly of Verified Laws regulating all spheres of life in the country. The Crown Document, on the basis of which all other legal acts were passed, is the Constitution of the Republic of Serbia [11]. Two laws stand out as important for workplace protection in the construction industry: The Labor Law [12] and the Law on Safety and Health at Work [13]. Then there are the bylaws (regulations and rules). As construction (by the scope of the activity covered) is a specific activity, the bylaws regulating the area of safety and protection at work in the construction sector are numerous: Rulebook on labor protection in the execution of construction works [14], Decree on safety and health at work in temporary and mobile construction sites [15], Rulebook on the content of construction works [16], etc. In this group of by-laws, for example, we can also put general acts such as the Rulebook on Preventive Measures for Safe and Healthy Work in the Use of Personal Protection Funds and Equipment [17], the Rulebook on Personal Protection Equipment [18], etc.

3. APPLICATION OF OCCUPATIONAL SAFETY AND HEALTH REGULATIONS IN PRACTICE

In the application of the above-mentioned regulations, some problems can be identified which are common when it comes to protection in the construction industry. That there is a problem in this field is in support of the Report of the Directorate of Safety and Health at Work for the year 2021, according to which construction sites are the third most frequent field where injuries occur at work (after factories and storage rooms) [19]. According to the cause of the injury, at the very top are the sliding, tripping and falling of the face at the same level, loss of control over the machine or over the material being processed, loss of control over the object being carried, the movement of the hand, etc. [19]. The highest number of work injuries by type was recorded in the group - bone fracture 923 (70.94%). Based on the these data, the results of research into relevant scientific literature and the analysis of subjects from court proceedings (including criminal proceedings against the employer) related to the occurrence of injuries at work, some frequent problems in the application of the regulations and in the legal solutions themselves can be observed. One such problem is the insufficient number of individuals for safety and health at work in enterprises. In order for these persons to be able to carry out their work at all the employer ' s sites in a study and quality manner, it is necessary to determine, for example, how many employees an employer must have one person for safety and health at work. Satisfying the quality of their work according to the existing regulations is often difficult to achieve when considering that, according to the Law on Safety and Health at Work, the employer has an obligation only to organize the performance of safety and health work at work, and one way is to

appoint a person for safety and health at work. This means that he can only employ one employee to perform these tasks regardless of the number of employees or the locations where the employer does his business. The number of individuals working for one employer for safety and health is a major problem, as their legal obligation is to monitor and control the application of safety and health measures to the employer on a daily basis [13]. This formulation creates doubts in practice and raises the question of how to interpret the term "daily" and whether, for example, it has fulfilled this obligation if, at the beginning of the shift, it has overridden the protective measures at work on the site, and the employee subsequently takes off his protective equipment.

Another frequent occurrence during workplace injury inspections is the insufficient control of the use of personal protection of staff equipment. Often employees at the very beginning of their shift use all protective equipment (vest, helmet, gloves, belt, etc.), and as the working day moves on, they use this equipment less and less lightly, realizing that the injury will not happen to them. This is a particular problem when working at altitude and using belts, because fatal injuries at work are happening in these situations. Then, it is rare that employees are not referred to periodic medical examinations, or they are referred to and have not carried them out and have not provided the employer with proof of the examinations carried out and the ability to work in a place of increased risk. Strictly speaking, an employer should not allow a person to perform a job at a higher risk before he provides evidence that he is medically fit for it. In practice, these persons perform these tasks before the employer receives confirmation of the medical work service of his medical fitness for the job. This may not be the cause of the injury at work, but the mere fact that the examination was not carried out suggests a suspicion that this was a factor that could have contributed to the onset of the injury at work.

Also, the machines used by the contractor must possess an expert finding that they are safe to operate [21], and the lack of such a finding is one of the frequent shortcomings in the application of the regulations. It has also been observed that there is often a lack of ownership of the construction site by the Elaborate, with a plan of preventive measures for safe and healthy work [15, 16], as well as an untimely declaration of the site to the competent bakery, or no declaration at all. [13] There are many more examples of such failures in the application of regulations on safety and health at work in the construction industry.

4. CONCLUSION

Construction is an extremely complex branch of the economy. The specificities of construction work are examined in the existence of two separate processes in the same project (design process and construction process), the involvement of a large number of workers of different profiles and different experiences, the realization of the project consists of a large number of work operations, the realization of work in open and bad weather conditions, the realization of work in a closed often cramped

space, at great heights or great depths, etc. All of these specificities generate risks to safety and health at work that must be identified before work starts, especially when considering that there are different types of construction work that require sensitization in terms of workplace protection measures.

The foregoing has caused the legal framework for safety and health at work, both internationally and nationally, to be extremely comprehensive and comprehensive. In the Republic of Serbia, the most important legal acts dealing with safety and health at work in the construction industry are the Labor Law, the Law on Safety and Health at Work, the Rulebook on Safety at Work in Construction, the Rulebook on Safety and Health at Work in Temporary and Mobile Construction Facilities and the Rulebook on the Content of Construction Facilities Design Texts. The enumerated legal acts have been drafted in such a way that they go deep into the issue of safety and health at work in the construction industry, respecting all its specificities. The legislator made sure that the existing legal framework in this area fully assists the employer and creates all preconditions for him to ensure safe and secure operation by assessing the risks and defining safety measures on mobile and temporary sites.

In the application of these regulations, some problems can be identified which occur frequently. These include the most frequent number of employees in the field of safety and health at work, insufficient control of the use of personal protective equipment, not wearing personal protective equipment, performing jobs in high-risk workplaces without reference to periodic medical examinations, not having an expert report on the machines used, etc.

Based on an analysis of legal solutions in Serbia, it can be concluded that work protection in the construction industry is seen in a special way by regulations, especially by sub-legislation. As the new law on health and safety at work is expected to be passed soon, it is logical that the new document should address some of the issues for which the practice has shown problems in the application of additional regulation and precision, especially with regard to construction. After the new law is passed, the logical sequence of moves should be to consider the existing bylaws, and there is plenty of room for improvement in the construction regulation. Of course, all this was preceded by the Safety and Health at Work Strategy for the next period [21], whose goals are so defined that they should contribute to the reduction of injuries at work and in the construction industry, and especially to the reduction of fatal injuries at work.

Finally, it should be borne in mind that any legal regulation, however high-quality and comprehensive, requires effective implementation in practice. For this reason, it is highly desirable to intensify the supervision of work inspections on construction sites. The aim of the inspection view should be to not only punish violators of certain regulations, but especially to achieve closer cooperation with employers and employees and their better understanding of safety and health regulations in construction work. In this way, the preventive role of the inspection view would be realized and would contribute to reducing

the unfavorable statistics in terms of the number of work injuries in the construction industry.

REFERENCES

[1] Mučenski, V. et al.: Analysis of Falls to the Level Below in Construction Industry of Serbia, *Proceedings form the Conference 50 Years of Higher Education, Science and Research in Occupational Safety Engineering*, Prašćević, M. (Ed.), pp. 237-240, Niš, Faculty of Occupational Safety in Niš (2018).
[2] Petrović, M.; Andjelić, K. & Prvulović Petrović, M.: *Safety of Workers carrying out construction works and use of machinery*, Military Technical Courier, 62(2014)2, pp. 151-165.
[3] Loncović M.: Occupational Safety and Health, *Available from* http://www.tolerancija.rs/bezbednost-zdravlje-na-radu/
[4] Universal Declaration of Human Rights, *Available from* https://www.un.org/en/about-us/universal-declaration-of-human-rights
[5] International Covenant on Economic, Social and Cultural Rights, *Available from* https://www.ohchr.org/en/instruments-mechanisms/instruments/international-covenant-economic-social-and-cultural-rights
[6] Occupational Safety and Health Convention, 1981 (No. 155), *Available from* https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C155
[7] Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187), *Available from* https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C187
[8] ILO, Labour standards, *Available from* https://www.ilo.org/global/standards/lang--en/index.htm
[9] Jovanović, P. & Božičić, D.: Occupational Safety and Health at Work, Proceedings of the Faculty of Law in Novi Sad, L(2016), pp. 753–771.
[10] Council Directive 92/57/EEC of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile construction sites, *Available from* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0057
[11] Constitution of the Republic of Serbia, Official Gazette of the Republic of Serbia, No. 98/2006.
[12] Labor law, Official Gazette of the Republic of Serbia, No. 24/2005, 61/2005, 54/2009, 32/2013, 75/2014, 13/2017, 113/2017, 95/2018.
[13] Occupational Safety and Health Act, Official Gazette of the Republic of Serbia, No. 101/2005, 91/2015, 113/2017.
[14] Rulebook on Occupational Safety During Construction Works, Official Gazette of the Republic of Serbia, No. 53/1997.

[15] Decree on Safety and Health at Work on Temporary and Mobile Construction Sites, Official Gazette of the Republic of Serbia, No. 98/2018.

[16] Rulebook on the Content of the Study on the Arrangement of the Construction Site, Official Gazette of the Republic of Serbia, No. 102/2015.

[17] Rulebook on Preventive Measures for Safe and Healthy Work When Using Means and Equipment for Personal Protection at Work, Official Gazette of the Republic of Serbia, No. 92/2008, 101/2018.

[18] Rulebook on Personal Protective Equipment, Official Gazette of the Republic of Serbia, No. 23/2020.

[19] Report of the Administration for Safety and Health at Work for 2021.

[20] Rulebook on the Procedure of Inspection and Verification of Work Equipment and Testing of Working Environment Conditions, Official Gazette of the Republic of Serbia, No. 94/2006, 108/2006, 114/2014,102/2015.

[21] Occupational Safety and Health Strategy in the Republic of Serbia for the Period from 2018 to 2022 with the Action Plan for its Implementation, Official Gazette of the Republic of Serbia, No. 96/2018.

ACKNOWLEDGEMENT

This research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Contract on the realization and financing of scientific research work of the scientific research organization in 2022 number 451-03-68/2022-14/ 200148.

SAFETY MANAGEMENT SYSTEMS AS AN INTEGRAL PART OF THE ORGANIZATIONAL SYSTEM

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Abstract: *In an era of advanced communication and information technology and a sudden transition from industrial to it-information society, technology development has become, among other things, the basis for changes to manage safety elements in a workplace. This is why business management system in a field of Hazard, Risk and Safety sought and ordered the application of information technology in various types. Quality and organized computerization leads to changes in methods of achieving the desired goals, designed to identify hazards, assess the risks from those hazards, put measures in place to mitigate those risks, implementation of the educational process, definition of organizational structure, increase in the quality of the all aspects related to health and safety. In the Republic of Croatia, in accordance with time and environment, the importance of introducing computerization in safety and hazard management as objective and philosophy of the facility has also been noted. The subject of this paper is to show importance in the implementation and daily use of the information at the different decision-making levels of the organization using safety management systems.*

Key words: *Informatization, organization, safety, business aspect*

1. INTRODUCTION

There are many misconceptions about what an information system in a business organization represents, how it correlates with current information technology and real business processes, how the initial idea of creation is achieved and how it is used, who are the people in charge of designing, realizing and maintain, what are the starting points of use and how to continue to use it that the very concept of information system has a clear future. The purpose of this paper is to clarify and point to examples from practice through a brief analysis of information systems used in the Republic of Croatia closely related to occupational safety.

The rapid development of science is leading to significant changes in all spheres of society and technological innovation is always a strong driver of change in education, business processes and thus in understanding the importance of protecting workers from many dangers. Dangers that most often result in the development of occupational diseases and / or injuries that cause high medical costs, which can be an economic and psychological burden on workers and company management, especially if they work contrary to the prescribed rules of occupational safety.

Today's information channels determine the need for complete and permanent implementation of the described procedures contained in the IT form for the formal system in which they will be used. With the increase in the quality of the organization, the man achieved more and more significant results, and consequently the time he needed to perform work processes decreased. Man uses the organization and belongs to it all his life because he solves all work and life issues with people and with the help of people around him, more precisely - organized. The organization provides a person with the opportunity to achieve a goal that he could not achieve on his own, while helping him to achieve the same, better, more economical and more efficient.

The goals of the organization are of great importance. The more precisely they are defined, the easier it is to choose the means for their realization. The goal consists of three basic components[1]:

• starting point,

• end point,

• time spent between starting point and end point.

Figure 1. Strategy, organization design and effectiveness

2. SAFETY MANAGEMENT SYSTEM (SMS)

A safety management system is a term used to refer to a comprehensive business management system designed to manage safety elements in a workplace (Safety Management Systems – SMS). A basic safety management system's main purpose is to accomplish the following elements[2]:

- To ensure everyone in the organization can recognize and understand real or potential hazards and associated risk.
- To prevent or control operational hazards and associated risk.
- To train employees at all levels of the organization so they can demonstrate the importance of correcting potential hazards they may be routinely exposed to as well as how to protect themselves and others.

In a nutshell, it is an integral part of the risk management system to ensure safe operation of the facility by regulating various control measures for the facility. One of the main properties in SMS is that it shall be comprehensive, so, related to control measure, SMS needs to address the following issues[3]:

- Identification of control measures and definition of the performance standard
- Implementation of control measures. Layers of protection in control measures are checked; if one layer does not function well then another is to be brought to implement and enhance the control measure.
- Monitoring and periodic performance checks
- SMS should be in a position to identify anomalies, then report them and rectify the shortcomings. So, SMS audits the system as well as compliance against documented SMS.
- All concerned shall have easy access to and cooperation in the decision-making process.

2. SAFETY MANAGEMENT SYSTEM IN CROATIA (IS ZNR)

State institutions strive to computerize their business processes and thus enable faster and better data processing. The main purpose of such informatization is the collection, processing and analysis of collected data. The collected data are processed and analyzed depending on the need and purpose. in 2019, one such information system related to occupational safety was prepared, called the Occupational Safety and Health Information System (IS ZNR), under the supervision of the Ministry of Labor and Pension System.

It has become active and requires participants to enter their activities into it. It is mandatory for now for authorized persons who provide occupational safety services.

IS ZNR is a web application that is accessed through a single Internet portal: https://isznr.mrms.hr/. IS ZNR records data on authorized persons to perform occupational safety activities and specific occupational safety activities they perform for employers.[4]

Data from IS ZNR are used for supervision over the work of persons authorized to perform occupational safety, preparation of expert opinions on occupational safety for various entities, monitoring the state of occupational safety,conducting statistical surveys on occupational safety, development of programs, guides, methods and models of occupational safety, determining criteria and procedures related to the organization of work, providing assistance to employers' associations, trade unions, persons authorized for occupational safety and administrative bodies, implementing actions in certain areas of occupational safety and health and improving the overall state of safety at work.

The authorized person is obliged to keep up-to-date records on the performance of occupational safety activities of the employer together with the corresponding one under the records of conducted internal inspections based on the contract on performance of occupational safety activities for the employer. A person appointed by the employer to perform occupational safety activities (occupational safety expert of the first degree, occupational safety expert of the second degree, authorized person or employer), in order to conduct continuous professional training, information and exchange of information in the field of occupational safety, to the Occupational Safety and Health Information System according to the Instructions for access to electronic services published on the website of the ministry responsible for labor[5].

The occupational safety and health information system contains data on persons authorized to perform occupational safety and health activities and their performance of occupational safety and health activities for employers, various data that all employers are obliged to regularly submit to the Ministry of Labor and Pension System. via the specified Information System.

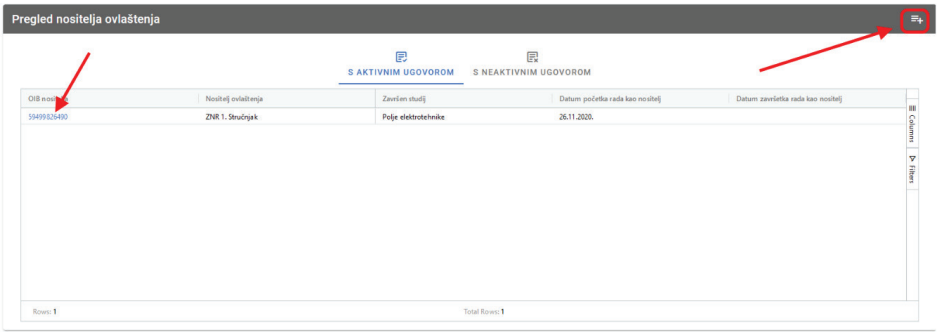

Figure 2. Authorization holders

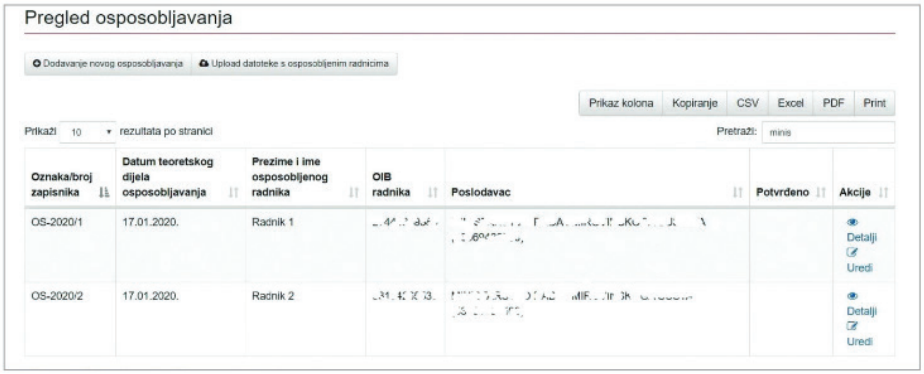

Figure 3. Overview of in-app training

4. CONCLUSION

A safety management system must define clearly how to organization intends to execute stand goals and objectives, how to measure the effectiveness of actions to reach the safety vision. Getting employees involved in the development of the safety management system is particularly important to create ownership and buy in. Involvement in the development of the safety management system will help to ensure that it fits within the existing organizational culture. Clearly defined and well communicated safety roles and responsibilities for all level of the organization are critical in the beginning phases of developing a SMS. These outline all expectations about performance and accountability among the leadership team, all employers etc.

The safety management system must have a feedback loop that communicates to the leadership team the status of the various programs and systems required to control hazards and associated risk. These systems can range from voluntary standards established by industry or trade groups, consulting organizations, and international standards organizations to required governmental legislation.

REFERENCES

[1] Lugar, S.: *INFORMATION SYSTEM AS AN INTEGRAL PART OF THE ORGANIZATIONAL SYSTEM ON EXAMPLE "ISVU"* https://urn.nsk.hr/urn:nbn:hr:128:989416 *Accessed:* 05.04.2022

[2] Nathan Crutchfield,James Roughton, Safety Culture, Chapter 5 Overview of Basic Safety Management Systems*, Elsevier*, 2014, Pages 93-107.

[3] Swapan Basu, Plant Hazard Analysis and Safety Instrumentation Systems, Chapter II Evaluation of Hazard and Risk Analysis, *Elsevier*, 2017, Pages 83-167.
[4] Ministarstvo rada, mirovinskoga sustava, obitelji i socijalne politike. https://uznr.mrms.hr/znr/is-znr/ *Accessed:* 10.04.2022
[5] https://narodne-novine.nn.hr/clanci/sluzbeni/2019_05_50_975.html , *Accessed:* 11.04.2022

Figure.1. Strategy, organization design and effectiveness, https://www.aihr.com/blog/organizational-design/ , *Accessed:* 09.04.2022

Figure 2. Authorization holders,

https://uznr.mrms.hr/wp-content/uploads/ISZNRv2.0_uputa.pdf , *Accessed:* 10.04.2022

Figure 3. Overview of in-app training,

https://hrcak.srce.hr/file/343857 , *Accessed:* 10.04.2022

CRITICAL INFRASTRUCTURE DEFENSE POLICY OF THE REPUBLIC OF SERBIA IN THE LIGHT OF THE LAW PROVISIONS

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Abstract: *The topic of critical infrastructure has become an indispensable topic, especially in the last few years. We encounter elements of critical infrastructure in all spheres of daily activities. One of the important tasks of of Republic of Serbia on its path of European integrations is the adoption of a normative framework related to critical infrastructure that is in line with the elements of European Council Directive 2008/114/ES. The Republic of Serbia has adopted the Law on Critical Infrastructure, which entered into force in November 2018. In the next period, following are planned measures and activities within which the standards prescribed by the above law will be implemented. Also, the Republic of Serbia can consider solutions and models of the countries in the region which could serve as a starting point, but not apply them, which is completely justified considering specific that each state has for itself.*

Key words: *critical infrastructure, legislation, identification of critical infrastructure, protection of critical infrastructure*

1. INTRODUCTION

The topic of critical infrastructure is becoming an unavoidable topic, especially in the last few years. We encounter elements of critical infrastructure in all spheres of daily activities. The rapid development and improvement of information technologies are changing the security environment. As critical infrastructure became an important segment of national security, the protection of critical infrastructure began to develop and today it represents one of the main priorities of every state. [1]

The basic questions addressed to the social community that organizes the critical infrastructure system are who and what should be protected from and how to organize the critical infrastructure system. The answer to these questions should

provide concrete solutions aimed at possible sources of endangerment. At the same time, it is also a path towards the establishment and organization of a security system that begins with explaining, evaluating, and classifying the forms and sources of threats to the values of the social community. [3]

Methods and means of protection of critical infrastructures prevent or mitigate: human attacks on critical infrastructures (terrorists, criminals, hackers, etc.), the occurrence of natural disasters (earthquakes, storm winds, floods, etc.), fires, and explosions in nuclear or chemical complexes. [7]

Generally speaking, the thought related to critical infrastructure in the territory of the Republic of Serbia is not yet sufficiently developed following the needs. Of course, we must not ignore the fact that there is goodwill and the intention to pay special attention to this area, which is reflected in the effort to establish an adequate system of KI, which is confirmed by numerous academic contributions to the area, as well as a large number of conferences and workshops on that topic as well as demanding research. [4]

2. CRITICAL INFRASTRUCTURE MANAGEMENT POLICY IN THE REPUBLIC OF SERBIA

Critical infrastructure is a relatively new concept in Serbia, as the term was mentioned for the first time only in 2011 in the Decree on the content and method of preparing a plan for protection and rescue in emergencies. Namely, the Regulation in Article 8 emphasizes the assessment of critical infrastructure from the point of view of natural disasters and other major disasters but does not provide an interpretation of the definition of this term. [2]

Also, the Guidelines on the Methodology for Developing Vulnerability Assessments and Protection and Rescue Plans establish the criteria for evaluating ten sectors of critical infrastructure from the point of view of their vulnerability to natural disasters and other accidents. Although the methodology contains the most comprehensive approach to the protection of critical infrastructures in domestic legislation, it is oriented towards identifying the sources of danger and the consequences that disruptions and interruptions in the functioning of infrastructures have on the economy and ecology. The approach contained in the methodology does not include an assessment of the vulnerability and resistance of critical infrastructures to all types of threats, as well as measures to increase the resistance that should reduce the harmful consequences of natural and other disasters on the infrastructures themselves, including the effects of interdependence. In particular, the need to develop models and methods for increasing the resilience of critical infrastructure systems to improve capacities that amortize the effects of threats to protected values is highlighted. For the stated reason, it is necessary to define the criteria for identifying potential threats, i.e. hazards and the generation of hazards and interdependencies adapted to different sectors of critical infrastructures by international, European, and national standards. [9]

One of the main reasons for the adoption of the Law on Critical Infrastructure ("Official Gazette of RS" 87/2018) is the absence of a single Law in this area and

the need to unify it. The law first defines the terms included in the content, starting with what is the critical infrastructure sector, then how identification, determination, and protection are carried out, who are the operators, what is the security plan, liaison officer, and finally what is the European critical infrastructure. The principles of action contained in this Law apply to competent authorities, organizations, and citizens, and these subjects are obliged to comply with them. [6]

The principles are exhaustively enumerated in the Law, namely the principle of an integrated approach, the principle of responsibility, the principle of protection against various types of threats, the principle of continuous planning for the protection of critical infrastructure, and the principle of data and information exchange and data protection. The law defines critical infrastructure as a system, network, facilities, or parts whose interruption of functioning or delivery of goods or services can have serious consequences for national security, health, lives and property, the environment, and the safety of citizens, i.e. can threaten the functioning of the Republic of Serbia. The ministries responsible for certain areas are responsible for the identification and categorization of critical infrastructure. The criteria for identification are prescribed by the Government. The sectors in which critical infrastructure is identified are energy, transport, water, and food supply, health, finance, telecommunications and information technologies, environmental protection, and the functioning of state bodies. for the contact between the operator and the competent Ministry, which provides constant control, informs about changes, coordinates the Security Plan, and deals with other tasks related to critical infrastructure. This person is appointed by the Ministry at the proposal of the operator, three months after the system has been determined, and he must have a license to perform the above tasks. When it comes to critical infrastructure in planning documents, special attention is paid to the part of preventive activities and response to emergencies. In the event of the occurrence of threatening circumstances, the Headquarters for Extraordinary Circumstances reacts in cooperation with the Ministry. [8]

The criteria by which critical infrastructure is identified are determined based on the assessment of the consequences that may arise due to damage or destruction of critical infrastructure, as well as based on the consequences that may arise in the event of endangerment of critical infrastructure.

Sectors in which critical infrastructure has been identified and determined are:

1) energy;
2) traffic;
3) water and food supply;
4) health care;
5) finances;
6) telecommunication and information technologies;
7) environmental protection;
8) functioning of state bodies. [10]

The field of CI protection has just been normatively regulated and a legal framework has been created for the definition, identification, designation, and protection of national and European critical infrastructure. The adoption of the Law on Critical Infrastructure did not solve the problems and shortcomings in the area of KI, it is necessary to work on developing the awareness of owners and operators of KI, strengthen the public-private partnership in the protection and resilience of KI, as well as the exchange of experience and knowledge with domestic and international institutions.

Involvement on the international stage for each country implies certain obligations towards the organizations in whose work it participates. In the case of Serbia, the most significant international obligations stemming from the country's official strategic goal of becoming a member state of the European Union. In 2012, Serbia officially became a candidate country for EU membership, and the first negotiation chapters were opened in December 2015. The process of accession to the Union entails the harmonization of the country's legislative framework with the existing common normative framework and EU principles. When it comes to the field of information security, in the process of developing the national normative framework, Serbia must take into account the existing legislation in the European Union, which also includes trends that are currently under development and will most likely become common principles of the Union countries by the time accession of Serbia to the EU.

By analyzing the results of the research conducted by the author on subjects of critical infrastructure that exists in the Republic of Serbia, it can be concluded that the respondents expressed positive attitudes about the quality of human resources and that the evaluations about the quality of material and financial resources are unsatisfactory. When it comes to human resources, the ratings are quite high, however, they must be taken with a grain of salt because all these personnel is not strictly specialized in the area of KI protection, but these jobs were added to them as part of regular activities. Such a situation requires strengthening the quality of human resources and adapting the system of education for future experts in the field of KI protection in the Republic of Serbia. Respondents stress the limitation of financial resources, which can be a significant factor in the normal development of the CI protection system. [5]

The largest number of respondents (about 70%) defined KI as facilities that are most vulnerable to emergencies (power facilities, traffic, PTT traffic, military

facilities, water supply, sewerage, etc.). [5]

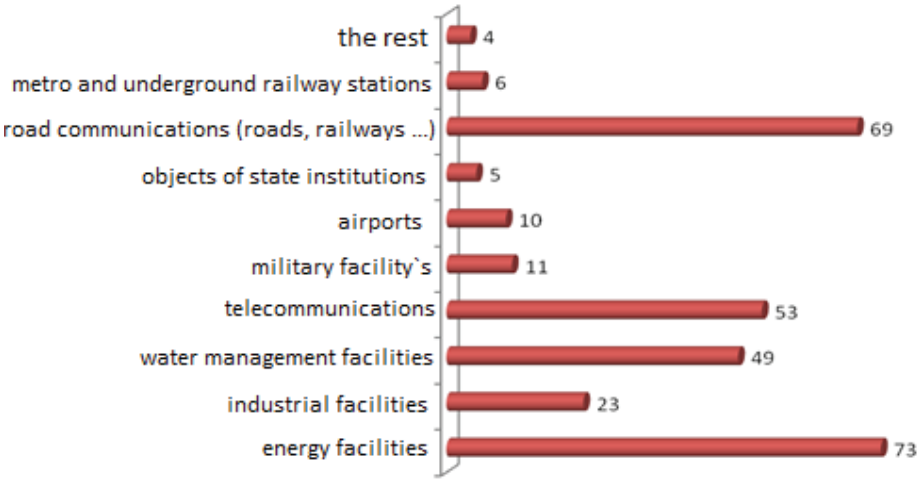

Chart 1 . Degree of danger from natural and technical-technological risks

3. CONCLUSION

The modern world faces great dangers both for individuals and for society as a whole. The positive sides of technological progress are one dimension of existence, but the negative side of that progress should not be replaced. It is generally known that there is no absolute security, as an imperative of today's time, the issue of security is imposed as a basic issue for all governments and decision-makers.

It is an indisputable fact that an efficient system of critical infrastructure is the basis for the smooth functioning of both individuals and society as a whole. Over the last few years, the understanding of the importance and protection of KI has changed significantly. Previously, CI vulnerability was associated with problems related to the functioning of high-risk technologies, while today CI and its protection represent a very important issue for both national and international security. Natural and social risks, emergencies, and disasters have become an integral part of everyday life, and leave very serious consequences (human casualties, material losses, environmental degradation). These events require the maximum engagement of available resources, from the local community through the region to the state level, putting to a serious test political leaders and their ability to return society to a state of normal functioning as efficiently as possible.

Given that the Republic of Serbia is a country that was exposed to the transition process, the process of defining, identifying, and analyzing critical sectors and subsectors will certainly be difficult. On this occasion, the biggest problem is the complexity of infrastructure systems and the identification of specific risks and

threats to which they are exposed. One of the main issues concerns the determination of the order of implementation of actions during the development of an adequate KI protection system. Namely, the risks, threats, and vulnerabilities to which a certain system is exposed should first be determined, after which the critical sectors are identified and a specific classification is developed. Also, it is necessary to invest in outdated infrastructural facilities, which represents a large investment and financial expenditure.

A large number of experts in the field of critical infrastructure define this area emphasizing that it is a very important segment of national security and security in general. People have become aware that it is not possible to protect everything at all times, and that they have to decide which infrastructure is of key importance to them and why. They are also aware of the importance of critical infrastructure but have not yet agreed on its unique definition, which leads to different approaches to protecting critical infrastructure, which is at the intersection of politics, business, technology, and risk. [11]

REFERENCES

[1] Herga, M.: "Nacionalna kritična infrastruktura", Menadžment i sigurnost - M&S Planiranje i sigurnost, 2010.Herga, M.: "Nacionalna kritična infrastruktura", Menadžment i sigurnost -M&S Planiranje i sigurnost, 2010.

[2] Nacionalna strategija zaštite i spasavanja u vanrednim situacijama, "Službeni glasniku RS", br. 86/2011 od 18.11.2011. godine.

[3] Mićović, M.: „Specifičnosti zaštite kritične infrastrukture", Bezbednost,, Ministarstvo unutrašnjih poslova, Beograd, Vol.56, br. 3/2014.

[4] Mićović, M.: "Specifičnosti kritične infrastrukture u Republici Srbiji", Monografija, Kriminalističko-policijski univerzitet, Beograd, 2020.

[5] Mićović, D.: „Bezbednosni aspekti funkcionisanja kritične infrastrukture u vanrednim situacijama", Doktorska disertacija: odbranjena na Fakultetu bezbednosti Univerziteta u Beogradu 27. juna 2016., zavedena pod brojem 63/7-11 od 23. 2.2016., UDK broj: 614.8:351.78(043.3).

[6] Petrović V., Beriša H., Dzeletović M., "Kritična infrastruktura odbrambene tehnološke i industrijske baze Republike Srbije - stanje i perspektiva ", Vojno delo, br. 2, 2019.

[7] Radvanovsky, R., McDougall, A., : "Critical Infrastructure, Homeland Security and

Emergency", Preparedness. Boca Raton, FL: CRC Press/Taylor & Francis Group, 2010.

[8] "Sl. glasnik RS", br. 87/2018.

[9] "Sl. glasnik RS", br. 80/2019.

[10] "Sl. glasnik RS", br. 69/2022.

[11] Whale, T., Beaty, G.: #Emergency Management Guide for Business Industry", Federal
Emergency Management Agency (FEMA), Internet edition (https://www.fema.gov/media-library/assets/documents/3412).

Civil protection

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Abstract :

Civil protection is a system of organizing participants, operational forces and citizens to protect and rescue people, animals, material and cultural goods and the environment in major disasters and disasters and eliminate the consequences of terrorism and war destruction. In the Republic of Croatia, Civil Protection is regulated by the Civil Protection System Act. The law regulates the system and operation of civil protection; rights and obligations of state administration bodies, units of local and regional self-government, real and natural persons; training for the needs of the civil protection system; civil protection financing and other issues related to civil protection. In the city of Sisak, civil protection is managed by the Chief of Civil Protection Staff. The Civil Protection Headquarters is a professional, operational and coordinating body for the implementation of civil protection measures and activities in major disasters.

key words: civil protection, city of sisak, chief of civil Protection staff, The civil protection headquarters, disasters

1. INTRODUCTION

This paper analyzes the system of civil protection. Its role and importance in the event of accidents or disasters was particularly emphasized. The civil protection system consists of measures and activities. They regulate the rights and obligations of the participants, the organization and operation of all parts of the civil protection system and the way of connecting the institutional and functional resources of the participants, which complement each other into a single whole for the purpose of reducing the risk of disaster and protecting and rescuing citizens, material and cultural assets and the environment on the territory of the Republic of Croatia from the consequences of terrorism and war destruction.

The civil protection system is organized at the local, regional and national level. The main task is to connect the resources and capabilities of the participants, operational forces and citizens into a single whole in order to reduce the risk of disasters, provide a quick and optimal response to threats and dangers and mitigate the consequences of a major accident and disaster.

2. Operation of the civil protection system

The civil protection system operates through preventive and planning activities, development and strengthening of the readiness of participants and operational forces of the civil protection system.

The operational forces of the civil protection system continue to react to the actions of emergency services and regular forces of local and regional self-government units when they are unable to prevent the occurrence and/or development of a major accident and disaster.[1]

3. Participants in the civil protection system

Measures and activities in the civil protection system are carried out by the participants:

- Croatian Government
- The central body of state administration responsible for civil protection affairs
- State administration bodies and other state bodies
- Armed forces of the Republic of Croatia
- Local and regional self-government units.

4. Local and regional self-government units

Local and regional self-government units are obliged to organize tasks related to the planning, development, effective functioning and financing of the civil protection system.

Local and regional self-government units are obliged to strengthen and complement the readiness of the existing operational forces of the civil protection system in their area in accordance with the risk assessment of major accidents and the civil protection action plan, and if the existing operational forces cannot respond to the consequences determined by the risk assessment, they are obliged to establish additional civil protection units.[1]

5. Civil protection of the city of Sisak

In the area of the City of Sisak, measures and activities as part of civil protection are carried out by the following operational forces of the civil protection system:

- Headquarters of civil protection of the City of Sisak
- Public fire department of the City of Sisak, Fire Department of the City of Sisak,
- City Society of the Red Cross Sisak
- Croatian Mountain Rescue Service – Station Novska,
- General purpose civil protection unit,
- Coordinators on location,
- Commissioners of civil protection,
- Legal entities of interest to the civil protection system

5.1. The civil Protection Headquarters of the city of Sisak

The Civil Protection Headquarters of the City of Sisak was established by the Decision of the Mayor of the City of Sisak. It consists of the Chief, Deputy Chief of Staff and 12 members.

The Chief of Staff is the Deputy Mayor of the City of Sisak. The deputy chief of staff is the commander of the Public Fire department of the city of Sisak.

Representatives were appointed as members of the Headquarters:

- Komunalac Sisak d.o.o. trading company.
- Directorate of civil protection, head of civil protection Sisak,
- Sisak police stations
- Croatian Mountain Rescue Service Station Novska
- Hrvatske vode, VGI "Banovina" Sisak
- City Society of the Red Cross Sisak
- Administrative Department for Education, Culture, Sports, Veterans and Civil Society of the City of Sisak
- trading company Sisački vodovod d.o.o.
- Administrative department for administrative, property, legal and general affairs of the City of Sisak

- the trading company Gospodarenje otpadom Sisak d.o.o.
- of the trading company Auto promet Sisak d.o.o.
- Institute for Public Health [2,3]

The headquarters is a professional, operational and coordinating body. It is in charge of implementing civil protection measures and activities in major accidents and disasters.

The headquarters performs tasks

- collects and processes information
- warns early about the possibility of major accidents and disasters,
- develops a plan of operation of the civil protection system in its area,
- manages the response of the civil protection system in its area,
- performs tasks of informing the public
- proposes deciding on the termination of the implementation of measures and activities in the protection system.

The work of the Headquarters is managed by the head of the Headquarters, and when a major accident is declared, the mayor takes over the leadrship.

Calling and activating the Headquarters is ordered by the Head of the Headquarters, or in his absence, the Deputy Chief of the Headquarters.

The members of the Staff are invited in the manner determined by the Plan of inviting the Staff.[2]

Funds for the work of the Headquarters are provided in the Budget of the City of Sisak. The city of Sisak ensures the conditions for the work of the Headquarters. Administrative and technical tasks for the needs of the Headquarters are performed by the officers of the Administrative Department for administrative, property legal and general tasks, responsible for civil protection tasks.[2]

The civil protection headquarters stood out in particular after the catastrophic earthquake in the area of the City of Sisak of 5.1 degrees on the Richter scale on December 28, 2020 and the 6.2 degree earthquake on December 29, 2020. The task of the Civil Protection Headquarters was to repair the damaged infrastructure in the shortest possible time and enable citizens to live and work normally, and to help citizens who were left without housing conditions and to repair damage to the roofs of houses due to the collapse of chimneys.

After the earthquake, an inspection of buildings in the area of the City of Sisak was carried out by the Croatian Center for Earthquake Engineering organized by the Republic of Croatia. Based on their findings, the victims who were left without homes were placed in container settlements or in brick buildings (which received a green sticker) organized by the city civil protection headquarters. This is the result of the decision of the City of Sisak to take care of users in a more appropriate and better way due to poorer living conditions and easier organization of daily life.[4]

Currently, there are 159 people in container settlements, housed in solid facilities 46 in two locations in the City of Sisak.[4]

6. CONCLUSION

The Act on the Civil Protection System regulates the system and operation of civil protection, as well as the obligations of local and regional self-government units in the civil protection system. We can see that great autonomy is given to cities in the execution of jobs and tasks in the field of the civil protection system, from which the increasing obligations arise.

Civil protection should be developed in the conditions and circumstances in which we move and stay every day. The system of civil protection should be developed through European projects, and funds should be provided for the improvement of civil protection.

The City of Sisak continuously invests in organizing, equipping and developing the civil protection system, which increases the degree of readiness for possible threats and risks that may befall the City of Sisak.

The end of 2020 and the whole of 2021 was marked by a series of earthquakes, two of which were catastrophic. The operational forces of the City of Sisak were faced with a difficult task in these areas, and they showed readiness and completed all tasks. The consequences of the earthquake were eliminated in conditions aggravated by the COVID-19 pandemic, which presented additional challenges for the Civil Protection system of the City of Sisak.

REFERENCES

[1] Zakon o sustavu civilne “Narodne novine”,broj 82/15, 118/18, 31/20,20/21

[2]“Službeni glasnik Sisačko-moslavačke županije”, broj 18/21, Sisak, str.443.

[3]“Službeni glasnik Sisačko-moslavačke županije”, broj 25/21, Sisak, str.812

[4] Kategorija: Vijesti|Grad Sisak- sisak.hr/kategorija/vijesti/?fvp_paged=12

SCC -
Rules and regulations

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In recent years, trainings in the field of occupational safety and SCC trainings have been conducted in Croatia.

We can often hear the questions of what is the SCC and why must the training of workers be carried out if we have legally defined ways of conducting the training of workers in a safe way and which require significant additional financial resources?

Here we provide an explanation of the concept of SCC as well as the requirements that arise from it. The presentation provides answers to the questions: What is SCC ?, Who is it for ?, To what extent is it in line with the Legislation ?, What areas of safety and health does it cover? Who conducts SCC trainings in the Republic of Croatia, on the basis of which authorizations ?, What is needed to obtain SCCp certificates in the company ?, How much are documents valid and where can they be used - who seeks SCC certificates for workers and companies ?.

Keywords: SCC training, SCCp certificate

1. INTRODUCTION

Figure 1: SCC logo

SCC is a certifiable work safety management system

SCC combines aspects from (work) Safety, Health and Environmental protection (HSE)

Recognised internationally (Germany, Benelux, Switzerland)

Certifiable according to ISO / IEC 17021

Can be combined with other standardized systems like EN ISO 9001, EN ISO 14001, EN

ISO 45001.

2. HISTORY

1989: Common document for safety specialists in the petrochemical industry in Rotterdam (Netherlands)

1994 Accreditable common checklists (VCA)

1995 Adoption of the model in Germany (TGA)

1998: Adapted to the Austrian law and formation of SK SCC (SCC sector committee Austria, accredited with the BMWA)

2002: Mutual recognition and use of the SCC logo

International SCC platform: NL, B, D, A

2017: Recognized in INA dd and becomes mandatory for all contractors

Mostly recognized in Industrial sectors in which safety is a sensitive issue:

Petroleum industry
Petrochemical industry
Chemical industry
Paper industry
(Power plant and) plant engineering

3. TABLE OF SCC CONTENTS:

A01 - Introduction and Overview

A02 - Instructions and requirements for SCC certification bodies based on EN ISO / EC 17021

A03 - SCC checklist

A04 - Regulations for AUVA (personal check up)

A06 - Accident statistics and accident frequency
A07 - Assignement EN ISO 9001
A08 - Comparisons of old / new versions (2007/2011)
A09 - Hazardous work and activities in very hazardous work areas
A10 - Checklist for assessing subcontractors and manpower service providers by contractors
A15 - Personnel certification: Operational employees in the HSE area
A16 - Requirements for internal HSE training and test for operational employees
A17 - HSE test for operational senior management
A18 - HSE test for operational employees
A23 - SCP Checklist

4. TYPES OF CERTIFICATION

SCC*: Scope 1, < 35 employees, restricted certification
SCC**: Scope 1, > 35 employees, unrestricted certification
SCCP: Scope 1, unrestricted certification for petrochemical industry
SCP: Scope 2, only for manpower service providers

5. SCC DOCUMENTS

Document A03 - SCC checklist: - 12 sections:

1. HSE policy, Organisation and management commitment
2. HSE - Risk assessment
3. HSE - Training, information and briefing
4. HSE – Awareness
5. HSE - Project plan
6. Environmental protection
7. Preparing for emergency situations
8. HSE – Inspections
9. Occupational health support
10. Procurement and testing of machines, devices, equipment and working materials
11. Procurement of services

12. Reporting, registering and investigating accidents, near misses and unsafe situations

Example of Compulsory question from the SCC checklist (document A03 and A23)

2.3. Is a LMRA (Last Minute Risk Analysis) carried out just before starting the work?

OBJECTIVE

Just before starting work on construction sites, in assembly operations etc., the employees

check whether all the hazards are known and appropriate measures have been taken.

MINIMUM REQUIREMENTS

The LMRA is carried out according to a defined procedure systematically and consistently.

Document A17 - Exam for operational managers

Proof of entry requirements (document A15)
List of questions from the SCC sector committee
70 multiple-choice questions (4 answer options)
Written answer (maximum 105 minutes)
at least 49 correct answers (> 70%)
Exam certificates valid for 10 years

Document A18 - Exam for operational employees

List of questions from the SCC sector committee
40 multiple-choice questions (4 answer options)
Written answer (maximum 60 minutes)
at least 49 correct answers (> 70%)
Exam certificates valid for 10 years

6. COMPATIBILITY WITH CROATIAN REGULATIONS

The requirements of the SCC contain the minimum prescribed by law and contain

additional requirements that primarily relate to additional supervision and prevention.

Additional requirements have been introduced for regular documentation of activities

such as:

- potentially dangerous situation
- LMRA
- internal controls by the management
- annual reports of occupational medicine
- education of workers and managers every 10 years
- development of a project plan for each site
- Safety pass
- Subcontractor supervision

In the same time in Croatia we have prescribed legal document (certificate) - ZOS form

as proof of the ability of workers to work safely.

Why we have to do additional document when it is not recognized by authorities?

7. WHO CONDUCTS TRAININGS IN THE REPUBLIC OF CROATIA?

There is no authorized SCC training company in Croatia at a moment according to ISO/IEC 17024.

The trainings are conducted by authorized companies through their representative offices

in Croatia, such as:

Bureau Veritas

TUV ….

SGS

8. SHOULD A COMPANY IMPLEMENT SCC IF IT HAS ISO 45001?

Currently, many companies have introduced both systems.

The questions of the purpose and cost-effectiveness of such an approach is raised.

Some companies have relaxed the requirements for companies that have introduced

ISO 45001, so they are no longer required to implement SCC.

It is to be expected that this will become a practice in the future.

9. CONCLUSION

At a moment, SCC has a serious application in the part of EU members and the requirements are very rigorous where, in addition to the application of certificates, Safety pass booklets are also required.

In Croatia, SCC is currently required in only one company, INA d.d. And it is questionable whether it will be extended to other companies, given that in the Republic of Croatia we have prescribed legal document (certificate) - ZOS form as proof of the ability of workers to work safely.

Some companies have introduced occupational health safety systems according to ISO 45001, so the question is whether they should have two certificates for the "same" thing? Which calls into question the survival of SCC norm in the future.

REFERENCES

[1] SCC Dokument A03, 2011-01, SCC checklist
[2] SCC Dokument A 15, 2011-01, Personal certification: Operational personnel in the
HSE area.
[3] SCC Dokument A 16, 2011-01, Requirements for internal HSE training and test for operational employees
[4] SCC Dokument A 17, 2011-01. HSE test for operational senior management
[5] SCC Dokument A 18, 2011-01, HSE test for operational employees
[6] ISO 9001:2015 Quality management systems — Requirements
[7] ISO 14001:2015, Environmental management systems
[8] ISO 45001:2018, Occupational health and safety management systems — Requirements with guidance for use
[9] ISO/IEC 17021-1:2015, Conformity assessment — Requirements for bodies providing audit and certification of management systems — Part 1: Requirements

[10] ISO/IEC 17024:2012, Conformity assessment — General requirements for bodies operating certification of persons

CROWDFUNDING AS AN ALTERNATIVE MODEL OF FINANCING PROJECTS – EXAMPLE OF TOURISM EVENT

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Abstract: *Crowdfunding is a way of financing projects and business which enables fundraisers to collect money from a large number of people via online platforms, used mostly by startup companies or financing new projects or ideas. Funding is done on the internet, ie on crowdfunding platforms via several different models. The subject of this paper is to present crowdfunding as a concept, to explain models of crowdfunding and to present one example of financing tourism event in the Republic of Croatia.*

Key words: *crowdfunding, financing, alternative model of financing, financing in tourism*

1. INTRODUCTION

In order to realize a project via financing from external resources, it is necessary to prepare business plan which has to be elaborated in detail. Based on a well-prepared business plan, investors such as banks, business angels, private equity funds or other make a decision to invest their funds in a specific business idea. One of alternative model of financing project is crowdfunding, which is used in Croatia for several years to finance some specific business ideas and projects. In tourism, specific music festival in Komiža, island Vis, is using crowdfunding platform to organize the event each year from 2013.

2. CONCEPT OF CROWDFUNDING

Crowdfunding is one of the modern ways of collecting financial resources for various activities from different groups of people, whether for financing projects related to culture or tourism, or the way to collect financial resources for the

treatment of seriously ill people or helping in the rehabilitation of earthquake-affected areas.

One of the definitions of crowdfunding points out that it is project financing or investment by a group of individuals, instead of specialized parties such as financial institutions, business angels, etc. [4]. Financial resources are collected from persons who are willing to support the project based on the presented plan, which would mean that collected money doesn't come from banks and other financial institutions, but from known or unknown persons who like the project and are willing to invest their money into it because they think it is market justified. Crowdfunding is an alternative funding mechanism for organizations and entrepreneurs to raise small amounts of money from the crowd as micro-investors [7], or a financial tool that allows entrepreneurs to receive funds from a large group of individuals [2].

One of the definitions emphasizes that crowdfunding includes an open invitation, usually via Internet, to collect financial resources in the form of donations, in exchange for a future product or some other form of reward for supporting a certain project [1]. All projects that want to be financed through crowdfunding must currently be presented to the general public exclusively via the Internet. Some of the most famous online crowdfunding sites are: Indiegogo, Kickstarter, GoFundMe, PledgeMusic and RochetHub.

A person who wants to raise money through these mentioned platforms uses all possible and available options to present his idea to potential investors in the best possible way - from creating a website with information about the project, photos and videos about the project, product or service for financing. Crowdfunding also makes it possible to develop a strong relationship with investors, who will later become advocates of the product itself after its launch on the market. The most important thing to take into account when starting a crowdfunding campaign is actually the quality of the idea and project itself, innovative solutions and the quality of the design itself. It is also necessary to present the idea well and to continuously inform the public about the advantages of the idea via Internet pages and/or social networks in order to reach as many interested investors as possible.

Crowdfunding is changing the financial industry on several levels [4]:

1. enables validation of the idea itself before the final product reaches the market
2. enables access to capital without additional collateral required by the traditional financial sector (for example, a real estate mortgage),
3. enables risk dispersion. The initiator of the campaign, who has worked out his business plan well, knows how much money he needs to start the business, and if he does not collect all the necessary money, he will not even embark on a business venture. On the other hand, donors contribute relatively small amounts that they can afford to lose
4. marketing dimension which is crucial for a successful campaign. Crowdfunding not only collects money for a business idea, but also creates a marketing campaign for it

The duration of the campaign depends on the crowdfunding model used and the characteristics of the business idea. The campaign lasts from 60 to 90 days, and

during that period the initiator of the campaign disposes of the amount that has been collected. Likewise, each campaign is transparent, that is, at any moment you can see how many funds have been collected for a certain project and how many people have been engaged in real time. Through the website of the platform used for crowdfunding, the target amount and the total amount collected, as well as the total number of donors or people who supported the campaign, were clearly set.

3. MODELS OF CROWDFUNDING

Several crowdfunding models are used in the world, and the criteria according to which the division is made are as follows: the goal and type of the project and the way of the investor's participation in the project, the future of the project depending on the achievement or non-achievement of the defined goal and the phase of the project for which the funds are collected [4].

3.1. The crowdfunding model that refers to the goal and type of project and the method of investor participation in the project

The crowdfunding model that refers to the goal and type of project and the way investors participate in the project is the most represented. The mentioned model is divided into several subgroups: funding based on donations, based on awards, lending and ownership. If the entrepreneur decides on a donation-based financing model based on a donation contract without a defined reward, it means that the entrepreneur will not offer potential financial supporters any "reward" for their payments. This model is one of the more common ones in humanitarian campaigns, where the aim is to offer help to people in difficult life situations (illness, property problems, etc.). Some of the most popular platforms based on the donation model are: GoFundMe, Generosity, Patreon, etc. If the rewards model is used, a sales contract for certain types of products/services is attached to it. The investor expects a certain reward for his payment. In most projects, the reward depends on the amount of funds paid; more precisely, the higher the amount paid includes the higher value of the prize. With this model, it is important to note that the platforms are excluded from responsibility for the delivery of the promised rewards, so if there is a dispute, the platform is protected and all responsibility rests with the initiator.

An example of financing with this model is a campaign on the "Kickstarter" platform through which a DJ collects funds to be able to create his album, and as a reward donors are provided with t-shirts, badges, a face-to-face conversation with a DJ, and even private lessons of "dj-ing" and much more. Platforms that work according to the reward model are: Kickstarter, Indiegogo, RocketHub, PledgeMusic, Croinvest, etc. One Croatian campaign that collected the most funds using the reward model is the social game Machina Arcana, which collected $618,305 (Kickstarter). The lending model is specific because with it, potential investors support a certain project through the loan of financial resources, but with

the obligation of the initiator to return the borrowed amount increased by a defined interest after a given period of time (eg. years). The process of returning the funds is easier because numerous donations have been received from a large number of people, but in small amounts. Some of the more popular platforms for implementing this crowdfunding model are: Kiva, Zopa, etc.

3.2. Crowdfunding models concentrated on the future of the project depending on reaching or not reaching the defined goal

Crowdfunding models concentrated on the future of the project depending on the achievement or non-achievement of the defined goal refer to the outcomes of the project which can appear in two forms: 1. "All or nothing" (fixed model) and 2. "Keep it everything" (flexible model) [3]. Some platforms offer both financing models, while some offer only one of the above. In the fixed "all or nothing" model, a fixed financial goal is set to be reached. If the campaign in a certain period of time collects a given amount of financial resources or more, that money will be paid to the entrepreneur in full, but if the money is not collected, all the money will be returned to the donors. The most famous platforms that provide only this model are: Kickstarter and Pozible. The basic advantages and disadvantages of the all-or-nothing model are shown in the table below.

Table 1: Advantages and disadvantages of the "All or nothing" model

Advantages	Disadvantages
Uncertainty spurs activity	The campaign is unsuccessful if there is not a sufficient number of investors, i.e. in a situation where when the goal is not achieved - all the money is returned to the investor
“Make or break”	
Higher payments	
Safety for donators	

Source: Civilno društvo Istra (2017)

Uncertainty stimulates activity implies a situation in which the campaign becomes exciting for donors because they do not know what will happen in the future and encourages them to donate. As for "Make or break", it is the donors who have the power and with their payment they can make the campaign successful. If they are not included, the whole stones fail. This power generates payments, especially as the end of the project approaches. [3]. As for larger payments, some of the platforms offer rewards for donations, so in this project those donors who require larger rewards also have larger payments, which is one of the great advantages of this financing model. Donors are safe in this matter, because if the project does not come to life, i.e. if not enough funds are collected as it was set, the donated funds are returned to the donors.

If another financing model is used, i.e. when the flexible "Keep everything" model is used, a default financial goal is also set, but it is specific that if the

necessary funds are not collected, the entrepreneur will be paid as many funds as are collected. The most famous platform that uses both funding models is Indiegogo.

Table 2: Advantages and disadvantages of the "Keep everything" model

Advantages	Disadvantages
The only advantage of this model is that no matter how much money the entrepreneur collects, it all pays off, regardless of the goal	Insufficient amount of money
	There is no urgency
	There is no guarantee
	Higher commission

Source: Civilno društvo Istra (2017)

The main drawback of this financing model is the insufficient amount of money, that is, the situation in which the entrepreneur finds himself if he does not collect the target value of the project. Given that with this financing model, the project has no urgency because the goal is not relevant, it becomes uninteresting to investors, so the payments themselves are turned into donations. Those entrepreneurs who offer a reward for each payment may not have the opportunity to send it to their investor in the future, so the guarantee for the promised rewards is cited as one of the disadvantages of this model. Crowdfunding platforms that support this financing model will take a higher commission on payments.[4]

3.3. Financing models according to project development stages

Financing models according to the stages of project development are as follows: [4]

- classic crowdfunding for projects whose realization will just begin
- partial crowdfunding for projects that have secured partial financing, however, additional funds are needed
- pre-sale crowdfunding for projects that are close to realization and that need funds for the final realization and
- distribution crowdfunding for projects that have been realized, but are looking for new funds.

4. EXAMPLE OF CROWDFUNDING CAMPAIGN IN TOURISM – GOULASH DISKO FESTIVAL

Goulash Disko Festival is a project of two young and ambitious people who have been organizing the festival on Vis (Komiža) since 2013 and financing it through crowdfunding. They chose the Ulula site to finance their project and every year so far, except for 2020, the project has taken place. The festival is always held at the end of September to close the entire festival season on the Adriatic Sea. The number

of tickets is limited, and the festival is specific in that festival-goers are expected to behave like a true "Goulashian" (act with love, awareness and respect). Goulash Disco music is special in that it encompasses and explores special musical genres such as: tropical grooves, oriental house, gypsydelic, voodoo jazz, swing folk, ethno dub, gypsy punk, organica, latintronics, etc. On the website of the festival, the innovators offered the possibility of registration if someone has a recommendation, wants to participate as a musician or participate in some other sense (volunteer, employee, etc.)

It is a five-day party that combines music, nature and admiration, and the festival itself has no sponsors and is independent of sponsors because it is financed through crowdfunding campaigns. The table below lists the planned and collected funding amounts in the period from 2013 to 2021.

Table 3: Crowdfunding amounts for the Goulash Disko Festival

Year	Planned amount	Collected amount	The share of the amount collected	Number of supporters
2013	5.000 €	6.403 €	128%	95
2014	10.000 €	12.701 €	127%	142
2015	10.000 €	13.232 €	132%	144
2016	10.000 €	25.000 €	250%	213
2017	20.000 €	46.808 €	234%	479
2018	25.000 €	54.214 €	216%	500
2019	25.000 €	87.458 €	349%	473
2020	25.000 €	72.300 €	289%	385
2021	25.000 €	50.000 €	200%	207
2022*	25.000 €	82.109 €	328%	293

**the campaign is still ongoing, data as of July 22, 2022.*

Source: https://www.ulule.com/goulash2022/ (22.07.2022.)

The data shows a steady increase in the amount of funding collected and an increase in the number of campaign supporters, except in 2020 and 2021, when the festival was not held due to epidemiological measures.

The financial plans have been increased over the years and every year the amount of funds collected exceeded the planned funds by more than 300% of the amount. The number of supporters of the campaign increased from 95 in the first year to as many as 473 supporters in 2019. In 2020 and 2021 the festival did not take place, so a large number of tickets were postponed and in 2022 there is a limit on the number of tickets. Despite this, the amount of funding collected far exceeded the set goal.

Ulule is a platform that operates on the principle of a reward model. In this case, as a sign of thanks to the investors, the organizers give prize tickets with a wealth of

content depending on the size of the stakes, so the investors in the project are mostly festival visitors themselves.

The festival has great significance for the destination itself and the development of tourism, as it enriches the tourist offer of the island of Vis and encourages tourist movements outside the season. The festival encourages the promotion of the island of Vis as a destination for entertainment tourism, camping tourism, naturism and more.

3. CONCLUSION

Crowdfunding is one of the ways of financing projects in tourism (alternative) that enables different ways of financing quality projects that have great potential. Crowdfunding projects can be placed on platforms in various categories, including entertainment, social, natural, etc., and that these projects have various direct and indirect impacts on other branches. One of the conclusions based on the example of the Goulash Disko Festival is that it has a positive effect on the tourism of the destination itself and that the recognition of the destination itself is visible in the media.

Croatia has great opportunities for the development of the crowdfunding industry, but for now it is not particularly interesting in the field of tourism. An important factor in the realization of such and similar projects is the trust and information of entrepreneurs and the public so that they are confident and persistent in taking such steps and methods of financing.

REFERENCES

[1] Belleflame P, Lambert T., Schweinbacher A.: *Crowdfunding: Tapping the Right Crowd*, SSRN Electronic Journal 29(5), 2012

[2] Chen W. D.: *Crowdfunding: different types of legitimacy*, Small Business Economics, July 2022

[3] Civilno društvo Istra, Vodič za crowdfunding (2017) https://www.civilnodrustvo-istra.hr/images/uploads/files/Vodi%C4%8D_za_crowdfunding_-_Hrvoje_Hafner_-_Udruga_SMART.pdf

[4] Galant A.: *Crowdfunding u financiranju kulture*, in Golja T., *Odabrane teme suvremenog menadžmenta u kulturi i turizmu*, Sveučilište Jurja Dobrile u Puli, Pula, 2017.

[5] Hefner H.: *Vodič za crowdfunding*, 2017., http://www.crowdfunding.hr/wp-content/uploads/2018/02/Vodi%C4%8D-za-crowdfunding-Hrvoje-Hafner.pdf (16.09.2020.)

[6] Ulule, https://www.ulule.com/goulash2022/ *Accessed:* 2022-07-22

[7] Van Looy, A.: Crowdfunding, in book: *Social Media Management* (pp 2017-223), Ghent University, May 2022

CONVENTION NO. 190 ON THE ERADICATION OF VIOLENCE AND HARASSMENT IN THE WORLD OF WORK (2019)

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Abstract: The demand of modern humane society is, among other things, "zero tolerance for violence and harassment". Convention No. 190 on the eradication of violence and harassment in the world of work and the content (2019) is a special international labor standard: eradicating violence and harassment in the world of work, dignified work, anti-discrimination, (equality between men and women) and safe working conditions. Convention No. 190 (2019) was adopted at the 108th session of the International Labor Conference, 21.06.2019. in Genoa. "The Convention is the first international instrument setting out specific, globally applicable standards on tackling work-related harassment and violence and specifying the measures required from states and other relevant actors." Violence and harassment represents a violation or abuse of the human rights of every person, enshrined in the highest standards of universal sources of human rights. They concern the equality of all human beings, material well-being, spiritual development, freedom and dignity, economic security and equal opportunities, the elimination of all forms of discrimination and all forms of discrimination against women, migrants and their families, the rights of persons with disabilities, violence-free work and harassment (in the world of work) as well as without work-related violence and harassment that may constitute a violation of human rights. Violence and harassment are unacceptable and incompatible with decent work, work culture and mutual respect.

Keywords: convention, violence, harassment, eradication, the world of work

1. INTRODUCTION

ILO Convention No. 190 (2019) emphasizes: violence and harassment affect the quality of services and can prevent access to the labor market, as well as staying and progressing at work; violence and harassment negatively affect work organization, workplace relationships, employee engagement, employer reputation and productivity; addressing the root causes and risk factors ... are necessary to stop violence and harassment in the world of work. Domestic violence can affect employment, productivity and health and safety and more.

2. CONTENT OF THE CONVENTION

The Convention has the content of eight parts (I-VIII) which define the concepts, subjects and relations on the eradication of violence and harassment in the world of work and more. "Violence and harassment in the world of work refers to a range of unacceptable behaviors and practices, or threats of such behaviors and practices, whether individual or repeated, aimed at, resulting or likely to result in physical, psychological, sexual or economic injury and includes gender-based violence and harassment." The spatial definition of the Convention are "all sectors, whether private or public (in the formal and informal economy) in urban or rural areas". Violence and harassment in the world of work occurs "during work, in connection with work, or as result of it". The Convention applies to workers and persons irrespective of their contractual status, persons undergoing training, including trainers and trainees, volunteers, terminated workers, jobseekers and job candidates, and individuals holding duty or employer responsibility; all who are engaged under a contract of employment, work-engaged pupils and students, etc. Violence and harassment can occur: at work but also in every place where the worker stays, on business trips, social activities, etc., in all types of communication related to work, in accommodation provided by the employer, when traveling to and from work. The Convention regulates these principles: the obligation of the state to respect, encourage and exercise the right of every person in the world of work without violence and harassment; cooperation of the state with the social partners in the regulation, implementation and protection and responsibility for the prevention and eradication of violence and harassment in the world of work; while respecting other principles (association, collective bargaining, prohibition of forced labor, elimination of child labor, combating discrimination, protection of "vulnerable groups" and others affected by violence and harassment "disproportionately in the world of work"). Special provisions of the Convention relate to the protection and prevention of violence and harassment, as well as to "enforcement and remedies", as well as "methods of application" through: national laws and regulations, collective agreements, "expanding or adapting existing occupational safety measures" and others methods aimed at "including the prevention of violence and harassment".

3. ILO RECOMMENDATION NO. 206 (2019) ON THE ELIMINATION OF VIOLENCE AND HARASSMENT IN THE WORLD OF WORK

Recommendation No. 206 (2019) was adopted at the same session as the Convention (as amended) No. 190 (2019) of the same name, and its content consists of four parts (I-IV) and basic principles, protection and prevention, implementation,

remedies and assistance, guidance, training and awareness raising (spread over twenty-three points). The recommendation covers the same areas as the Convention: human rights, decent work, anti-discrimination, equality between men and women, safe working conditions. The definitions in the Recommendation should be used as set out in the Convention. Emphasis was placed on the cooperation of employers and workers in the consistent application of the Law on Labor, Employment, Occupational Safety, Equality and Non-Discrimination, the Criminal Code and others ..., (all with equality and non-discrimination according to ILO instruments). The Recommendation sets out "the same starting points" as the Convention: involvement of employer and worker, full information, protection of "complainants", risk assessment of violence and harassment, protection of "vulnerable groups" of workers, implementation of "remedies and assistance", guidance, training and awareness raising, knowledge of a number of entities ("implementation").

4. ROOTS AND FOUNDATIONS OF THE CONVENTION AND RECOMMENDATIONS

After more than 100 years since the establishment of the International Labor Organization (ILO), Convention No. 190 (2019) and Recommendation no. 206 (2019) on the eradication of violence and harassment in the world of work were made. Violence and harassment exist in life and in the world of work and will not end with the ratification of the convention or the acceptance of the Recommendation. These are universal sources of rights with the main goal set in the ILO Constitution and other universal documents, building better working conditions and minimum standards at work and in connection with work, which includes the eradication of violence and harassment in the world of work. The roots and foundations of the Convention and the Recommendation are in the principles and standards of human rights and freedoms at work, as natural rights (welfare, debt development in conditions of freedom and dignity, economic security and equal opportunities, the right of every person to a world free of violence and harassment, which "affects the mental, physical and sexual health, dignity and family and social environment of a person").[1] Article 1 defines the terms: "violence and harassment" in the world of work as already mentioned as "gender-based violence and harassment" - it also means violence and harassment directed at persons because of their sex or gender or disproportionately affecting persons of a particular sex or gender and involving sexual harassment. For this purpose „each member shall enact laws and regulations...“[2] The eradication of violence and harassment in the world of work is "addressed through relevant policies,

[1] *ILO Convention No. 190 concerning the Eradication of Violence and Harassment in the World of Work* (2019), Republic of Croatia, Ministry of Labor, Pension System, Family and Social Policy, CLASS: 021-03 / 21-01 / 04, REGISTRATION NUMBER: 524 -03-02-02 / 1-21-1, Zagreb, April, (2021)

[2] *Labor Law*, "NN" 93/14, 127/17, 98/19, *Law on Protection of Reporters of Irregularities,* "NN" 17/19, *Law on Occupational Safety,* "NN" 71/14, 118/14, 154/14, 94/18, 96/18.

such as those concerning occupational safety, equality and non-discrimination and migration" (Article 11 of the Convention), "expanding or adapting existing occupational safety measures ... and adapting specific measures where needed. " "Victims of violence and harassment in the world of work should have access to compensation in cases of psychosocial, physical or any other injuries or illnesses that result in incapacity for work" (recommendation - cit. III. 15). "Members should function, develop, implement ... programs, ... guidelines, codes of conduct, public campaigns, ... materials ..." and others "in order to promote safe, healthy and harmonious work environments free of violence and harassment". It is difficult to list all the subjects in these relations, but it is important not to "bypass" the subjects of individual and collective labor relations. There are also "public officials in fulfilling their mandate in relation to violence and harassment in the world of work ..." (judges, labor inspectors, police officers, prosecutors and others).

INSTEAD OF CONCLUSION

ILO Convention No. 190 (2019) and Recommendation No. 206 (2019) on the eradication of violence and harassment in the world of work are one of the instruments of a universal character in the field of human rights, dignified work, anti-discrimination (equality between men and women) and safe working conditions. They "set specific and globally applicable standards for combating violence and harassment in the world of work ..." and determined the obligations of states and other entities. The future in the world of work must be free of violence and harassment. The Convention and the Recommendation provide a single definition of violence and harassment "covering a wide range of unacceptable behaviors", and violence and harassment in the world of work "constitute a violation or abuse of human rights". The state is obliged to regulate the rights prescribed in the mentioned documents.

LITERATURE AND REGULATIONS

[1] Law on Suppression of Discrimination "NN" 85/08, 112/12
[2] Law on Gender Equality "N.N" 82/08, 69/17
[3] Labor Law "NN" 93/14, 127/17, 98/19
[4] Law on Occupational Safety "NN" 71/14, 118/14, 154/14, 94/18
[5] ILO Convention no. 190/2019 on the eradication of violence and harassment in the world of work
[6] ILO Recommendation no. 206 on the eradication of violence and harassment in the world of work (2019).

MINIMUM SAFETY AND HEALTH REQUIREMENTS FOR THE WORKPLACE

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***Abstract**: safety and health requirements for the workplace are part of a unique system of safety at work that is part of system of safety and health at work and the working environment and the introduction of measures to encourage the improvement of safety and health of workers at work. This system is regulated by numerous legal norms of universal, regional and national (heteronomus and autonomus) legal sources of safety at work. These natural rights (human rights) for person at work are built into the highest legal norms. ILO conventions, EU directives and other regulations guarantee higher levels of protection of the safety and health of workers at work. Legal norms of these regulations are implemented by many entities, but at the heart of the relationship are employers and workers in maintaining jobs, equipment and devices, informing workers, counseling, participation in decision-making and other forms and contents of social dialogue on minimum labor standards for safety and health at work and workplace requirements.*

Keywords: legal sources, safety, health protection, workplace, standards and requirements

1. INTRODUCTION

On June 12th 1989, Directive 89/391 / EEC on the introduction of measures to encourage improvements in the safety and health of workers at work was adopted in Luxembourg. This Directive lays down minimum requirements to encourage improvements in health and safety and their higher levels. It is the responsibility of the Member States to "guarantee the safety and health of workers". On the basis of this "framework" (fundamental) directive, individual directives have been adopted (and are being adopted) which "cover" risks related to safety and health at work and in the workplace and work environment and implementation, primarily measures to prevent accidents at work, occupational diseases, other work-related diseases and the prevention of damage to the safety and health of workers. Obligations are that workers are regularly and fully informed about the risks to their safety and health and the measures taken to reduce or eliminate those risks, that employers and workers cooperate, conduct social dialogue and cooperate equally on issues of safety and health at work. Development, technological and scientific progress and economic reasons are taken into account ("but not exclusively"). The Law on Safety at work has

transposed (among others) Directive 89/391 EEC into the legal order of the Republic of Croatia[1]. Pursuant to Article 16 of Directive 89/391 / EEC, on November 30th1989 the Council of the EU (EC) adopted the first individual Directive 89/654 / EEC on the minimum safety and health requirements for the workplace, which was "transposed" into national law of the Republic of Croatia.

2. MINIMUM SAFETY AND HEALTH REQUIREMENTS FOR THE WORKPLACE

The term "place of work" is determined by regulations of universal, regional and national character, different name, content, adoption procedure, temporal validity and other nomotechnical characters (designation). "Workplace includes all places where workers must be or must go for work and which are under the direct or indirect control of the employer."[2] Council Directive 89/654 / EEC (Article 2) defines "for the purposes of this Directive" "place of work" means a place intended for work on the company's premises and any other place on the company premises which the worker has access during his work".[3] This Directive was "taken over" into the legal system of the Republic of Croatia by the Ordinance on Occupational Safety for Workplaces "N.N" 29/2013, which expired on October 3rd 2020. However, the Ordinance on Occupational Safety and Health for the Workplace "repeated" it.[4] Law on Safety at work (Article 3, paragraph 1, item 6) defines a place of work as "any place where workers and persons at work must be or must go to, or to which they have access during work due to jobs that perform for the employer as well as any space, i.e. the premises used by the employer for the performance of work and which is under his supervision" (direct or indirect).[5] The place of work is also the work site ("temporary or mobile place of work"). "New place of work" also means a place of work that already exists, but a worker who has been "referred" to that place has not worked at it so far. Other laws and by-laws (regulations) regulate the issue of safety and health protection at the workplace, but the provisions of these regulations must not be less favorable than ratified ILO conventions and EU recommendations. By-laws (implementing) regulations regulate: "foundation and construction of a facility; use of electricity, protection when using equipment, plants, devices and installations, fire

[1] Directive 89/391 / EEC of June 12th 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (SL.L. 183, June 29th 1989); Law on Occupational Safety "NN" 71/14, 118/14, 94/18, 96/18

[2] Učur, M.; Laleta, S.: *Conventions of the International Labor Organization with Comments*, ILO Convention (ILO, OIT) No. 155 on safety and health protection at work and the working environment, 1981, "N.N" 11/03", TIM press, Zagreb, Faculty of Law Rijeka, (2007)

[3] *Directive 89/654/EEC on November 30th 1989 concerning the minimum safety and health requirements for the workplace*, SL.L. 393, December 1989

[4] *Ordinance on safety at work for the place of work* "N.N" 105/2020, September 2020

[5] Labor Law - quote

protection and other issues", as part of the workplace. As of October 3rd 2020, the Ordinance on Occupational Safety at Work applies, which prescribes "minimum safety and health requirements for the workplace". This Ordinance "takes over" and "specifies" the provisions of Council Directive 89/654 / EEC as a basis and framework for "minimum requirements for the place of work, with the establishment of "exceptions" (for: designers, investors, contractors, installations, workplaces, exits in an emergency, open spaces, etc.).[6] Measures to encourage the improvement of safety and health protection of workers at work in the work environment or workplace Numerous subjects are determined by regulations on the relations of safety and health protection of workers at workplaces. The rights and obligations at workplaces where jobs with special working conditions are performed are specifically regulated, as well as the obligations of securing the workplace "if a minor, pregnant worker, worker who recently gave birth or is breastfeeding, and a disabled or older worker" works there. The employer has constant, demanding and expensive obligations: in accordance with and in connection with the provision of first aid... "according to a special rulebook, a ban on smoking and similar products (addictive substances, etc.); "highlighting" at the place of work signs, instructions, markings, documents (eg risk assessments and others); determine and implement measures according to the characteristics (specifics) of the workplace and place of work;[7] take "all steps or measures... at all stages of the company's work, aimed at avoiding or reducing occupational risks"; in order to protect health (integrity of the organism), functionality of the organism, adaptive ability and subjective experience of health. "Health" related to work "does not mean only the absence of disease or disability ... but includes physical and mental factors that affect health, and which are directly related to safety and hygiene at work“. Health is a state of complete physical, mental and social well-being, and not just the absence of disease and incapacity... ".[8] The right to health is one of the fundamental natural rights (human rights) enshrined in the most important sources of rights and in the constitution of democratic states; detect and eliminate hazards, harmfulness and effort that can cause injuries at work, occupational diseases, other consequences harmful to life and health and property of workers and employers; "... ensure that the workplaces used are safe, maintained, adapted for work and in good condition at all times...", perform inspections, i.e. tests of the means of work used, safety signs, personal protective equipment... (even in cases of “changes affecting the place of work..., technical changes, etc.); meeting the minimum safety and health conditions... "whenever necessary due to the characteristics of the workplace, activities, circumstances or hazards...", regular maintenance of the workplace, devices and equipment, hygiene

[6] Labor Law, *Council Directive 89/654/EEC – quote,* Ordinance on occupational safety for the workplace, No. 10/20, ROSIP d.o.o., Zagreb, pp. 47-58

[7] ŠOKČEVIĆ, S.: *Occupational Safety and Health Act with comments and interpretations*, The workplace consists jobs and tasks as its content, but also the means and procedures of workers at work in that workplace, organized and determined by the employer, TIM-press, Zagreb, (2014), pp. 153.

[8] UČUR, M.: *Social Law*, ILO Convention no. 155 (1981) - quote Article 3; Constitution of the World Health Organization "N.N - M.U.", Informator, Zagreb, (2000)

level and other...;[9] cooperation with workers and informing workers "about all aspects and measures that must be taken with regard to safety and health at work...". Social dialogue is a principle, but also a starting point and starting point in these sources of law.[10] Everything at the workplace is "subordinated" to the safety and health of workers at work: facilities, installations, faster and safer evacuation, fire detection and extinguishing, ventilation, room temperature, room lighting, thermal insulation, free movement at work, protection of pregnant women and breastfeeding, sanitary and other equipment, first aid, work for the disabled, outdoor workplaces and many other "standards".

INSTEAD OF CONCLUSION

Universal and regional regulations on occupational safety and health have all nomotechnical designations of regulations (which is equally enabled (and even required) by national regulations). They regulate the area of minimum safety and health requirements for the workplace, with precisely defined "exceptions" (to which they do not apply). The rank of the regulations has been determined. The legislation of the Republic of Croatia is harmonized with the relevant ILO Conventions and EU directives. This also applies when workplaces undergo changes... in order to apply "new" measures to ensure appropriate minimum conditions. This should be accompanied by autonomous normative general regulation of these issues and relations. With respect to the interdisciplinarity and multidisciplinarity of occupational safety, appropriate to the requirements of the place of work, type of activity, activities and risks.

NOTE ON LITERATURE

Basic literature and regulations are listed in the text of the paper and in the invitation notes.

[9] *Council Directive 89* (654) EEC concerning the minimum safety and health requirements at work - quote

[10] UČUR, M.: *Labor Law*, Strengths and Rank of ILO Regulations and the Acquis Communautaire and the Council of the EU - the Basis of National Labor and Social Legislation, Rosip, Zagreb, pp. 40.

INNOVATIVE INTERPRETATION OF CULTURAL HERITAGE AND SOCIAL SUSTAINABILITY

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Abstract
The European Union's strategy is focused, among other things, on creating a European society sensitized and open to social innovations. The European Association for the Interpretation of Heritage has also recognized its role in fostering social innovations and creating social values. The subject of this paper is innovative interpretation of cultural heritage, and the aim is to explore the role and importance of cultural heritage interpretation on the principles of education and universal values in order to create social innovations. Innovative interpretation of cultural heritage, as a tool for achieving social sustainability, is emphasized in this paper. The contribution of this paper is reflected in the review of the methodology of cultural heritage interpretation according to the European Association for Heritage Interpretation. Also, the paper highlights the recommendations for encouraging creative ideas of cultural heritage interpretation from the perspective and responsibility of various stakeholders, all with the purpose of generating social innovations and achieving social sustainability.

Key words*: interpretation, cultural heritage, social innovation, social sustainability, sustainable development*

1. INTRODUCTION

Nowadays, the mankind is once again faced with the need of conducting innovation and structural changes in many systems, but this time with a clear objective, and that is to achieve sustainable development of the society and economy. Implementation of the basic principles of sustainable development requires changes as well as connectivity and alignment of values, ambition, knowledge, skills, ideas, goals and new practices of various stakeholders. The acceleration of globalization, but also the increase of inequality between regions, increases the need for strengthening competitiveness, which is partly achieved by innovation. Due to many authors, such as Solow (1957) [21], Nadiri (1993) [13], innovations are an important pillar of development of the world economy, but they also have the impact on the quality of life [12]. Due to that it is important to create an environment that will stimulate the creation and dissemination of innovation. The

economic concept of innovation was introduced by Schumpeter in 1934 and describes innovation as the development of new products, new processes, new markets and new sources of raw materials, that is to say, to shape industrial organization anew [18]. After Schumpeter the role of innovation in economic development appeared in papers of other authors in this area such as Nelson & Winter (1982) [14], Franc et al. (2020) [6] .

The subject of this paper is the heritage interpretation as a type of social innovation, and the aim is to explore the role and importance of tourist interpretation of heritage content on the principles of education and universal values in order to create social innovations and create social values. Secondary data collected by the desk research method were used in the preparation of the paper. Methods of description, compilation, analysis, synthesis, specialization and generalization were used in the presentation of secondary data. Complex elements defined in the research goal, their characteristics, specifics, factors and mutual roles are analyzed. The contribution in this paper is reflected in the review of the methodology of heritage interpretation in tourism according to the European Association for Heritage Interpretation. Focus is on the universities as the co-creators of social values through heritage interpretation and stakeholders in the national innovation system. Universities generate and implement social innovations depending on the research areas and study programs.

2. SOCIAL SUSTAINABILITY AND SOCIAL INNOVATION

For quality, sustainable and smart development of a society in which there will be no inequalities, where every individual will feel appreciated and valuable part of the society, it is important to emphasize and achieve synergy of four sectors (public, private, educational, scientific and civil). The interdependence and interconnectedness of these sectors, and the balance of their impact, can contribute to the quality of life in the local community. The social component of development is an essential part of the sustainable development. Social sustainability implies the preservation of social capital through the preservation of common values and equal rights, while systematic social participation and strengthening of civil society are extremely important. Social, religious and cultural institutions have an important role to play in fostering mutual tolerance, honesty, discipline, morality, compassion, patience, indulgence. Social sustainability is about identifying and managing business impacts, both positive and negative, on people. Directly or indirectly, companies affect what happens to employees, workers in the value chain, customers and local communities, and it is important to manage impacts proactively [25]. Social sustainability can be defined as specifying and managing both positive and negative impacts of systems, processes, organizations, and activities on people and social life. The topics that social sustainability concept integrates include but are not limited to; health and social equity, human rights, labor rights, practices and decent working conditions, social responsibility and justice, community development and well-being, product responsibility, community resilience, and cultural competence

[20]. The literature on social sustainability is rich in approaches to the social pillar [2].

For the respect of basic human and universal values and strengthening civil society the development of social innovation can be useful. Social innovations are the result of companies' efforts with the aim of achieving social sustainability and co-creating social values. There are many examples of social innovations throughout history such are kindergartens, hospices, microfinance. **S**ocial innovations are usually motivated by social mission, and the value they create is necessarily a shared social and economic value of all participants involved. Social innovations are often the product of the cooperation between different sectors and they can arise in different sectors [1]. They are social practices that aim to meet social needs in a better way than existing solutions, and which stem from - for example - working conditions, education, community development or health. These ideas are aimed at expanding and strengthening civil society. According to Nordberg et al. social innovations are new ideas that create collaboration or new social relationships and thus meet local needs [15]. These ideas, like destination development and place branding, might come from different sources. Soule et al. define social innovation as the process of developing and deploying effective solutions to challenging and often systemic social and environmental issues in support of social progress. Solutions often require the active collaboration of constituents across government, business, and nonprofit world [22]. Social innovation refers to the design and implementation of new solutions that imply conceptual, process, product, or organizational change, which ultimately aim to improve the welfare and wellbeing of individuals and communities [16]. According to the EU Commission social innovations are new ideas that meet social needs, create social relationships and form new collaborations [5]. These innovations can be products, services or models addressing unmet needs more effectively. The European Commission's objective is to encourage market uptake of innovative solutions and stimulate employment. Many initiatives undertaken by the social economy and by the civil society have proven to be innovative in dealing with socio-economic and environmental problems, while contributing to economic development.

Universities also have mission to contribute communities with developing and generating social innovations. Civil mission of universities implies knowledge transfer to society, promotion of entrepreneurial skills, innovations, social welfare, etc. They concern the development of science and society through various forms of communication and social engagement [28]. These activities are usually classified in relation to university engagement in social and cultural life [29]. That engagement can be indicated by the following indicators: summer schools for the children of employees, courses offered to academic staff, cultural activities such as art exhibitions and film forums, etc. [27].

2.1. Different forms of heritage interpretation as potential social innovation in order to create social values

Interpretation in tourism can be personal and non-personal. Personal interpretation in tourism includes tourist guidance, lectures, thematic workshops, programs for children. Non-personal interpretation in tourism includes interpretation boards, exhibitions, websites and social networks, various audio-visual materials. A general division of interpretive devices is also cited in the literature as follows [3]:

- people - personal interpretation which can include tour guides, security guards and educators, park rangers, etc.,
- media – virtual environments, interactive devices, interactive and static exhibits, etc.,
- objects - artefacts, buildings, figures, etc.,
- self-guiding tools - maps, guidebooks, etc.,
- built structures – tourism interpretation centres.

Tilden (1957) developed six historio-cultural and natural interpretive principles which are used in tourism interpretation. They are as follows: (a) interpretation must relate what is displayed to the experience of the visitor, (b) interpretation is revelation rather than information, (c) interpretation is a teachable art, (d) interpretation provoke rather than instruct, (e) interpretation relate parts to an underlying whole and (f) children need a qualitatively different interpretive approach from adults. Tilden signals that the interpretation process is interdisciplinary and it is more of an art than a science [4]. We single out the study that seeks to examine whether interpretive information and interpretive principles affect perceived heritage values [26]. The study points out the significant role of the interpretation content. Empirical study was carried out in the World Heritage destination in China. Results of the study indicate that tourists focus more on the contents of the interpretation than the media interpretation through which it is delivered and that the cultural values of heritage are better interpreted by tour guides. Tour guides and their personal interpretation have a significant role and responsibility towards heritage. The tourism interpretation of museum content according to universal values is present in many countries. Universal values are meaningful values for (nearly) all humans. Universalism implies understanding, appreciation, tolerance and protection for the welfare of all people and for nature [19]. For example, Romanian Peasant Museum managed to retain its freshness and to connect Romanian traditional culture to European values. Study is concerning interpretation with particular focus on museum interpretation in Romania [4]. Some spaces with high emotional significance do not require a broad interpretation, as they are places that create a state and speak for themselves. Also the study reveals that the most of the visitors consider that the materials in English and other languages existing at the entrance of each museum room are efficient. Focus is on museums in Romania which must integrate in this new wave of Western inspiration with their role of social and cultural pillars of society [4].

European heritage interpretation can give new meaning to their heritage phenomena (European history, reality and hence to Europe's shared values).

Collective identities and value development are in relation to multiple perspectives in heritage interpretation [11]. Interpretation can be one key to solving critical issues of the European Union by engaging citizens at first-hand [11]:

- with world-famous as well as less notable sites that can symbolise European development,
- with historical movements and achievements that embrace several European countries,
- with Europe's shared values, by reflecting the way that people lived in the past.

For European societies aiming to become 'united in diversity' an absolutist value system is problematic. Diversity involves a range of different values preferences and world views [9].

Interpretative services are an essential part of the work of heritage management [17]. Interpretive agents should seek for values, assuming that all values are applied in any person [11]. Interpretive agents are managed by heritage managers with the goal to co-create social values in general.

2.2. An example of good practice - heritage interpretive content as a potential co-creator of social values

The European heritage interpretation based on qualitative standards stems originally from an innovation transfer project launched by partners from several different European Union countries. The concept is based on harmonized standards of interpretation, criteria and skills of performers who act as representatives of European heritage interpretation on universal values. Various associations and institutions in the world offer courses to specialized staff in tourism interpretation: the European Association for Heritage Interpretation (so-called Interpret Europe), the Scottish Association for Interpretation (Interpret Scotland), the Australian Association for Interpretation (Interpret Australia) and the National Association for Interpretation (NAI) [8]. All of them use the principles of interpretation laid down by Freeman Tilden as a framework [4]. Interpret Europe has become aware of the importance of professional tour guiding and heritage interpretation. European Association for Heritage Interpretation was singled out as the civil association based on voluntary membership with its headquarters in the Republic of Germany so-called "Interpret Europe". The Interpret Europe mission is aimed at empowering all those who inspire meaningful connections with Europe's natural and cultural heritage. The organization includes individuals who work as guides or trainers, designers, authors of texts or planners who continuously learn about natural or cultural heritage and transfer knowledge to various stakeholders in society [7]. There are numerous examples of good practice in interpreting European heritage on universal values using the Interpret Europe methodology (eg. Tocati Verona International Festival of Street Games, Festung Dresden, Plato's Museum Greece). Interpretation includes several standardized elements: respect for the phenomenon being interpreted, active involvement of all participants in the interpretation and transmission of the message based on universal values.

Universities make a significant contribution to create a society of knowledge. This paper highlights an example which potentially becomes a co-creator of social values through the interpretive content of heritage based on universal values. Universities are key stakeholders in innovation systems at the micro, meso and macro levels, directly and indirectly affect major social challenges. The teaching process of the course “Tourist Valuation of Cultural Heritage” of the undergraduate professional study of Karlovac University of Applied Sciences Business Department activates student participation in academic service learning, critical thinking, divergent and creative thinking by creating creative attitudes. Innovative teaching process of the course is carried out initially by the implementation of the project "With Knowledge to the Star” by Civil association KA-MATRIX in partnership with Karlovac University of Applied Sciences, co-financed by the European Union and the Government of the Republic of Croatia. The example implies the elements of unique urban unit heritage on the methodology of interpretation universal values. Elaboration involves defining themes, phenomena, facts, meanings, and messages [10] that co-create social values. Interpreted facts about the phenomenon of unique urban unit in which the Karlovac University of Applied Sciences is located arouse certain feelings and have a special meaning for the individual, directly or indirectly connected with the University. The interpretation concludes with a clear message that encourages respect for heritage. The interpretation of the phenomenon based on universal values also raises awareness of the fundamental social values inherent in all people, regardless of their current level of connection with the observed phenomenon. Students present the phenomenon to the local community with the aim of integrating higher education into social events, intrigue listeners and potentially contribute to design collective consciousness. An example based on Tilden's principles is provided in table 1 [23], [24].

Table 1: Elements of interpretive speech (selected parts) concept based on Tilden's principles

Phenomenon	**Theme**	**Message**
Premises of Karlovac University of Applied Sciences - yesterday and today	Premises of Karlovac University of Applied Sciences from different time perspectives	Knowledge (for)ever – wisdom is golden and knowledge is the treasure of the wise

Facts Elaboration	**Meanings Elaboration**	**Elaboration of Methodological Steps according to the Phenomenon**	**Elaboration of Shape Style Setups and Guiding Tools**
Elaboration of key facts	Meanings (feelings) that fact evokes in an individual	Personification, Comparison, Contrast, Oxymoron Quotation, etc.	Defining the selected setup for interpreting the facts (linear, conference, tutorial,

			etc.) and guiding tools (photo frames, mirrors, flags, panels, photographs, etc.)

Source: (according to Ludwig, T., 2015: Interpretation guide, Bildungswerk interpretation, Werleshausen and Interpret Europe, European Association for Heritage Interpretation, available from www.interpret-europe.net, accessed March 15, 2022)

Tilden's principles are recognized in the experience of the chosen phenomenon through the stimulation of meanings for the individual which evoke feelings and values. The phenomenon has special significance from the participant perspective in the interpretation. Interpretation intrigues and grows on universal concepts.

Table 2: Example of interpretive speech concept (selected parts) based on Tilden's principles

Phenomenon	**Theme**	**Message**
Premises of Karlovac University of Applied Sciences - yesterday and today	Premises of Karlovac University of Applied Sciences from different time perspectives	Knowledge (for)ever – wisdom is golden and knowledge is the treasure of the wise

Facts Elaboration	**Meanings Elaboration**	**Elaboration of Methodological Steps according to the Phenomenon**	**Elaboration of Shape Style Setups and Guiding Tools**
Long ago, prominent students of the former Cadet School (Premises of Karlovac University of Applied Sciences in the 19th century) wore the uniforms with a gold-embroidered ribbon on their sleeves. They were Infantry Regiment No. 1	Pride Treasure Strength Cognition Dignity Permanent Value	Quote: "The value of gold is in its pricelessness" Croatian scientist Ante Crncevic Figurative *language style* Figures of speech Comparison: A gold ribbon on the sleeve as a path of priceless and successful students towards well-being.	Conference shape style setup Photographs

under the name "His Majesty Francis Joseph" (1830-1916).			
Today, Karlovac University of Applied Sciences Library is a collection of new knowledge produced by students who are at the crossroads of their lives. Their new knowledge (diploma thesis) is painted in gold.	Pride Strength Intelligence Development Wisdom	Figurative *language style* Figures of speech Comparison: Golden diploma thesis (bachelor and master degree) of students as objects of high value, an exceptional pledge of a prosperous future.	Conference shape style setup Tutorial shape style setup Discovering the diploma thesis (bachelor and master degree)

Source: (according to Ludwig, T., 2015: Interpretation guide, Bildungswerk interpretation, Werleshausen and Interpret Europe, European Association for Heritage Interpretation, available from www.interpret-europe.net, accessed March 15, 2022)

In the case of Karlovac University of Applied Sciences, heritage interpretation intrigues and grows on universal concepts of knowledge, pride, wisdom and strength. The University takes initiative and actively participates in the creation of social development through the interpretation of cultural heritage in the area that is located. Also, it addresses different target groups, but still with a strong emphasis on young population.

3. CONCLUSION

The potential for the quality development of society exists only through networking and cooperation of various stakeholders. It is important to develop social innovations that will contribute to sustainable social and economic development and encourage socially useful activities and fundamental human values. Nowadays, there are debates about the third mission of higher education institutions, which involves the active involvement of higher education institutions in solving community problems and encouraging and teaching students how to become active participants in the social life of the community. An active model of teaching where students are viewed as an active and self-regulating learner, rather than simply a passive recipient of teacher, instruction has become an imperative in a modern teaching process. The role of one university is emphasized in the presented case with the focus on potential co-creating social values by heritage interpretation as a type of social innovation.

Heritage interpretation has a special role for the local population as well as for tourists. All types of heritage require sustainable interpretation, either on local, national, regional and global levels. Heritage interpretation enables citizens to give heritage a deeper meaning. Close cooperation of universities, where heritage interpretation is taught, is necessary in order to make use of the most recent research findings about values and socio-cultural features of the heritage. Universities can encourage wider public to participate in interpretation of cultural and natural heritage and to share values. Heritage interpretation provides a key opportunity to link citizens to their shared values.

REFERENCES

[1] Angelidou, M.; Psaltoglou, A.: An empirical investigation of social innovation initiatives for sustainable urban development, *Sustainable Cities and Society*, Vol. 33, (2017), pp. 113-125

[2] Boyer, R. et al.: Five Approaches to Social Sustainability and an Integrated Way Forward, *Sustainability Review*, Vol. 8 (2016) No. 9, available from www.mdpi.com (accessed June 15, 2022)

[3] Cave, J.; Jolliffe, L.: *Visitor Interpretation, Tourism: The Key Concepts*, Robinson, P. (Ed.), Routledge, ISBN 9780415677936, London, (2012), pp. 273-275

[4] Dumbraveanu, D.; Craciun, A.; Tudoricu, A.: Principles of interpretation, tourism and heritage interpretation – the experience of Romanian museums, *Journal of Studies and Research in Human Geography*, Vol. 10 (2016) No.1, pp. 59-75

[5] EU Commission, www. ec.europa.eu/info/index_en (accessed March 15, 2022)

[6] Franc, S. et al.: Društvene inovacije kao važan element europskih razvojnih strategija, *Revija za socijanu politiku*, Vol. 27 (2020) No. 3, pp. 309-328

[7] Interpret Europe, European Association for Heritage Interpretation, www.interpret-europe.net (accessed March 15, 2022)

[8] Kohl, J.: *Interpretive Theme Writer's Field Guide*, National Association for Interpretation, InterpPress, ISBN 13978-1879931336, Fort Collins, (2018)

[9] Lehnes, P. (Ed.): *Delphi, Can Heritage bring Europeans togather*?, University of Freiburg, Delphi 2018-1-DE02-KA204-005084, Germany, (2020) available from www.delphi-eu.org (accessed May 15, 2022)

[10] Ludwig, T.: *Interpretation guide*, Bildungswerk interpretation, Werleshausen, ISBN 978-3-9815219-9-3, Germany, (2015)

[11] Ludwig, T., Glen, M. H. (Ed.): *Study of engaging citizens with Europe's cultural heritage: How to make best use of the interpretive approach*, Interpret Europe, ISBN 978-3-947745-00-5, Witzenhausen, (2017) available from www.interpret-europe.net (accessed March 15, 2022)

[12] Mumford, M. D.; Moertl, P.: Cases of social innovation: Lessons from two innovations in the 20th century, *Creativity Research Journal*, Vol. 15 (2003) No. 2-3, pp. 261-266

[13] Nadiri, I.: *Innovations and Technological Spillovers*, NBER Working Paper 4423, National Bureau of Economic Research, Cambridge, MA, (1993)
[14] Nelson, R. R.; Winter, S. G.: *An Evolutionary Theory of Economic Change*, Harvard University Press, ISBN 9780674272286, Cambridge, (1982)
[15] Nordberg, K. et al.: Community-driven social innovation and quadruple helix coordination in rural development, Case study on Leader group Aktion Österbotten, *Journal of Rural Studies*, Vol. 79, (2020), pp. 157-168
[16] Organization for Economic Cooperation and Development OECD, available from www.oecd.org (accessed March 15, 2022)
[17] Salazar, N. B.: *The double bind of world heritage tourism*, Chapter 8: *World Heritage Tourism*, Dalarna University, ISBN: 978-91-85941-50-6, Dalarna, Sweeden, (2013), pp. 274-291
[18] Schumpeter, J.: *The Theory Of Economic Development*, Harvard University Press, ISBN 9780674879904, USA, (1934)
[19] Schwartz, S.: Basic Human Values: Theory, Measurement and Applications, *Revue Francaise Sociologie*, Vol. 47 (2006) No. 4, pp. 1-49, available from https://www.researchgate.net/publication (accessed March 15, 2022)
[20] Şebnem Yılmaz Balaman: *Biomass-Based Production Chains, Decision-Making for Biomass-Based Production Chains*, eBook, Elsevier Academic Press, ISBN 978-0-12-814278-3, London, San Diego, CA, (2019), pp. 77-112 available from https://www.researchgate.net/publication/327437659 (accessed June 15, 2022)
[21] Solow, R.: A contribution to the theory of economic growth, *The Quarterly Journal of Economics*, Vol. 70 (1965) No. 1, pp. 65-94
[22] Soule, S. A.; Malhotra, N.; Clavier, B.: Definig Social Innovations, Center for Social Innovation, Graduat School of Stanford Business available from https://www.gsb.stanford.edu/experience/about/centers-institutes/csi/defining-social-innovation (accessed March 15, 2022)
[23] Tilden, F.: *Interpreting our Heritage: Principles and Practices for Visitor Services in Parks, Museums, and Historic Places*, University of North Carolina Press, ISBN 0-8078-4016-5, USA, (1957)
[24] Tilden, F.: *Interpreting Our Heritage*, 4th edn., The University of North Carolina Press, ISBN: 978-0-8078-5867-7, Chapel Hill, (2007)
[25] United Nations Global Compact, https://www.unglobalcompact.org/what-is-gc/our-work/social (accessed June 15, 2022)
[26] Weng, L.; Liang, Z.; Bao, J.: The effect of tour interpretation on perceived heritage values: A comparison of tourists with and without tour guiding interpretation at a heritage destination, *Journal of Destination Marketing and Management*, Vol. 16 (2020), pp. 1-11
[27] Compagnucci, L.; Spigarelli, F.: The third mission of the university: a systematic literature review on potentials and constraints, *Technological Forecasting and Social Change*, Vol. 161 (2020), pp. 1-30
[28] Di Berardino, D.; Corsi, C.: Aquality evaluation approach to disclosing third mission activities and intellectual capital in Italian universities, *Journal of Intellectual Capital*, Vol. 19 (2018) No. 1, pp. 178-201

[29] Mora, J.G. et al.: Higher education in Albania: developing third mission activities, *Tertiary Education and Manag*ement, Vol. 21 (2015) No. 1, pp. 29–40.

CIVIL PROTECTION OF THE CITY ZAGREB

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Abstract: *Civil protection is a system for organizing participants, operating forces, and citizens to protect and save people, animals, material and cultural goods and the environment in major accidents and disasters and the consequences of terrorism and war-ravages. In the city of Zagreb, for the purpose of performing all the functions of the Civil Protection System, an emergency management office set up in the work is established. This office consists of the headquarters of the Civil Protection of the City of Zagreb, which has recently been very well known to the citizens of Zagreb because of the pandemic Covida-19. The characteristics of the operation of Civil Protection in Zagreb concerning health institutions and critical infrastructure facilities are analyzed. The results of the analyses have shown that the civil protection of the City of Zagreb is regulated at a high level. Units, appointed headquarters, and control group of civil protection units have been established, additional internal acts have been adopted regarding the process to strengthen readiness in case of major accidents/disasters not prescribed by the Law and by the bylaws which are deemed to be an additional advantage. The state of the alarm system in the City of Zagreb is satisfactory, and the testing of siren is carried out regularly. It is increased provisioning for the civil protection system so, the assessment of the fiscal situation is favorable. It is concluded that the readiness of the operational capacity of the city of Zagreb is high. The objective of the work is to meet the action of the Civil Protection Agency in the event of possible threats and risks.*

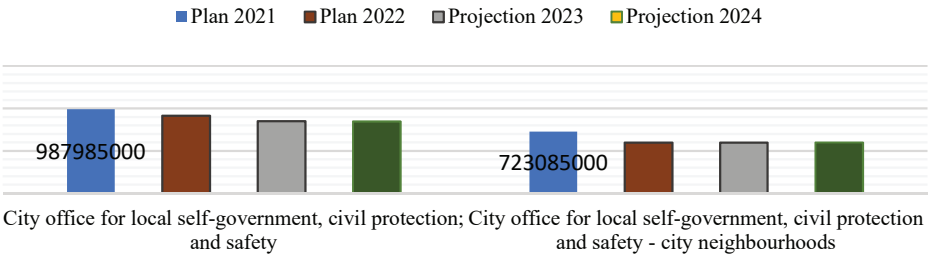
Key words: Civil protection, Zagreb City, threats and risks, provision, operational capacity

1. INTRODUCTION

Civil protection is a system of organizing participants, operational forces, and citizens to protect and rescue people, animals, material and cultural goods, and the environment in major disasters and disasters and to eliminate the consequences of terrorism and war destruction [1]. Therefore, civil protection is the basis of the protection and rescue system in most countries. It is organized and developed to protect and save the population, material and cultural goods, and all other values on this planet from endangerment and possible consequences.The need to organize and develop civil protection has arisen through the historical development of the international community and all possible forms of threat so far, with unforeseeable consequences for all of us. Since 1935, with the financial support of the city municipality, the first information and promotional courses on the need and manner of implementation of protection for doctors, veterinarians, chemists, pharmacists, and other experts have been held in Zagreb. In the same year, an exhibition of civil

protection and defense against air attacks was organized in Zagreb (the first in Croatia and the former Yugoslavia). Thanks to good preparations, civil protection in Croatia, and especially in Zagreb, was quite successful throughout World War II. The knowledge and experience gained in the development of civil protection were also welcomed in the conditions of the anti-fascist struggle of the Croatian people in World War II [2]. The preliminary results of the 2021 Census of Population, Households, and Dwellings [2] [3].The knowledge and experience gained in the development of civil protection were also welcome in the conditions of the anti-fascist struggle of the Croatian people in World War II [2]. According to the first results of the 2021 Census of Population, Households and Dwellings [2] [3], the total number of inhabitants in the City of Zagreb was 769,944, the number of private households was 299,792, and housing units, 393,433. with final data from the Census of Population, Households, and Dwellings [2]. The total number of inhabitants of the city of Zagreb was 769,944. The number of private households was 299,792 and the number of housing units was 393,433. With final data from the Census of Population, Households, and Dwellings [2]. In 2011, the number of inhabitants in the city of Zagreb decreased by 2.5%, i.e. by 20,073 people. The number of private households decreased by 1.2%, i.e.by 3,649 households, while the total number of housing units increased by 2.4%, i.e.by 9,100 housing units [3]. Revenues and receipts of the budget of the City of Zagreb for 2022 are planned in the amount of 15,126,911,800, (CK) of which 10,194,000,000 refers to revenues and receipts of the City budget. 4,932,911,800 (CK) refers to own and assigned revenues and receipts of budget users, including surplus from the previous period that are not part of the budget cash flow. Within the budget of the City of Zagreb [4], there is an organizational classification for the budget of the City Office for Local Self-Government, Civil Protection, and Security (Chart 1).

Chart 1. Budget of the City of Zagreb for Civil Protection



Source: Zagreb city – webpage: https://www.zagreb.hr/financije/113891

According to Chart 1, the commitment to the civil protection system has been increased and the assessment of the fiscal situation is favourable. In addition, this is supported by the budget of the City of Zagreb for 2022 and projections for the next two years. The civil protection budget for the fire station for 2022 and further projections are shown in Table 1 to indicate that the total planned cash for the

operation of the civil protection activities is 700.000,00. The largest part of the asset is allocated to the item-revenue from services.

Table 1. Review of the budget of the Civil Protection of the City of Zagreb - Financial plan of own revenues for 2022 with projections for 2023 and 2024 (Fire Station Zagreb)

Ordinal number	Term	2022	2023(projection)	2024 (projection)
1	Revenue from provided services - POSEDARJE	110.000,00	110.000,00	110.000,00
2	Revenue from provided services - SERVICE	1.000,00	1.000,00	1.000,00
3	Revenue from provided services DIRECT NOTICE FOR FIRE	150.000,00	150.000,00	150.000,00
4	Revenue from provided services – RENT FOR ANTENA PILLAR	60.000,00	60.000,00	60.000,00
5	Revenue from provided services OTHER SEVICES FOR FIREFIGHTERS	370.000,00	370.000,00	370.000,00
6	Revenue from provided services ACCOMODATION IN FIRE STATION	2.000,00	2.000,00	2.000,00
7	Revenue from provided service - INTERESTS	7.000,00	7.000,00	7.000,00
8	**IN TOTAL**	**700.000,00**	**700.000,00**	**700.000,00**

Source: Fire Station Zagreb city - Archives intervention. Accessible at: https://vatrogasci.zagreb.hr/default.aspx?id=1214

On December 28, 2016, the City of Zagreb Mayor adopted guidelines to prepare for the risk assessment of major accidents in the City of Zagreb and for 2017, the mobilization of the Civil Protection Center of the City of Zagreb. In addition, the Emergency Management Office adopted the following internal acts:

1. Standard operating procedure for the activities of employees of the Office assigned to passive duty.

2. Report on verification of the place (area) for evacuation of the population and directions of evacuation in the City of Zagreb within the Operational Plan for Rescue in the Event of Earthquakes

3. Report on the visit and analysis of locations for disposal of construction material from ruins in the event of a strong earthquake in the City of Zagreb

The Civil Protection Headquarters of the City of Zagreb has brought:

- Operational Procedural Act of the Civil Protection Corps for the Purposes of the City of Zagreb; and

- Operational Procedural Act of the Civil Protection Unit of the City of Zagreb for Search and Rescue in Ruins

This may be grouped into:

-nomination decisions (units and duties in the civil protection system),

-planning documents, which are legal obligations, and plans that are also not legal obligations but are of interest to strengthen readiness in case of major accidents or disasters. In continuation it is analyzed the characteristics of the operation of the Civil Protection of Zagreb by segments and assignments are analyzed below, regarding health institutions and critical infrastructure facilities.

Table 2. Segments and tasks for Civil Protection Zagreb city

Ordinal number	Segment	Tasks
1	Construction machinery	to provide names and surnames and contacts of responsible persons responsible for communicating with the Civil Protection Officer
2	Disposal and transport	Disposal segment: Number of beds available immediately and / or after the conversion of space, number of persons in charge of conversion and adjustment
3	Food and drinking water	It should be assessed in the light of the average stock situation in the logistics center and the capacity of food preparation facilities.
4	Critical infrastructure operation	Plan in the case if redundant systems are possible to avoid interruption of supply to primary users
5	Communications	providing satellite coverage cars for the transmission of signals from the Republic of Zagreb Civil Protection Center
6	Healthcare	responsible contact persons: number of additional beds which can be provided in the event of a crisis - the amount of the most urgent medicines possible to be provided
7	Air, soil and water analysis and remediation	assessment of operational capacity (capacity) with indication of equipment that can be used / made available (number of people / list of equipment / required remediation time depending on the activity if it is possible to estimate)

Table 2 provides the presentation of a plan of action by the Civil Protection of the City of Zagreb through segments and tasks [5], for example. The "healthcare" segment includes the task of collecting data on contact persons, data on the number of bearings in the event of a crisis, and a list of the most needed medicines.

2. THE RESULTS

An analysis of the situation since 2020 showed that the operational forces of the civil protection system were: [1]:

-Civil Protection Division of the City of Zagreb,

-Civil Protection Staff of the City of Zagreb City,

-The operational forces of the fire department,

- Operational forces of the Croatian Red Cross-the City Society of the Red Cross in Zagreb,

- Operational forces of the Croatian Rescue Service - Station Zagreb,

- Citizens' associations of interest in the civil protection system,

- civil protection units for the purposes of the city of Zagreb,

- civil protection units for the specialist use of the city of Zagreb,

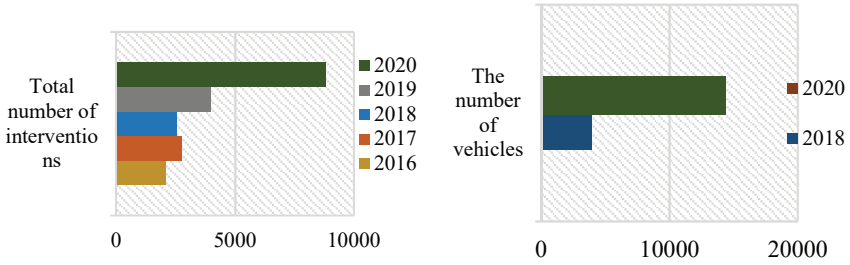
- Commissioners and Deputy Commissioner of Civil Protection,

- legal persons of interest in the civil protection system in the city of Zagreb.

Analysis of the situation for 2020 for the City of Zagreb showed that the City of Zagreb has established 17 general purpose civil protection units (territorial jurisdiction by city districts) and specialist purpose civil protection units (civil protection units for search and rescue from ruins, civil protection units for search and flood rescue, and civil protection units for technical and tactical support). The members of the Headquarters in all city districts are equally named. A new decision on civil protection commissioners is being drafted to comply with the provisions of the new ordinance on mobilization, conditions, and manner of work of operational forces of the civil protection system (Official Gazette 69/2016) [1]. Furthermore, the analysis of the Civil Protection System of the City of Zagreb showed that the roles and tasks of the Civil Protection Headquarters of the City of Zagreb (Official Gazette of the City of Zagreb 18/17, 19/17, 5/18, 14/18, 18/19 and 08/20) glasnik Grada Zagreb, 2016-2020) relate to the collection and processing of early warning information on the possibility of major accidents and catastrophes, implementation of the civil protection system action plan in its area, manages the response of the civil protection system, informs the public and proposes decisions on termination measures and activities in the civil protection system. On February 25, 2020, the Civil Protection Headquarters of the City of Zagreb was activated in order to take measures to combat the epidemic caused by the SARS-CoV-2 virus, and after the earthquake that occurred on March 22, 2020.ž The third part of the analysis consists of the Civil Protection Headquarters of the City Districts of the City of Zagreb (Official Gazette of the City

of Zagreb 21/17) which participate in the implementation of measures and activities of the civil protection system in the city districts of the City of Zagreb. Through the Civil Protection Headquarters of the City Districts of the City of Zagreb, passes were issued to enable the movement of citizens of the City of Zagreb outside their place of residence, in accordance with the Decision of the Civil Protection Headquarters of the Republic of Croatia (CLASS: 810-06/20-01 /7, registration number: 511-01-300 - 20-14 of 23 March 2020) Operational forces of the Fire Brigade (Public Fire Brigade of the City of Zagreb and voluntary fire brigades in the Fire Brigade of the City of Zagreb). In addition, the archive of interventions by the City of Zagreb has shown that every year the number of interventions and fire actions is growing, with the increase of material damage and human life losses (charts 2 and 3).

Chart 2. The number of interventions for Zagreb Chart 3. The number of fire brigade vehicles



Source: Fire station Archives Zagreb city

The Unit of Fire Brigade Zagreb City has been composed of 305 operational firefighters deployed in five fire stations in the City of Zagreb, namely: The Fire Station Centre, Fire Station Dubrava, the Fire Station Jankomir, the Fire Station of Novi Zagreb, and the Fire Station Zitnjak. Fire teams shall continuously perform exercises involving other services to rescue citizens in the event of a disaster caused by an earthquake or collapsed buildings. The operating forces of the Croatian Red Cross-City Society of the Red Cross in Zagreb and the City Society of the Red Cross in Zagreb is a full member of the Croatian Red Cross. The specialties of the City Society of the Red Cross in Zagreb are the organization and operation of the rescue, the reception and distribution of humanitarian assistance, first aid, lifesaving and rescue training, and the total number of members of the intervention team is 123, of which 87 are active members. The Society has 13 vehicles and tangible means and equipment for carrying out measures and activities for civil protection systems, namely: first aid purses (30 pieces) bag sleeping (500 pieces, tent (9 pieces) beds (38 pieces), dryers (82 pieces), immobilization desk (1 piece), computer (1 piece), boat + sidecar (1 piece), blankets (900 pieces), aggregates (3 pieces), pump water (2 pieces). Citizens' associations with an interest in the civil protection system are composed of two members: the Croatian Association of Persecuted Dogs (HUOPP) and the Training Club of official and sports dogs "Zagreb" (KOSSP), which are both voluntary organizations engaged in training dogs and their guides to participate in

search campaigns for lost and missing persons. There is a Zagreb speleological alliance founded to develop and improve speleology as an expert and scientific activity in Zagreb and Zagreb County. Regarding the testing of alarms for the City of Zagreb, a drill that serves to check the functionality of the public alarm system and prevent failures of the corrosion inhibitors in case the system is not used for a longer period. The public alarm system in the City of Zagreb is operated by the Zagreb County Centre 112, and regular testing of the alarm is carried out every first Saturday of the month at 12.00. Risk assessment and threat to the City of Zagreb, for a threat-earthquake point to the following: The earthquake can mean potentially catastrophic consequences: a large percentage of residential buildings, problems in communication, and a significant negative impact on social values (buildings were built prior to the first regulations for the design of rock-resistant buildings). Preventive measures in the event of earthquakes are an anti-seismic design, the construction of early warning systems, and education and training of operational forces. Alerting, intelligence, evacuation, disposal, shelter, first aid, and others are measures taken in the event of an earthquake. Otherwise, the risk assessment results obtained for each of the risks (earthquake, flood, industrial accident, flood, heat wave, and pandemics) are shown in Table 3 below:

Table 3: The results of Risk assessment for Zagreb City

SCREENPLAY	EVALUATION
Earthquake	
Flooding	
Industrial accidents	
Heat wave	
Epidemic and pandemic	

3. CONCLUSION

Based on the research , it has been observed that the civil protection of the City of Zagreb is regulated at a high level. Additional headquarters and control groups for civil protection units have been established. Additional internal acts have been adopted regarding the process to strengthen readiness in case of major accidents or disasters not prescribed by the law and by the bylaws, which are deemed to be an additional pre-costume. Considering all the above, the adoption of strategies, normative regulation, and the elaboration of estimates and plans are considered relevant to a high-level civil protection system. There is an exchange of information between the executive body of the city of Zagreb responsible for the field of civil protection, duty, and other institutions of interest on the possible rapidly growing threats. The state of the alarm system in the City of Zagreb is satisfactory and is regularly tested for alarms. The County Centre 112 regularly reports on-call officials of the emergency management office on any event involving major and more complex emergency services, and cooperation with neighboring local and regional self-government units. The operational capability of civil protection systems at the level

of the City of Zagreb is continuously strengthened. The city of Zagreb has recognized the risk of a global pandemic in due time and has started the preparations of a system to respond to the procurement of protective equipment and resources, enabling the health system and operating forces of the city of Zagreb to operate safely. The fundamental operational forces of the civil protection system have effectively and effectively responded to all the tasks assigned to them in accordance with their activities and operational readiness. In the City of Zagreb's budget for 2022 and projections for 2023 and 2014, the projections for further development of civil protection systems are foreseen.

REFERENCE

[1] IUS INFO, *Analiza stanja sustava civilne zaštite Grada Zagreba za 2017.,* Zagreb: Službeni glasnik Grada Zagreba br. 3/2018, 2017.

[2] I. Toth, »Civilna zaštita s propisima,« 2007.

[3] Odjel za statističke i analitičke poslove, *Popis stanovništva , kućanstava i stanova 2021 -prvi rezultati,* Zagreb: Gradski ured za gospodarstvo, ekološku održivost i strategijsko planiranje, 2022.

[4] Grad Zagreb, *Proračun Grada Zagreba- mesna samouprava, civilna zaštita i sigurnosti,* Zagreb, 2022.

[5] Ured gradonačelnika, *Plan djelovanja Civiline Zaštite Grada Zagreba,* Zagreb, 2019.

[6] Narodne novine 69/2016, *Pravilnika o mobilizaciji, uvjetima i načinu rada operativnih snaga sustava civilne zaštite,* Zagreb, 2016.

[7] Službeni glasnik Grada Zagreb, *Službeni glasnik Grada Zagreba 18/17, 19/17, 5/18, 14/18, 18/19 08/20,* Zagreb, 2016-2020.

[8] Grad Zagreb, *Službeni glasnik Grada Zagreba 11/17,* Gradska skupština, 2018.

[9] Grad Zagreb, *Procjena rizika i prijetnji,* Gradska skupština Grada Zagreba, 2019.

THE INFLUENCE OF WORK AND THE WORKING ENVIRONMENT ON THE HEALTH OF THE EMPLOYEES OF THE INSTITUTE OF EMERGENCY MEDICINE

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Abstract: *This paper shows how work and the working environment affect the employees of the Department of Emergency Medicine, and the paper consists of a theoretical and an experimental part. Through the theoretical part, it was explained what the employees' jobs are and what dangers, harms, and efforts the employees face, while the results of the survey method were presented through the experimental part.*

Keywords: *emergency medicine, biological hazards, chemical hazards, physical hazards, protection at work*

1. INTRODUCTION

Emergency medicine can be seen as precarious field of work because of its fast development and unpredictable physical and psychological demands in its workplace. Tasks of emergency medicine on the one hand require certain physical abilities such as strength, speed, dexterity, and on the other hand various social abilities such as communication skills, teamwork, and many others. Emergency medicine workers face many situations in the field and for this reason they can be

exposed to numerous risks and injuries at work and several occupational diseases related to work.

A disease that has arisen as a result of harmful effects related to work, intensity of harmfulness and the duration of exposure to that harmfulness is at a level that is known to cause damage to health - we call it an occupational disease. It is proven by using algorithms in occupational medicine, and the process itself includes data collection, linking the disease to exposure at work, clinical picture, and findings. [1]

By obeying the rules, principles, measures, procedures and activities, safety and health protection at work is achieved and improved with the main goal of preventing possible risks at work, such as injuries, occupational diseases, illnesses related to work and other material and non-material damages in connection to the work. [2]

2. EMERGENCY MEDICINE JOBS

The county institute and its branches in the county perform the activity of outpatient emergency medicine (ambulatory care), and teams are involved in the organization of the activity. Outpatient emergency medicine performs the following tasks:

- after receiving emergency medical calls, directs teams to intervention and manages the communication system
- taking care of emergency conditions of sick and injured persons
- emergency medical care of the mother during transportation
- emergency medical care in the resuscitation area
- transporting sick person by the shortest possible route to the nearest appropriate health facility to continue the treatment process
- cooperation with healthcare institutions and healthcare professionals during diagnosis and treatment
- participating in coordination with the Croatian Institute for Emergency Medicine during the organization and implementation of health care in extraordinary circumstances
- implementation of binding standards of operational work protocols, procedures, and algorithms of action in the field of emergency medicine
- ensures the use of equipment according to established standards
- submitting prescribed documentation and reports to the Croatian Institute for Emergency Medicine
- cooperating with the Croatian Institute for Emergency Medicine and performing other tasks upon request [3]

3. RISK CATEGORIES

Employees of the Institute for Emergency Medicine are exposed to many dangers, possible harms, and making effort at work and in connection to work. According to the rulebook on risk assessment, hazards can be divided into mechanical hazards, fall hazards, electrical hazards, thermal hazards, and fire and explosion hazards. Harms are divided into chemical, biological and physical, while efforts are divided into statodynamic, psychophysiological, vision efforts and speech efforts. [4]

When talking about risks in emergency medicine, there are many – such as injuries from needles or sharp objects, which employees mentioned as the most common danger (shown in graph 3), dangers in relation with transport vehicles – possible falls of workers at the same level, falls into depth or from a height, danger from handling devices and equipment with electrical power and the danger of hot or cold substances.

In the category of harm, there may be direct or indirect contact with various chemical substances and poisons, contact with infectious people, materials, animals and plants.

In the case of exertion, there is a constant position of the body during work such as standing or sitting, a bent position of the body and physical work where we include lifting and carrying patients and pushing various loads. In the case of psychophysiological efforts, unfavourable work rhythm, disturbed biorhythm due to night work, disruption of social needs due to field work, responsibility for people's lives and material goods, and a high probability of an extraordinary event happening.

4. EXPERIMENTAL PART

The survey method was used to create this paper. 213 respondents participated in the survey, i.e., employees of the Institute for Emergency Medicine from all over Croatia, of which 116 were women and 97 were men, as it can be seen in chart 1. The data was collected in the period from May 9 to 23, 2022. The survey questionnaire contained 6 questions, and only in the second question (chart 2) was the possibility of multiple answers offered, where it is evident that the neck and shoulders are the most stressed during work, next the spine, followed by the eyes, arms and hands. Only a small number of respondents believe that their lower extremities are burdened during work.

chart 1. number of respondents by gender and age

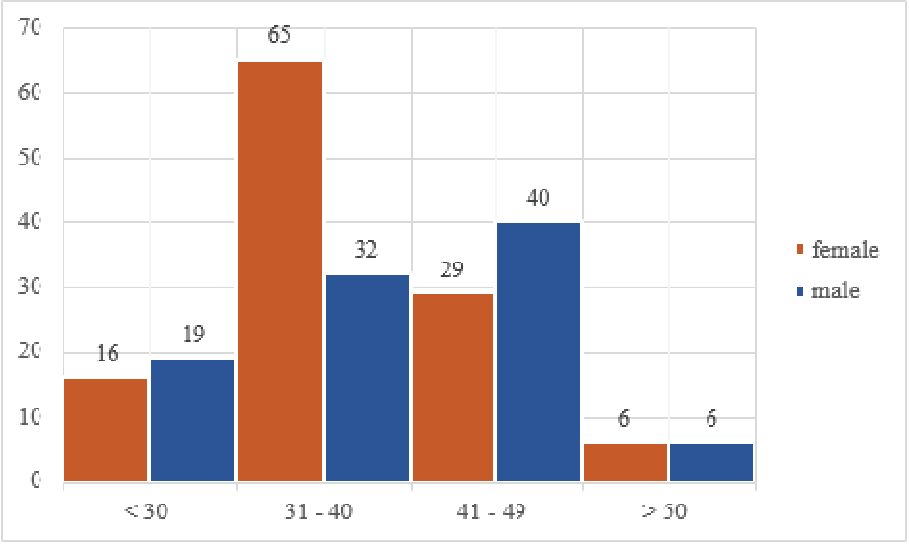


chart 2. the most stressed parts of the body at work

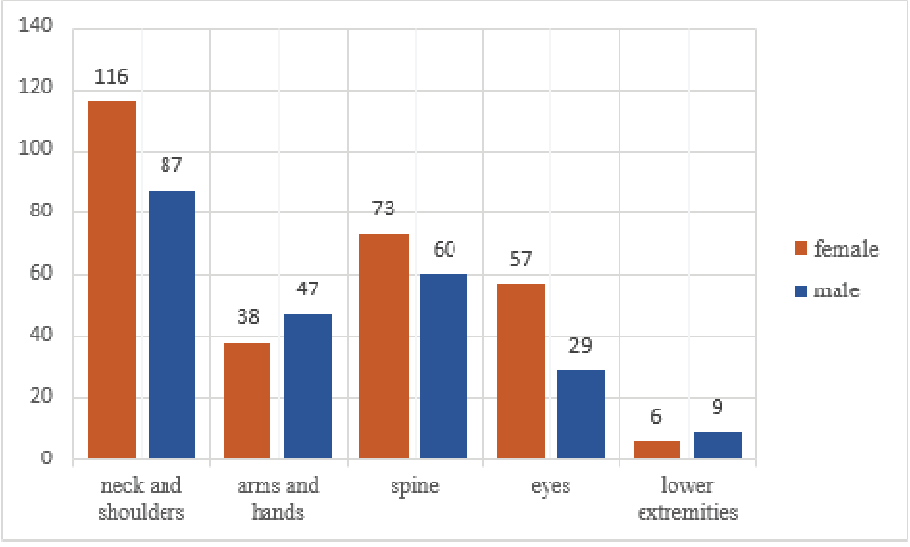
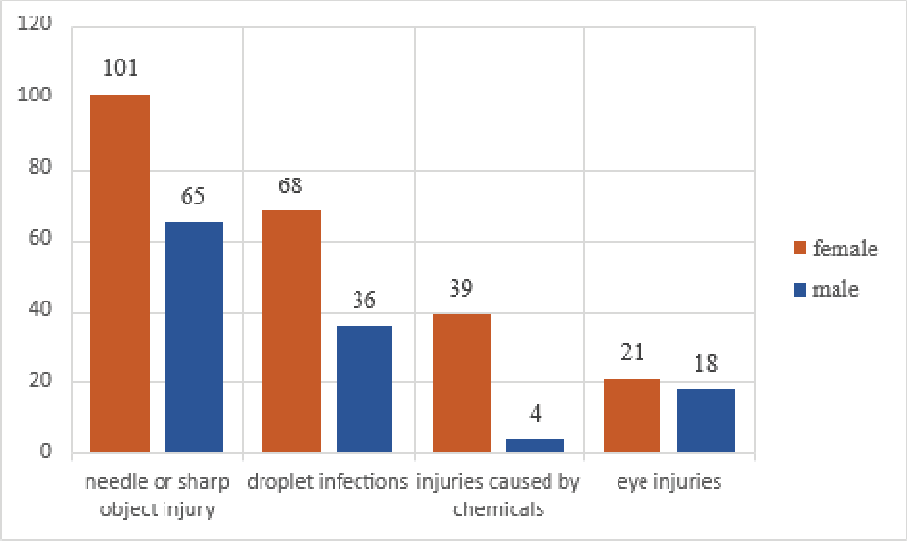
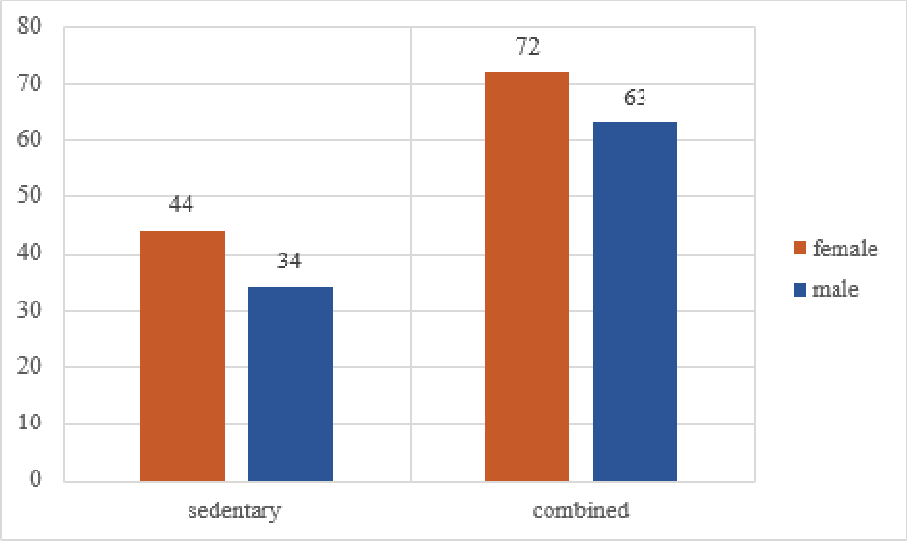


chart 3. work-related injuries and illnesses



The most common injuries and illnesses associated with work in the Department of Emergency Medicine are shown in chart 3, where respondents claim that they were most often injured by a needle or some other sharp object, followed by droplet infections and eye injuries occur the least. Women rated their own health as good, while men rated their own health as very good (chart 4).

chart 4. body position during work



The next two graphs show the rating of the workplace danger of the respondents and the grading of their own health on a scale from 1 to 5. In chart 5, a rating of 1 represents not dangerous at all, while a rating of 5 represents a very dangerous workplace, and the majority of male and female respondents answered that their workplace is not dangerous. In the perception of one's own health (chart 6), 1 represents a very poor state of health, while a score of 5 is an excellent state of health. Most female respondents consider their state of health to be good, while 48 male respondents rate their state of health as very good.

chart 5. presentation of the perception of workplace danger

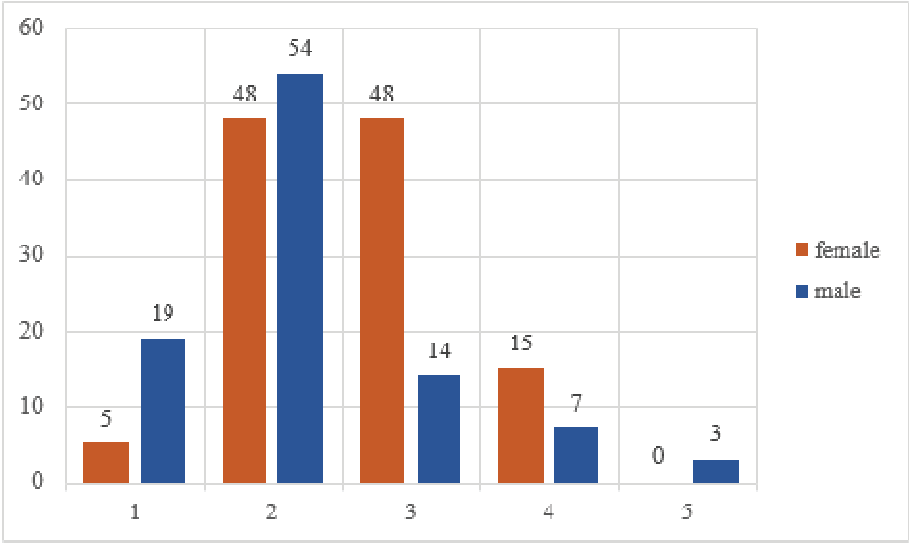
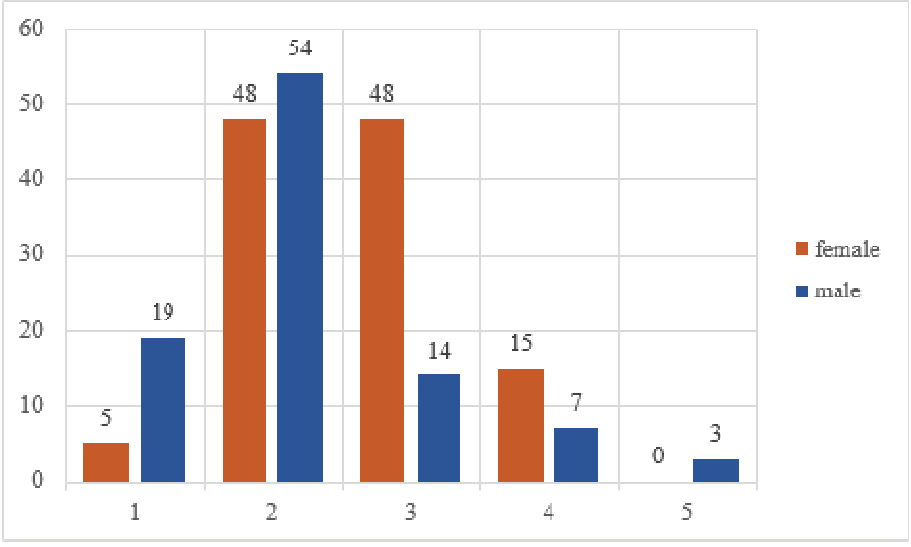


chart 6. presentation of health perception



5. CONCLUSION

Every employee must acknowledge the fact that there is no job that does not require a certain level of responsibility, and that there is a certain risk in every job – low, medium or high risk. Also, we should be aware of the fact that risk also occurs outside the work environment.

The obligation of every employer is to eliminate or reduce the risk to the minimum possible extent based on the general principles of prevention. In accordance with the above, the jobs in the Institutes of Emergency Medicine are classified as jobs with special working conditions, and all employees are obliged to respond to health fitness checks in accordance with the points from the Ordinance on jobs with special working conditions, which result from the updated Risk Assessment for each workplace.

In addition to what is previously stated, in order to prevent various health problems, it is necessary to ensure optimal working conditions, ergonomically design the workplace, use personal protective equipment and take care of the health of your own body.

REFERENCES

[1] Law on the List of Occupational Diseases, *Available from* https://www.zakon.hr/z/1395/Zakon-o-listi-profesionalnih-bolesti *Accessed*: 2022. june 27.
[2] Law on Safety at Work, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2014_06_71_1334.html *Accessed*: 2022. june 29.
[3] Rulebook on the conditions, organization and method of performing emergency medicine, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2016_08_71_1697.html *Accessed: 2022. june 29*
[4] Rulebook on creating a risk assessment, *Available from https://narodne-novine.nn.hr/clanci/sluzbeni/2014_09_112_2154.html Accessed:* 2022. july 1.

IMPLEMENTATION OF IFS STANDARD IN A FOOD INDUSTRY

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Abstract: *IFS - International Featured Standards is recognized standard that prescribes food safety and quality requirements for food manufacturers. IFS is applicable to all food manufacturers, but it should be emphasized, has been specifically developed for private label manufacturers as they contain numerous requirements to comply with the manufacturer' s specifications. IFS Food version 6, was developed with participation of certification bodies, retailers, industry and catering establishments from around the world. IFS is supported by almost all the world' s retail chains. Like other GFSI standards, IFS enables your company to operate in accordance with chain requirements and customer expectations. The quality assurance system of a manufacturing company, which has an implemented system in accordance with IFS was used to create this article.*

Keywords: *HACCP, IFS, production process, quality management*

1. INTRODUCTION

One of the most important characteristics of today's economy is its extremely rapid changes. Global market changes, new technologies in all areas, new manufacturers and suppliers and the growing demands of customers and users, determine the new style of management of organizations, where management must find just as fast answers and solutions. The goal of any organization is very clear: to live and succeed. They must produce what the market, ie. customers want with a certain level of quality and with an acceptable price and delivery times.

Customers know what is quality and demand more and more and they know exactly and feel the quality of the product for they have invested their money. The realization at the competitive struggle for customers is't longer the decisive price but

the quality of products and the reputation of manufacturers, has forced many manufacturers to think long-term and understand the concept of quality. Quality has become a fundamental factor of economic efficiency and a basic principle of operation of all successful organizations. Since the food market has become global and the problem of food safety is becoming bigger than ever. Croatian food producers and distributors are also increasingly required to apply certain standards, primarily by large retail chains, but also as consumer demands for which the quality and safety of food products are increasingly important. The spread of different norms at the field of food has led to an increase in costs and, above all, to the difficulty of finding market participants who could no longer assess the actual degree of control carried out in the agri-food chain. For that reason, 2000. year the GFSI - Global Food Safety Initiative (Global Food Safety Initiative) was established. GFSI supports recognized certification schemes, including IFS - International Featured Standards. IFS is a non-profit organization that develops IFS standards for the food industry (Bureau Veritas Croatia, 2017). The goal of IFS standards is to help retailers ensure the safety of their products and monitor the quality of the food brands they sell. This standard ensures the control of food products throughout the process, from production to the final consumer. The IFS standard contains 250 requirements divided into 6 chapters.

2. TECHNICAL REQUIREMENTS: NORMA IFS – INTERNATIONAL FEATURED STANDARDS

Evidence of responsible behavior in food production and trade, in today's global world, has become a basic criterion of consumers around the world. The goal of security system certification is to protect the interests of consumers and enable the safe functioning of the global food market. With ever-increasing customer demands, increased responsibilities of retailers, wholesalers and food service providers, growing legal requirements and globalization of product supply, it has become necessary to develop a single Standard for food quality and safety assurance. In order to create common standards for food safety in the food chain, in 2002 German retail food retail chains from HDE (Hauptverbanddes Deutschen Einzelhandeles) began to develop IFS standards. In 2003., French food retailers from the FCD (Fédération de sentrepises du Commerceet de la Distribution) joined the IFS working group and contributed to the development of IFS standards.

IFS was conceived as a standard for selecting brand manufacturers, but over time it has become the norm for retail chains in selecting suppliers for all food products. The BRC standard (British Retail Consortium - British Retail Chain Association) was used for the content of the IFS standard, and the structure was taken from ISO 9001: 2000. The IFS standards meet the criteria of the food safety management system, the criteria of good practices such as good manufacturing practice and the criteria for establishing a HACCP system. This can be seen from its structure:

- Responsibility of the top management,
- Quality management system (including HACCP),
- Resource management,

- Production process management,
- Measurement, analysis and improvement.

The IFS standard is actually the sum of the requirements that food business operators must meet in order to be certified. The application of the standard is voluntary and is mostly introduced at the request of the customer.

IFS is applicable to manufacturers, carriers, wholesalers, retailers, brokers, and storage service organizations (IFS Food, 2014). Standards are developed and issued by the IFS International Technical Committee. We distinguish the following IFS standards:

- 1. IFS Food,
- 2. IFS Food Store,
- 3. IFS Broker,
- 4. IFS PACsecure,
- 5. IFS Logistics,
- 6. IFS HPC,
- 7. IFS Cash & Carry.

2.1. IFS Food Standard

The IFS Food Standard is one of the standards under the IFS (International Featured Standards) brand. This is the norm for auditing food quality and safety. The IFS Food standard applies when products are "processed" or when there is a risk of the product becoming contaminated during packaging. The IFS food standard is important for all food producers, and especially for those who produce their own product brands, as it contains many requirements related to compliance specifications.

2.2. Contents of IFS standards

PART 1: Audit Protocol

1. History of Internationally Prominent Standards and IFS Food Standards,
2. Introduction,
3. Types of audits,
4. Audit scope,
5. Certification process,
6. Awarding certificates,
7. Distribution and storage of audit reports,
8. Additional activities,
9. Complaints and objections procedure,
10. Ownership and use of the IFS Food mark,
11. Revision of the Standard,
12. IFS Integrity Program.

PART 2: List of audit requests

1. Responsibility of Senior Management,
2. Food quality and safety management system,
3. Resource management,
4. Planning and production process,
5. Measurement, analysis, improvements,
6. Food defense and external inspections.

PART 3: Requirements for accreditation bodies, certification bodies and auditors
1. Introduction,
2. Requirements for accreditation bodies,
3. Requirements for certification bodies,
4. Requirements for IFS auditors.

PART 4: Reporting, audit XpressTM program Iifs Audit Portal
1. Introduction,
2. Reporting,
3. Audit XpressTM program,
4. IFS audit portal and IFS databaseEach table is numbered.

2.3. Basic objectives of IFS food

The basic goals of IFS Food as well as other IFS Standards are:
- establishing a common standard with a unified grading system,
- work with accredited certification bodies and qualified IFS approved auditors,
- ensuring comparability and transparency throughout the supply chain,
- reducing costs and time for both suppliers and retailers.

The IFS standard ensures a high level of transparency throughout the supply chain, ie. food trade.

2.4. IFS certificates

Organizations operating in the food chain and wishing to obtain IFS certification should select an approved certification body that is qualified to conduct audits according to IFS standards. Only IFS approved certification bodies can perform IFS audits and issue IFS certificates. The certification body and the organization to be certified sign a contract setting out the scope of the audit, the duration of the audit, the responsibilities and obligations of the certification body and the organization to be certified (Lazibat, 2009). The certification body will calculate the duration of the audit according to the reported audit scope. The certification body should provide an audit schedule. The audit timeline includes details regarding the scope and complexity of the audit. The audit should be planned on the basis of an introductory meeting, an assessment of existing food quality and safety systems, a site assessment and interview with staff, a conclusion drawn from the audit and a final meeting. The

person in charge selected by the organization applying for certification should be available to the auditors throughout the audit. The governing and management staff of the organization should be present at the introductory and closing meeting. Auditors assess all requirements of the IFS Food standard that correspond to the structure and activities of the organization being audited. In order to determine compliance with the requirements of the IFS Food Standard, the auditor must evaluate each requirement of the standard. The assessment of each of the requirements is scored depending on compliance with the requirements as:

- Full compliance with the requirements specified in the Standard,
- Almost complete compliance with the requirements specified in the Standard, but a small deviation was found,
- Only a small part of the requirements has been implemented,
- The Standard requirement has not been applied (Lazibat, 2009).

There are two types of non-compliances in IFS that can be "Major" and "KO" - Knockout. Both lead to deduction of points from the total amount (15% is deducted from Major, and 50% of possible amount is deducted from Knockout). If the organization receives at least one of these nonconformities, the certificate cannot be awarded until the nonconformities have been corrected. For all products and for all certification levels, the frequency of IFS Food audits is 12 months, starting from the date of the audit and not from the date of certification (IFS Food, 2014). During the final meeting, the auditor presents all findings and discusses nonconformities that may be observed during the audit process. The certification body will send the auditor's organization an auditor's report containing all the results of the audit. After the non-compliance has been eliminated, a certificate can be awarded proving that the organization has successfully met all the requirements of the IFS Food standard. The certificate is issued for one specific location, in order to make the use of the IFS standard international and widely understood, the scope of audits on the IFS certificate has always been translated into English (Kondić, 2002; Lazibat, 2009). The copyright for IFS Food and the registered trademark is the full property of IFS Management GmbH. The IFS Food mark can be downloaded via the secured section on the IFS audit portal.

3. CONCLUSIONS

For the successful operation of the company, it is important to invest in the quality of the process because it is also a long-term investment in the product.

The International Food Standard is based on the requirements of retail chains for the distribution of safe products in accordance with applicable legislation that are produced under controlled conditions from controlled raw materials and with minimal risk of deviation from the specified product parameters.

The requirements of the standard are based on the quality management system, good agricultural and production practice and the HACCP system.

The basis of the standard is the establishment of a common standard with a single rating system, ensuring transparency throughout the supply chain and reducing time and costs for both suppliers and retailers.

REFERENCES

[1] Herceg, Z.: *Procesi u prehrambenoj industriji*, Plejada, ISBN: 978-953-7782-06-1, Zagreb, (2011)

[2] IFS Food: *Standardi za auditiranje kvalitete i sigurnosti hrane za prehrambene proizvode,* interna skripta Bureau Veritas Hrvatska (Verzija 6), (2014)

[3] Injac, N.: *Mala enciklopedija kvalitete*, Oskar, ISBN: 953-6619-03-2, Zagreb, (2002)

[4] Kondić, Ž.: *Kvaliteta i ISO 9000*, Tiva, ISBN: 953-6775-42-5, Varaždin, (2002)

[5] Lazibat, T.: *Upravljanje kvalitetom*, Znanstvena knjiga d.o.o., ISBN 978-953-95902-1-3, Zagreb, (2009)

[6] Lovrić, T.: *Procesi u prehrambenoj industriji s osnovama prehrambenog inženjerstva*, Hinus, ISBN: 953-6904-08-X, Zagreb, (2003)

[7] Skoko, H.: *Upravljanje kvalitetom*, Sinergija d.o.o., ISBN: 953-97944-4-7, Zagreb, (2000)

[8] Svijet kvalitete, Zahtjevi standarda IFS food ver. 7: *Available from* http://www.svijet-kvalitete.com/ *Accessed:*2021-02-09.

[9] Jinan Hanmei Machinery Co., Ltd: *Available from* https://www.ecvv.com/product/4865753.html *Accessed:* 2021-03-11.

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MULTIDISCIPLINARY ASPECTS

IMPACTS OF COVID-19 ON PUBLIC PROCUREMENT

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Abstract: the COVID-19 pandemic has caused certain difficulties on the world market, especially in the processes of supply chains and logistics, which has led to disruptions in the course of procurement and delivery of goods, services and various consumables. That is referred to the increased demand for medical products and hospital infrastructure, and also, on goods for various purposes. It was the responsibility of contracting authorities to coordinate public procurement procedures to ensure working conditions for a safe workplace and to promote the health of entire organizations. For these reasons, at the level of the European Union, the European Commission has adopted Guidelines on using the public procurement framework in the emergency situation related to the COVID-19 crisis with a number of communications and publications to allow flexibility in the implementation of these procedures. The aim of this paper is to present the issues of public procurement procedures in the COVID crisis and to present the guidelines of the competent public procurement authorities.
Key-words: public procurement, COVID in public procurement

1. INTRODUCTION

For the public procurement system, the European Commission adopted Directives on public procurement or basic principles of transparency, equal treatment, open market competition and good procedural management. The aim of designing the directives is to achieve a procurement market that is competitive, open and well regulated for the responsible use of public funds. By April 18, 2016, three directives were adopted. [1] Directive 2014/24/EU defines procurement as the acquisition through a public procurement contract of works, goods or services procured by one or more public contracting authorities from economic entities, regardless of whether the works, goods or services are required public purpose. [2] The Directive on the procurement of entities operating in the water, energy and transport sectors and the postal services repealing to the Directive 2014/17/EU which governs the procurement of economic entities from the aforementioned activities. [3] Directive 2014/23/EU on the award of concession contracts represents a balanced and flexible legal framework for the contracts in order to ensure efficient and non-discriminatory market access for all economic entities of the European union, especially in the possibility of small and medium-sized enterprises accessing concession markets. [4] Healthcare,

infrastructure and energy sector are sectors of activities that depend on public procurement procedures. The largest expenditures, roughly second-rate needs of national governments, are taken by healthcare at over 9% of GDP. [5] According to the analysis of the European Commission, every year in the European Union more than 250,000 public bodies spend about 14% of GDP or approximately 2 trillion euros annually on purchasing goods, works and services. Improving the implementation and obtaining efficient results of the implementation of public procurement procedures can bring great savings with an efficiency improvement of 1% or 20 billion euros could be saved per year. [6]

2. EXAMPLES OF THE IMPACT OF COVID ON CHINA AND ITALY

First negative impact of COVID was felt in China, considering the role it plays in supplying the global market. Shipping cargo has been held up in China's main container ports. Also, travel restrictions have led to a shortage of truck drivers or a lack of shipping routes for maritime transport activities. The total volume of containers handled in Chinese ports fell by 10.1% in the first months of 2020 due to significant restrictions on ocean freight including key exporters such as Brazil, India and Mexico or importers such as the European Union. Land transportation remained partially available roads, except in countries with severe lockdown conditions. Transport capacities were increased due to additional demand, especially for the transport of food and medical equipment, regardless of the reduced availability of healthy employees. Other economic sectors, such as production, were not at full capacity due to new conditions of limiting the number of people. On the other hand, rail services has increased their transport routes due to higher air freight rates, empty sailings and longer transit times for trucks. The air freight rate fell by 19% in March 2020 due to a sharp decrease of the number of passengers and a decline in manufacturing in China. The total reduction in capacity is greater than the net reduction in demand, which supports higher air fares. For these reasons, demand was mostly affected at the same time due to the delay in deliveries of logistics company and interruption of supply chains. In period from January 24 to February 26, 2020, the volume of long-distance transportation fell by 15% compared to 2019. By the end of February, the volume of this transport achieved growth of 50% and 92% in March. The rapid recovery is the result of transport policies through the abolition of state tolls for highways and quarantine requirements for trucks transporting essential goods. [7]

In Europe, COVID crisis has gained a lot of negative consequences in Italy. At the height of the pandemic, there was a shortage of supplies of life-saving infrastructure with supply chain disruptions, blockades, production disruptions and transportation bottlenecks. The weakness of the European market in the field of public health and the complete dependence on third domestic suppliers was well presented. The lack of products on the market has sharply raised prices considering the situation in Europe. Despite the existence of the pandemic and plans at the national and regional level, the systems were not ready to handle the excessive demand for products of the same purpose. Another challenge was the lack of coordination at multiple levels, especially in coordination of the state of supplies in cooperation with the Italian

Department of Civil Protection. This challenge had the greatest impact on the urgency of conducting public procurement, including transport and production. The third challenge was the centralization of procurement or creating the risk of fraud in the public procurement system or insufficient transparency in relation to value for money, innovation or achieving efficiency. The consequence of these effects is the problem of bureaucratic compliance and the creation of mistrust within the public sector which includes authorities and potential suppliers. For these reasons, the competent public subjects in Italy lost the opportunity to adopt and establish appropriate institutional and organizational approaches to encourage cooperation between companies. [5]

3. GUIDELINES OF THE EUROPEAN COMMISSION FOR PUBLIC PROCUREMENT IN THE EMERGENCY SITUATION RELATED TO THE COVID-19 CRISIS

Considering the situation that the COVID pandemic has caused throughout Italy, the European Commission has prescribed Guidelines for public procurement in a crisis situation caused by the disease COVID-19. Public contracting authorities in the European Union are the main providers of procurement for the mentioned items. For this reason, public authorities must take care of their availability. The guidelines refer to public procurement procedures in situations of exceptional urgency, which enables public contracting authorities to procure what is necessary within a few days, even a few hours. For the above reasons, there are no procedural restrictions in the EU directives. Public contracting authorities can choose between the following options;

- significant shortening of deadlines when conducting an open or limited procedure
- carrying out the negotiation procedure of public procurement without public announcement or;
- alternative analysis and solutions for activating the remaining roles on the market. [8]

The European public procurement framework allows contracting authorities to procure goods and services directly related to the COVID crisis as quickly as possible by establishing and allowing contacts with potential contractors within and outside the borders of the European Union by telephone, e-mail, in person or by engaging agents with better business connections. Also, it is possible to send representatives directly to countries that have the necessary supplies and can ensure immediate delivery. Therefore, it is allowed to address potential suppliers, i.e. exchange of information and realization of contracts for the increase, start or renewal of production. [8]

An active role in the public procurement market implies the implementation of market connection activities. Public contracting authorities can use digital tools that innovate the current market situation affected by COVID in a way to participate in the innovation environment and with certain private entities that can offer solutions or participate in entrepreneurship. When determining the deadlines for the submission of requests for participation and bids, the public contracting authority is obliged to define complexity of the procurement and the time required to prepare requests for

participation and bids while respecting the minimum prescribed deadlines in accordance with the provisions of Article 227 of the Croatian Law on Public Procurement. [9] One of the most significant changes expressed in the Communication of the European Commission is the shortening of the deadlines for submitting bids in public procurement procedures for open and limited procedures.

In an open procedure, the deadline for submitting bids can be shortened from 35 days to 15 days when the urgency is justified in accordance with Article 27 Paragraph 3 of Directive 2014/24/EU. In a limited procedure, the deadline for submitting a request for participation can be shortened to 15 days according to Article 27 paragraph 3 of Directive 2014/24/EU, or the deadline for submitting offers to 10 days in order to award the contract as quickly as possible according to Article 28 paragraph 6 of Directive 2014/24/EU. [9] The most necessary supplies in these procedures are goods, services and implementation of public works for hospitals and health institutions, depending on the nature of the procedure and the subject of procurement on an individual basis. When it comes to large short-term needs, delivery time increase significantly as the infection curve grows. In the case of calls for exceptional urgency, the need for public procurement must be fully justified without delay. [8]

An additional instrument for faster awarding of contracts is the publication of the negotiation procedure without the publication of a call for tenders. In this procedure, the public contracting authority invites one or several economic entities to submit an initial offer. After that, they can negotiate with the bidders about the initial and subsequent offers in order to improve their content. [10]

For the complete justification of the implementation of this procedure, the contracting authorities are obliged to submit a report on the selection of the satisfaction of certain criteria. One of them is the impossibility of predicting certain events, i.e. predicting the specific development of the pandemic and the needs of health institutions. The second criterion is meeting the urgency of the procedure with an emphasis on the needs of healthcare institutions. The third criterion is the disconnection of the cause-and-effect relationship between the needs of hospitals and the condition of the pandemic. The fourth criterion is the implementation of this procedure only for the most urgent needs until a more stable solution is found which led to the need of finding the way to implement joint procurement. The goal of the joint procurement implementation mechanism is to ensure common and fair access to individual health countermeasures in order to increase security of supply at appropriate prices for participating member states. The agreement on joint public procurement was signed by 36 countries by April 2020, including all member states of the European Union and EEA states, the United Kingdom, Albania, Montenegro, North Macedonia, Serbia, Bosnia and Herzegovina and Kosovo. [11] Agreement on joint public procurement is determined by Decision 1082/2013/EU, i.e. its fifth article. In accordance with the fifth article of the Decision, participation in the joint procurement procedure is opened to all member states under the signed agreement until the start of the public procurement procedure. [12]

Table 1.: Joint procurement

ITEMS	AVAILABILITY	VOLUME	BUDGET CEILING
Gloves and coveralls	April 2020-2021 (gloves); May 2020-2021 (coveralls)	Several million	€97 million
Eye and respiratory protection	April 2020-2021	20 million goggles, 12 million face shields, 37 million FFP2 masks, 26 million FFP3 masks, 301 million surgical masks	€1.4 billion
Ventilators	April 2020-2021	110,000 units	€1.4 billion
Laboratory equipment	May 2020-2021	30 different lots	€192 million
Medicines used in intensive care units	October 2020 - September 2022*	103 million vials of 19 medicines (analgesics, antibiotics muscle relaxers, anesthetics, resuscitation, other); NB. Includes dexamethasone under lot 1; (use of dexamethasone in COVID-19 patients on oxygen or mechanical ventilation)	€543 million
Remdesivir (Veklury)	October 2020 - April 2022**	Over 500,000 treatment courses	€3.4 billion
Medical equipment for vaccination	December 2020 - March 2022*	1.2 billion syringes, 588 million needles, 760 million pairs of gloves, 307 million aprons, 1.18 million vaccine carriers, 3.38 million waste containers, 98 million disinfectants, 5.5 million anesthetic consumables	€2.27 billion
Rapid antigen tests	February 2021 - 2022	557 million tests, 1,733 reading devices	€2.67 billion
Monoclonal antibodies	April 2021 - end 2021***	220,000 treatments of VIR-7831 (sotrovimab), 220,000 treatments of bamlanivimab and etesevimab combination, 55,000 treatments of Regn-COV2 (combination of casirivimab and imdevimab)	€937 million

Since the beginning of the pandemic, participation has been achieved in twelve joint procurement procedures. More than 200 contracts have been concluded for the ordering of basic medical supplies and innovative therapies worth 13 billion euros. When conducting joint procurements, the European Commission played the role of coordinator, while the member countries played the role of buyers. [13]

4. CONCLUSION

COVID-19 represents a health crisis that has an impact on all spheres of life. There was a big standstill in the logistics sector regarding orders from private and public entities. This affected on the product flows of various products, the health and safety of workers due to the lack of necessary regulations or protocols in emergency situations. With the onset of this kind of pandemic and the stagnation of the global market, deficiencies in legal regulations were well presented. These shortcomings enabled faster action and implementation of public procurement procedures. For these reasons, the European Commission for the member states of the European Union established Guidelines that facilitate the urgent procurement of certain products. After that, a large number of joint public procurements were carried out. It can be concluded that the COVID pandemic caused negative effects on the global market at the very beginning, causing a long-term recovery of commodity flows.

LITERATURE

1) European Commission; Legal rules and implementation; https://ec.europa.eu/growth/single-market/public-procurement/legal-rules-and-implementation_en (12.6.2022.)

2) Directive 2014/24/EU of the European Parliament and the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0024&from=EN (12.6.2022.)

3) Directive 2014/25/EU of the European Parliament and the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC https://eur-lex.europa.eu/legal content/EN/TXT/PDF/?uri=CELEX:32014L0025&from=EN (12.6.2022.)

4) Directive 2014/23EU of European Parliament and the Council of 26 February 2014 on the award of concession contracts; https://eur-lex.europa.eu/legal-content/HR/TXT/PDF/?uri=CELEX:32014L0023&from=DA (12.6.2022.)

5) Accounts Chamber of the Russian Federation, Public procurement during the COVID-19 pandemic, 2020.: https://ach.gov.ru/upload/pdf/ENG%20Covid-19-procurement.pdf (12.6.2022.)

6) European Commision; Public procurement; https://ec.europa.eu/growth/single-market/public-procurement_en (13.6.2022.)

7) International Finance Corporation: The Impact of COVID-19 on Logistics https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/infrastructure/resources/the+impact+of+covid-19+on+logistics (13.6.2022.)

8) European Commission, Communication from the Commission; Guidance from the European Commission on using the public procurement framework in the emergency situation related to the COVID-19 crisis; https://eur-lex.europa.eu/legalcontent/HR/TXT/HTML/?uri=CELEX:52020XC0401(05)&from=EN (13.6.2022.)

9) Croatian Law on Public Procurement; https://www.zakon.hr/z/223/Zakon-o-javnoj-nabavi (13.6.2022.)

10) Temporis; Public Procurement in the time in the pandemic time (COVID 19) , Negotiated procedure without prior publication invitations to tender; https://biltenjavnenabave.hr/system/files/img/1_Pregovaracki%20postupak_03042020_Final.pdf (14.6.2022.)

11) European Commission; Joint Procurement of medical countermeasures; https://ec.europa.eu/health/other-pages/basic-page/joint-procurement-medical-countermeasures_hr (14.6.2022.)

12) Decision No 1082/2013/EU of the European Parliament and of the Council of 22 October 2013 on serious corss-border threats to health and repealing Decision No 2119/98/EC; https://ec.europa.eu/health/system/files/201611/decision_serious_crossborder_threats_22102013_en_0.pdf (14.6.2022.)

13) European Commission; Ensuring the availability of supplies and equipment; https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/public-health/ensuring-availability-supplies-andequipment_en#identifying-demands-and-matching-supplies-of-medical-equipment (14.6.2022.)

ANALYSIS OF APPLICATION OF THE SAFETY SYSTEM ON TABLE SAWS

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Abstract: *The aim of paper is to analyze the application of the safety system on table saws. The research methodology used to analyze the application of the safety system on table saws is presented, using the method of description using a checklist. The research was conducted on a sample of 18 table saws, where it was determined that the most significant problem was the lack of a rip fence. The results obtained from the analysis of the application of the safety system on table saws were discussed and further research was proposed.*

Keywords: *table saw, safety system, methodology, analyze, check-list.*

1. INTRODUCTION

Wood processing machines are not only related to the wood processing industry, that is, to companies whose main activity is the processing of wood and similar sheet materials. There are a large number of companies for which mechanical wood processing is not a primary but a secondary activity. These are construction companies, lumber stores, public companies in cities, agricultural companies, foundries, heating plants, service companies, etc. [1]. Machines used in wood processing industries are dangerous, especially when handle without proper safeguards. Workers can suffer injuries from minor cuts to amputations and blindness, [2].

Table saws are very common machines for processing wood and similar sheet materials, primarily due to the simplicity of their construction and the possibility of application for different types of processing. It is used for transverse and longitudinal cutting of wood, [3]. Due to the wide application, the relatively high peripheral speed of the cutting tool and the way of working (in most cases, the wood is manually pushed towards the cutting tool), table saws are very dangerous machines on which numerous injuries to workers have been recorded. When working on a table saw, the worker's fingers (Figure 1) or hand can be cut off (amputation), which is mainly caused by the lack of a blade guard around the saw blade and riving knife.

Over 30,000 table saw injuries occur annually. Table saw injuries can be grouped into blade contact injuries and non-blade contact injuries, which include blunt trauma due to kickback, eye or respiratory injuries due to sawdust. Blade

contact injuries are by far the most common, representing over 85% of table saw injuries. The vast majority of injuries are to the fingers or thumbs. Lacerations were the most frequent injury sustained (66%) but amputations were not uncommon (10%–15%), [4].

Figure 1: Examples of hand injuries caused by table saws, [3]

2. MATERIAL AND WORKING METHODS

2.1 Defining the research problem

The research problem is the lack of data on the fulfillment of safety measures in table saws, especially those related to the existence and correctness of the safety system: blade guard, riving knife, guard around the transmission mechanism and rip fence.

2.2 The aim of the research

The aim of the research is to determine the percentage of table saws that have non-conformities regarding the safety system in the observed companies.

2.3 Research hypothesis

It is assumed that in the companies where the research was conducted, the percentage of table saws that do not have a rip fence is the highest.

2.4. Research methods

In the existing checklists in the Republic of Serbia, mostly YES/NO answers are offered, where in some questions for a dangerous situation, the answer is YES, and in some questions the answer is NO, so transparency is at an enviable level. It was suggested that the newly formed check-ability of the analysis of the safety system in table saws be answered with "Dangerous", "Not Relevant" and "Safe", in order to

raise visibility to a higher level. After completing the checklist, answers of the type "Safe" and "Not Relevant" do not require taking corrective measures, while answers of the type "Dangerous" require analysis and proposed measures that are entered in the column "Corrective measures which should be applied". Based on the analysis of the application of safety systems and expert findings for periodic inspections and checking the correctness of table saws, a set of questions was asked in the newly formed checklist for the analysis of safety systems on table saws. The method of description was used, that is, the procedure of describing by giving comments on the questions asked, [5]. An example of a completed checklist for the analysis of safety systems on table saws is given in Table 1.

Table 1. Analysis of the application of the safety system on table saws
(D – Dangerous, N/R – Not Relevant, S – Safe)

ANALYSIS OF THE APPLICATION OF THE SAFETY SYSTEM ON TABLE SAWS					14/18	25.05.2022.
Name and registered office of the employer		/				
Activity (business area)		/				
Type of machine	Table saw	Manufactures	/			
Type / model	/	The year of production	/			
Serial number	The question	Comment	D	N/T	S	CORRECTIVE MEASURES which should be applied
1.	Blade guard	There is a blade guard.				
2.	Riving knife	There is no riving knife behind the saw blade				Install riving knife
3.	Guard around the transmission mechanism	There is a guard around the transmission mechanism				
4.	Rip fence	There is a rip fence.				

2.5. A sample research

The research included a sample of 18 table saws for which data on the existence of the safety system was collected. The research lasted two months (April-May 2022) and was conducted in 18 companies.

2. RESEARCH RESULTS AND DISCUSSIONS

The results of research related to the existence of a safety system on table saws: a blade guard around the saw blade, a riving knife, a guard around the transmission mechanism and a rip fence are given in Table 2.

Table 2: The result of the analysis of safety systems on table saws

SAFETY SYSTEMS	ANALYSIS OF THE APPLICATION OF THE SAFETY SYSTEM ON TABLE SAWS		
	The total number of analyzed table saws	Number of negative (dangerous) answers	% negative answers
Blade guard	13	5	27,78
Riving knife	9	9	50
Guard around the transmission mechanism	11	7	38,89
Rip fence	7	11	61,11

The main danger of injuring the worker while working on a table saw is the rotation of the saw blade. Protection is achieved by using and properly fitting a blade guard, which prevents accidental contact of the worker's hand with the saw blade, as well as material particles flying into the worker's eyes.

Of the total number of analyzed table saws, five, that is, 27.78%, were not equipped with a blade guard around the saw blade, Figure 2/left. Thirteen table saws have a blade guard around the saw blade, that is, this protection measure is fulfilled by 72.22%, Figure 2/middle/right.

Figure 2: Blade guard (own source)

Riving knife, which is placed directly behind the saw blade, has the basic function of preventing narrowing of the resulting slot in the workpiece and possible kickback, [6].

Examples of table saws with a riving knife are given in Figure 3. The riving knife has nine analyzed table saws, so 50% of these machines meet this safety measure.

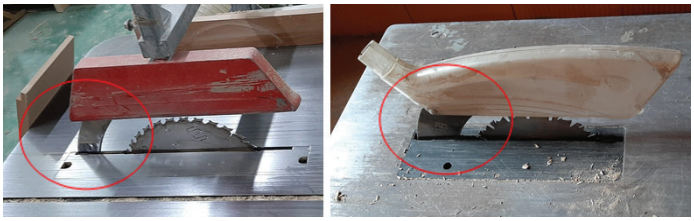

Figure 3. Riving knife (own source)

Seven, i.e. 38.89% of the analyzed table saws, do not have a guard around the transmission mechanism, Figure 4/left. A closed case (Figure 4/middle) or protective armor (Figure 4/right) is used to protect the worker from catching the saw blade under the work table or transmission mechanism.

Figure 4: Guard around the transfer mechanism (own source)

On the working table of the table saw there are rip fence that ensure the guidance of the workpiece, whether it is cut longitudinally, transversely or at an angle, [6]. Eleven, or 61.11% of analyzed table saws do not have a rip fence.

Modern constructions of table saws have mechanisms that can instantly stop the rotation of the saw blade - the cutting plate in case of need, [6].

SawStop technology stops the saw blade when contact with skin is made, resulting in a small cut, rather than a more complicated laceration or amputation, [4].

SawStop is a table saw manufacturer that has developed the first passive safety system for table saws, [7]. A SawStop brake cartridge is attached to the underside of the table saw. This cartridge applies a small electric charge to the saw blade. The charge is continuously monitored and when the contact with a conductive material, such as a human finger, lessens the charge the blade is lowered below the table surface and stopped. SawStop is not designed to replace traditional blade guards and safe practice, but to add an extra level of protection when cutting wood, [4].

Figure 5. SawStop passive safety system for table saw, [7]

A manual pusher and/or a mechanized moving pusher can be used to push the workpiece. All analyzed table saws had a manual pusher, and none of them had a mechanized moving pusher.

3. CONCLUSION

The paper provides an analysis of the application of the safety system, which was carried out on a selected sample of 18 table saws.

The research hypothesis was proven because it was determined that of the 18 analyzed table saws, the blade guard around the saw blade is absent in 5 (27.78%), the guard around the transmission mechanism is absent in 7 (38.89%), the riving knife is absent in 9 (50%) 11 (61.11%) do not have a rip fence, which represents the biggest problem in the application of prescribed safety and health measures at work and ensuring the use of a safe table saw.

Further research should be focused on the analysis of the application of safety systems on table saws on a much larger sample in order to obtain more relevant data.

REFERENCES

References should be indicated in the text using consecutive numbers in square brackets, e. g. □1□. In the bibliography (by ISO 690) they should be cited including the title of the paper:

[1] Gavanski, D.: Bezbedan rad na mašinama za obradu drveta, 20. Međunarodna DQM konferencija *Upravljanje kvalitetom i pouzdanošću* ICDQM-2017, Zbornik radova, Papić, LJ (Ed.), pp. 254-259, ISBN 978-86-86355-33-1, Prijevor, Serbia, Jun 2017, Istraživački centar za upravljanje kvalitetom i pouzdanošću.
[2] Okuma, S., Orhorhoro, E.K., Olorunleke, A.: Safety analysis and implementation for safer design of wood processing machines; a case study of

Southern Nigeria, September 2020, *International Journal of Current Research in Science Engineering & Technology* 2(9). e-ISSN: 2582-5208. Available from https://www.researchgate.net/publication/350451353_SAFETY_ANALYSIS_AND_IMPLEMENTATION_FOR_SAFER_DESIGN_OF_WOOD_PROCESSING_MACHINES_A_CASE_STUDY_OF_SOUTHERN_NIGERIA Accessed 2022-07-19

[3] Gavanski, D.: *Bezbedan rad na kružnim testerama*, 10. Međunarodno savetovanje Rizik i bezbednosni inženjering, Zbornik radova, Savić, B. (Ed.), pp. 201-210, Kopaonik, Serbia, Januar 2015, Visoka tehnička škola strukovnih studija u Novom Sadu, Fakultet tehničkih nauka Univerziteta u Novom Sadu, Departman Inženjerstva zivotne sredine.

[4] Chung, K., Shauver, M.: *Table saw injuries: epidemiology and a proposal for preventive measures*, Plast Reconstr Surg. 2013 Nov; 132(5): 777e–783e. *Available from* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4154236/pdf/nihms620818.pdf Accessed 2022-07-19

[5] Gavanski, D.; Blanuša, V.: *Analiza primene sistema zaštite na stonim i stubnim bušilicama*, Poljoprivredna tehnika, Vol. (XLVII) No.2, pp. 11-19, ISSN 0554-5587.

[6] Trbojević, N.: *Zaštitni uređaji na strojevima*, Zavod za istraživanje i razvoj sigurnosti d.o.o., Veleučilište u Karlovcu, Zagreb, (2015).

[7] Decoding SawStop's Finger Detection System, *Available from* https://thenewbiewoodworker.com/2019/07/03/decoding-sawstops-finger-detection-system.html Accessed 2022-07-19

PERCEPTION OF CLIMATE CHANGE BY FEMALE FARMERS IN SERBIA – A CASE STUDY

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Abstract: *Climate change has been recognized as one of the biggest and most serious challenges facing the planet – humankind, natural environment, and global economy. The changing climate also poses a considerable challenge for agriculture, specifically for the shaping of agricultural policies. Agriculture is a branch of economy that is inseparable from the climate, depending on it but also affecting it. As the climate changes, so do its impacts on agricultural production. This paper presents the data obtained from an empirical study on a sample of 132 female respondents in Serbia regarding the degree of their ecological awareness, climate change perception, and attitudes about the impact of climate change on agricultural production. The results show that the respondents are aware of climate change and its negative impact on agricultural production. The obtained data can further be used as guidelines for adopting appropriate agricultural policies in Serbia, all the more so because the gender dimension is significantly underrepresented in the struggle against climate change.*

Keywords: *climate change, female farmers in Serbia, ecological awareness, case study*

1. INTRODUCTION

The notion of global warming of the atmosphere related to climate change has been publicly known since the 19th century, evident from the gradual increase of average air temperature. Global warming is the result of greenhouse gas emissions and it can be characterized as the first and obvious factor of increase in Earth's surface temperature. The greenhouse effect was first described by the French mathematician and physicist Jean Baptiste Fourier in 1824 [1]. Subsequent work by renowned scientists and Nobel prize recipients established the relevance of CO_2 emissions for the atmosphere and how much their increase and/or decrease would affect the Earth's temperature. Even though CO_2 is always present in the atmosphere, the doubling of its concentrations due to various human activities results in the increase of Earth's surface temperature by 5-6 °C over a period of 3,000 years [2].

Agriculture is directly connected with climate change bidirectionally. On the one hand, temperature increase, prolonged dry periods, and floods negatively impact agricultural production. On the other hand, according to Garnett, the production, processing, transport, storage, preparation, purchase, and consumption of agricultural products also contributes to the global greenhouse gas emissions from 15% to 30% [3].

The changed climate conditions of agricultural production are evident; however, the question arises how the individuals involved in agricultural production perceive such conditions. This paper focuses on the perception of climate change by female farmers. Activities of female farmers include crop production, animal husbandry, preparation of agricultural products for personal use or sale, product sale, and marketing [4]. Their specific societal position may affect their recognition and perception of climate change. Female farmers' perception of climate change is important in two ways. On the one hand, it allows them to transition from the traditional agricultural practices and adapt them to the altered climate conditions that negatively impact agricultural production. On the other hand, proper perception may reduce the negative impact of agriculture on climate change.

Climate change perception is a complex process involving a series of psychological constructs, such as knowledge, beliefs, attitudes, and concern over if and how the climate is changed [5]. The perception is influenced and shaped, among other things, by the traits of individuals, their experience, the information they receive, and the cultural and geographical context within which they live [5, 6]. Therefore, measuring climate change perception and attempting to establish its properties is no easy task, especially if the focus is on climate change perception by female farmers.

The fluctuations of local weather conditions on a daily, seasonal, and even annual basis pose one of the many challenges facing female farmers when they are trying to differentiate between regular short-term variations and climate change manifestations [7]. In fact, local short-term variations tend to be more prominent than long-term trends and can thus be crucial for the shaping of climate change perception [8]. Even though the perception by those who directly depend on the weather for income, such as female farmers, is usually fairly adequate, it can also be greatly influenced by the farmers' socio-economic status, cultural patterns, and the local surrounding itself [5, 9].

Life experiences influence perception – individuals who were directly affected by extreme climate events tend to report that the probability of such an event repeating is relatively high [10]. One's climate change perception may also be influenced or modified by the information one receives. Finally, it needs to be noted that perception is a partially subjective phenomenon, which is why different people at the same location may have different perceptions of climate change even though they experience the same weather patterns [11].

This paper presents a portion of the results of a broader study examining the level of ecological awareness and regularities in the patterns of female farmers' perception of the impact of climate change on agricultural production in Serbia. Predictors such as education and cultural patterns were used.

2. MATERIALS AND METHODS

A special questionnaire was designed for the study. The level of ecological awareness was tested using the New Ecological Paradigm (NEP) scale, which comprises 15 items [12], and a five-point Likert scale. The Cronbach α for scale reliability is 0.86, which indicated that the scale is reliable. Based on previous studies, scores from 15 to 47 were interpreted as anti-ecological awareness, scores from 48 to 60 as mid-ecological, and scores from 61 to 75 as pro-ecological awareness [13].

The study was conducted from October 2021 to February 2022, based on a random sample comprising 132 female respondents from the Nišava District, specifically from the Municipality of Svrljig.

The results were processed using methods of descriptive statistics. Data processing was conducted using SPSS 20.0 software.

3. RESULTS

Of the 132 respondents, the majority has a secondary education (48.5%), followed by higher education (33.3%), and primary or lower education (18.2%), but only 17.42% own their own farmland. They are mainly involved in outdoor olericulture (57.7%) (with significantly fewer practicing it inside greenhouses (18.2%)), followed by pomology (37.9%), and viticulture or other activities, such as growing medicinal plants, nursery production, etc. (fewer than 10%). Arable crop farming and olericulture is practiced by 51.5% of the respondents, while 36.36% are involved in greenhouse farming and animal husbandry.

3.1. Level of ecological awareness among female farmers

The obtained results indicate that the majority (less than a half) of the respondents have mid-ecological awareness, followed by anti-ecological awareness (less than a third), and pro-ecological awareness (less than a quarter) (Table 1).

Table 1. Level of ecological awareness

	Frequency	Percent	Valid Percent	Cumulative Percent
Anti-ecological awareness	46	34.8	34.8	34.8
Mid-ecological awareness	58	43.9	43.9	78.8
Pro-ecological awareness	28	21.2	21.2	100.0
Total	132	100.0	100.0	

According to the obtained data, a connection was found between the level of education and the level of ecological awareness (Pearson Chi-Square=9.564; df=4;

Asymp.Sig.=0.048). Most respondent with primary/lower and secondary education exhibited anti-ecological awareness, while the majority of respondents with higher education exhibited mid-ecological awareness. It was determined that the percentage of respondents with anti-ecological awareness decreases and the percentage of those with pro-ecological awareness increases the higher their level of education is (Table 2).

Table 2. Education and level of ecological awareness

Education	Ecological awareness			Σ
	Anti-ecological	Mid-ecological	Pro-ecological	
Primary/lower	45.8%	41.7%	12.5%	100%
Secondary	42.2%	40.6%	17.2%	100%
Higher	18.2%	50%	31.8%	100%
Total	34.84%	43.94%	21.22%	100%

3.2. Predictors of female farmers' climate change perception

Considering that cultural patterns in the social environment in which female farmers live largely shape their climate change perception, we relied on potential predictors influencing their perception, such as education, farmland ownership, independence in decision-making related to agricultural production, access to information, and involvement in climate change adaptation activities.

With regard to the female farmers' level of education and ownership of arable land, the obtained data suggest that the respondents with completed primary or lower education, specifically 52.4% of them, more frequently reported that their husbands owned the farmland. As the level of education increases, the percentage of respondents who do not own any farmland decreases. Thus, only about half as many respondents (25%) with higher education stated that their husbands owned the farmland. This leads to a conclusion that education may be one of the cultural pattern predictors influencing climate change perception through access to resources for agricultural production. Highly educated female farmers are more often the owners of farmland, which makes it easier for them to practice agricultural production, as opposed to those with lower levels of education.

Cultural patterns heavily influence women's ability to make independent decisions regarding the manner of agricultural production. Accordingly, the predictor *decision-making* was included among the potential factors influencing climate change perception and considered in relation to the respondents' level of education, which led to the following conclusions. In 66.7% of the cases, older respondents without a primary education stated that decisions regarding agricultural productions are made by multiple members of their household, which can be explained by the existence of family cooperatives – multigenerational communities in which the decisions about agricultural production are made collectively. The highest percentage of independent decision-making regarding agricultural production was found among the respondents with university education (12.5%). This percentage is low even in the single category of respondents with higher education, but it is still significantly higher than in the categories of respondents

with lower levels of education. Additionally, there is a partial regularity in the increase of the respondents' education level and the increase in the number of responses in which they state that they make decisions together with their husbands, which suggests that there is a democratic familial pattern of decision-making regarding agricultural production among the more educated respondents.

Regarding the relationship between the respondents' level of education and their identification of drought as one of the more significant agricultural effects of climate change, respondents with higher levels of education more readily perceive drought as an effect of climate change that has a considerable negative impact on their agricultural production. Specifically, 14.3% of the respondents with primary education stated that drought had had significant impacts on their agricultural production, whereas the same response was provided by a considerably higher percentage of respondents with university education (37.5%).

The respondents were also asked to state whether they had heard that their local self-government was holding workshops on female farmers' education for climate change. The results indicate that the respondents were more likely to have this information if they had a higher level of education. Thus, 66.7% of the respondents with no education and 47.6% with primary education responded that they had never heard about such workshops, as opposed to 32.8% of those with secondary and as few as 12.5% of those with higher education. Indicatively, female farmers with higher levels of education more frequently participated in the workshops. The data show that women with no education and with primary education have never participated in such activities, whereas 3.1% of women with secondary, 25.0% with college, and 25% with university education did participate in a workshop on climate change organized for female farmers by their local self-government.

4. CONCLUSION

The obtained results indicate that the majority of surveyed female farmers have mid-ecological awareness and that there is a connection between the level of education and the level of ecological awareness. In addition, the majority of them properly perceive the negative environmental and climate change impact of specific aspects of agricultural production. They are also aware of the negative agricultural impact of climate change. All of this suggests that the respondents have latent ecological awareness.

This study showed that gender plays a significant part in climate change perception and that vulnerability and adaptation may be influenced by different responsibilities, traditions, and cultural norms that shape the awareness of individuals. It was observed that women often have limited opportunity to be informed and to participate in environmental decision-making, agricultural production, and climate change adaptation, most likely because of a strong influence of patriarchal culture. To a great extent, education can lead to proper perception of

climate change and contribute to the emancipation and improved status of women in agriculture.

It should be emphasized that agricultural cooperatives, civil society organizations (CSOs), as well as dedicated public policies could contribute to gender equality on the local level in terms of climate change and agricultural development through women empowerment programmes and affirmative action to improve the level of resource control by women. Future research should focus on complementary issues, which include gender equality policies in agriculture and climate change adaptation.

REFERENCES

[1] Harris, J. M (2009*), Ekonomija životne sredine i prirodnih resursa: Savremeni pristup* [Environmental and Natural Resource Economics: A Modern Approach], Status, Beograd.

[2] Peđak, J. (2009) "Klimatske promjene i društvene uloge znanosti i politike" [Climate Change and the Social Roles of Science and Politics], *Zbornik radova Društvena istraživanja* Zagreb, br. 1-2, pp. 91–100.

[3] Garnett, T.: *"Cooking Up a Storm. Food, Greenhouse Gas Emissions and Our Changing Climate"*, Centre for Environmental Strategy, University of Surrey, 2008, United Kingdom.

[4] Ilić Krstić, I. & Miltojević, V.: "Žene u poljoprivredi i adaptacija na klimatske promene" [Women in Agriculture and Climate Change Adaptation*], Svet rada,* vol. 17, br. 3, 2020, pp. 295–304.

[5] Whitmarsh, L., and Capstick, S. (2018). "*Perceptions of Climate Change*," in Psychology and Climate Change: Human Perceptions, Impacts, and Responses. Editors S. Clayton and C. Manning (Academic Press), 13-33. doi:10.1016/B978-0-12-813130-5.00002-3

[6] Van der Linden, S. (2015). The Social-Psychological Determinants of Climate Change Risk Perceptions: Towards a Comprehensive Model. J. *Environ. Psychol*. 41, 112–124. doi:10.1016/j.jenvp.2014.11.012

[7] Hansen, J., Sato, M., and Ruedy, R. (2012). Perception of Climate Change. *Proc. Natl. Acad. Sci*. 109 (37), E2415–E2423. doi:10.1073/pnas.1205276109

[8] Lehner, F., and Stocker, T. F. (2015). From Local Perception to Global Perspective. *Nat. Clim Change* 5, 731–734. doi:10.1038/nclimate2660

[9] Weber, E. U. (2015). Climate Change Demands Behavioral Change: What Are the Challenges? Soc. Res. 82 (3), 561–580. *Available at*: https://www.jstor.org/stable/ 44282122.

[10] De Matos Carlos, S., da Cunha, D. A., Pires, M. V., and Do Couto-Santos, F. R. (2020). Understanding farmers' perceptions and adaptation to climate change: the case of Rio das Contas basin, Brazil. *GeoJournal* 85, 805–821. doi:10.1007/s10708-019-09993-1

[11] Simelton, E., Quinn, C. H., Batisani, N., Dougill, A. J., Dyer, J. C., Fraser, E. D. G., et al. (2013). Is Rainfall Really Changing? Farmers' Perceptions, Meteorological Data, and Policy Implications. *Clim. Development* 5, 123–138. doi:10.1080/17565529.2012.751893

[12] E. R. Dunlap, D. K. Van Liere, G. A. Mertig, and R. J. Emmet: "Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale", *Journal of Social Issues*, Vol. 56, No. 3, 2000, pp. 425–442.

[13] J. Welsch: "*Perception and Attitudes of Landowners towards Re-establishing Native Vegetation on Private Land*" (Master thesis), Lincoln University, Natural Resources Management and Ecological Engineering. Lincoln University, 2011, Baltimore. https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/4278/Welsch_narm%26ee.pdf?sequence=3&isAllowed=y

ACKNOWLEDGEMENTS

The research is funded by Ministry of Education, Science and Technological Development of the Republic of Serbia (Contracts No. 451-03-68/2022-14/ 200148).

USE OF COERCIVE MEANS IN PRIVATE SECURITY SECTOR

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Abstract:

In this paper, the legal basis and ways of using coercive means by private security employees will be presented. Given that the new Law on Private Protection from 2020 has expanded the number of means of coercion that can be used by members of private protection, these new means of coercion will be addressed in this paper. An analysis of the means of coercion and the powers of members of private security in the European Union will also be presented.

Keywords: *private security, powers, coercive means*

1. INTRODUCTION

With the passing of the Law on the Protection of Persons and Property[1] in 1996, the legal and organizational regulation of private security activities began in the Republic of Croatia. Until then, this activity, popularly called "policing", was in the gray zone of business activities, and it was performed by persons who were not educated in how to professionally and legally perform private protection tasks, often themselves recorded in police records as perpetrators of criminal acts and misdemeanors. with elements of violence and property crimes, with primitive behavior with which they often caused incidents themselves at the events they were "policing".The above-mentioned law determined powers in general, and in particular the use of coercive means, which it reduced to physical force and firearms. By specifying only two means of coercion, which are located at the ends of the spectrum of means of coercion, many principles of the exercise of authority and the use of force by members of the private security were not respected.

The Law on Private Protection[2] from 2003. solves the problem of the private protection system in a better way by defining more precisely the activities of private protection, the criteria that people must meet in order to be employed in private protection companies, the types of jobs and the level of authority of members of private protection, and the clear powers that can be applied with the extension of means of coercion to guard dogs. The new law brings significant progress in the legal and organizational sense, although there are still many issues that have not been fully defined. Amendments to the Law on Private Security from 2010 opened, among other things, the private security market in the Republic of Croatia to foreign security companies. But the issue of authority, and especially the use of force, has not changed, which was given a critical opinion in a professional article from 2013[3].

The 2017 National Security Strategy assigns the private security sector an important role in protecting national security[4].

The new Law on Private Protection[5], which was adopted in 2020, defines in more detail the activity of private protection, the obligations and rights of service providers and recipients, extends the duties to specialist security guards and risk assessment makers, and expands the means of coercion with two more means, which will be described in more detail.

It defines private protection as a security economic activity that is carried out in order to achieve an acceptable level of private and public security of citizens and their property and to maintain order and peace within the contractual scope[5].

2. POWERS OF PERSONS IN PRIVATE PROTECTION SECTOR

The powers of persons performing private protection duties stemmed from police powers, both according to legal provisions and tactics, so they are also called "parapolice" because they are similar or the same as police powers (securing the scene, giving warnings and orders). If we compare the strategy and powers of private protection in the Republic of Croatia, then we can say that preventive action is the basic strategy in most EU member states, and the powers that are applied are very similar to the powers of the private sector in most countries of the European Union. This is primarily about the application of the so-called "civil powers", necessary defense[6] and last resort[6] and "civil arrest"[7], and then also special powers such as identity verification, securing the scene or using coercive means. As an exception, we can mention Latvia, where members of private security can arrest a person who breaks the law or illegally enters a protected facility[8] , while in other countries it is about preventing the escape of the perpetrator and detaining him until the police arrive.

When it comes to the use of firearms, as the most severe means of coercion, the provisions in EU countries, including the United Kingdom, are different. In the UK, Ireland, Denmark, France and the Netherlands, members of private security are not allowed to use firearms when performing body protection[8] .

The powers listed in the Law on Private Protection remained the same as in the law from 2003. Only the set of means of coercion was expanded from the previous physical force, firearms and guard dog, with sprayers of permitted harmless substances and means of binding. In previous expert articles (Kalem 2012 and 2013) the powers and use of physical force, guard dog and firearms were explained, so in this article we will deal with the principles and rules of using sprayers of permitted harmless substances and handcuffs.

3. MEANS OF COERCION IN PRIVATE PROTECTION

Security guards and specialist security guards can use means of coercion when performing physical protection duties to:

- to protect people's lives,
- overcoming resistance,
- prevention of escape,
- rejection of attacks and
- elimination of danger if warning measures and orders do not achieve the goal .

The funds prescribed by the Law on Private Protection are :

- physical strength,
- firearms,
- guard dog,
- dispenser of permitted non-harmful substances i
- use handcuffs[5].

Only security guards and specialist security guards are authorized to use means of coercion[5].

Obligations when using means of coercion:

- issue a warning and order, whenever possible, before use
- stop using when resistance stops, because any excessive use is punishable,
- always use a means that achieves the goal and causes the least harm to the person it is used against
- be especially considerate and in the last resort apply to a child, a person with a disability, a person whose movement is significantly impaired, a pregnant woman and a sick person,
- if the person on whom the means were used is injured during use, immediately provide first aid and, if necessary, call for emergency medical assistance,
- means of coercion should be used on non-vital parts of the body and where the least harmful consequences are caused and the goal of use is achieved
- report the use to the competent person and submit a written report.

3.1. Sprayer of permitted non-harmful substances

The sprayer of permitted harmless substances is a means of coercion that is used if milder forms of physical force were not effective or did not achieve the goal . It is a liquid based on the extract of hot peppers, approximately 3% of the extract to the amount of liquid that is under pressure in the metal atomizer. The maximum reach of the jet is up to approx. 7 meters, and the best effect is achieved at distances of 2 to 5 meters, targeting the attacker's face (mucous membrane of the eyes, nose and mouth). The sprayer is used so that the security guard occupies the so-called "interview stance" (figure 1), holds the sprayer in the dominant hand, usually the right, with the nozzle directed towards the attacker, while the other hand is used to protect the head from possible attacks, throwing objects and the like. After the warning and the command, the safety cover is raised with the thumb, the trigger is pressed and a short-term jet is released (figure 2). After using and defeating the attacker, it is necessary to provide him with help by rinsing the irritated mucous membrane with a decontamination agent. If the decontamination agent is not at hand, the mucous membrane can be washed with cold water. The sprayer MUST NOT be used to overcome passive resistance.

Figure 1. - Interview attitude[9]

Figure 2. – Use of a sprayer[10]

3.2. Use of handcuffs

The security guard and specialist security guard are authorized to use handcuffs to prevent a person from resisting or repelling an attack aimed at a security guard and specialist security guard or another person, the escape of a person or self-injury or injury to another person. "Handcuffs", single-use tension straps (figure. 3) or hand tools (straps, ropes) are considered means of tying.

Figure 3. – Handcuffs

Use of handcuffs limit the mobility of the body, primarily the hands of a certain person, by tying the hands behind the back, for the purpose of temporarily restricting the person's freedom of movement, with the application of the least possible harmful consequences for the person over whom the authority is applied. When using tying

means, the following are prohibited: tying persons of different sexes, tying a person to fixed objects (radiator, etc.), tightening clamps around the hands too tightly in order not to stop the blood flow. As a rule, one person is tied to this asset. Exceptionally, two people of the same gender can be tied so that the same hands are tied on the back of the person (right and right or left and left). Before using coercive means, the security guard and specialist security guard must undergo training in handling the means.

4. CONCLUSION

Coercive means are the most serious violation of a certain person's physical integrity and their human rights. Every society is particularly sensitive to the use of force by bodies or organizations authorized to use force. Any abuse and excessive use, excess of authority, unprofessional behavior causes indignation and often stormy reactions from the public towards those who used force illegally. In training and later through regular activities, it is necessary to educate and train members of private security in order to adopt funeral professional standards, communication skills and knowledge about the conditions and methods of applying powers and especially means of coercion so that cases of excesses are as rare as possible. This is the task not only of private protection and the bodies that carry out training and supervision of the work of private protection, but also of the entire public, which should be monitored and warned of possible abuses and excesses of authority.

REFERENCES

[1] Law on Protection of Persons and Property (Official Gazette 83/1996), 1996., Zagreb, Croatia
[2] Law on Private Protection (Official Gazette 68/2003), 2003., Zagreb, Croatia
[3] Kalem, D,: Powers of persons performing private protection duties, *Sigurnost* Vol. (55) No. 3, pp. 237 - 252, 2013., Zagreb, Croatia
[4] National Security Strategy of the Republic of Croatia (Official Gazette 73/2017), Zagreb, Croatia, 2017., Zagreb, Croatia
[5] Law on Private Protection (Official Gazette 16/20), 2020., Zagreb, Croatia
[6] Criminal Code (Official Gazette 125/11, 144/12, 56/15, 61/15, 101/17, 118/18, 126/19, 84/21), 2021., Zagreb, Croatia
[7] Law on Criminal Procedure (Official Gazette 152/08, 76/09, 80/11, 121/11, 91/12, 143/12, 56/13, 145/13, 152/14, 70/17, 126/19, 126/19, 80/22), 2022., Zagreb, Croatia
[8] Hans Born, Marina Caparini, and Eden Cole,: Regulating Private Security in Europe: Status and Prospects, Geneva Center for the Democratic Control of Armed Forces, 2007., Geneve, Switzerland

[9] https://www.google.com/search?q=interview+position+of+police+officer&client=firefox, accessed on 7/30/2022.
[10] Personal photo collection of Davor Kalem, 2022., Zagreb, Croatia
[11] Personal photo collection of Davor Kalem, 2022., Zagreb, Croatia

CHALLENGES OF ONLINE TEACHING IN HIGHER EDUCATION DURING THE PANDEMIC PERIOD

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Abstract: *The most widespread global pandemic, COVID-19, has led to the closure of educational institutions and the transition to online learning and virtual education. In order to identify the challenges and difficulties that university teachers encountered during the implementation of teaching in an online environment, as well as their personal perceptions of online teaching, an empirical study was conducted. The research sample consisted of 102 teachers from all five universities of the Republic of Serbia. The research was based on a descriptive method, surveying and scaling techniques, and a questionnaire with a Likert-type scale, prepared especially for the needs of the research. The paper presents the differences in teachers' attitudes based on their academic rank, length of service, as well as previous training in the field of ICT.*

Keywords: *online teaching, university teachers, COVID-19 pandemic*

1. INTRODUCTION

In the literature, the global pandemic COVID-19 is observed and defined as an emergency situation that has opened numerous research directions and encouraged researchers of various theoretical orientations to examine its health, economic, political, social and other consequences. The transition to online and digital formats of education, as a consequence of the mass closure of schools, colleges and universities, has brought online forms of teaching and learning to the center of pedagogical and andragogical research interest [1, 2].

Online learning research usually explore stand-alone online learning tools, instructional methodologies or techniques, unique environments within a blended fully online learning. The emphasis is commonly on the students' attitude, perception, assessment, evaluation, satisfaction, and performance [3, 4]. Research is also focused on the problems and difficulties that accompany online learning. In addition to the socio-economic (availability of appropriate computers and software) and organizational problems (Internet availability – especially in rural areas), digital literacy (of both teachers and students), presence of students in online classes,

teaching problems, misperceptions of online learning, absence of emotional connection between teachers and students, difficulties in communication and interaction, etc., a special emphasis is put on the health problems that accompany long-term use of computers for learning or teaching (problems with vision and eyes, musculoskeletal system, etc.) [5], and the psychological consequences and problems of mental health (anxiety, fatigue, burnout, etc.) [6].

Although a big number of research has been done quantitatively and qualitatively to investigate the effectiveness of online learning [3], not much research has been dedicated to identifying the challenges and difficulties that university teachers face in implementing this form of teaching. Starting from that, the paper explores the problems that accompany online teaching in higher education.

2. METHODOLOGY

The paper presents a part of the research results on the experiences in the implementation of online teaching in higher education during the COVID-19 pandemic. The research sample consisted of 102 teachers from the University of Belgrade, Novi Sad, Nis, Kragujevac and Pristina. The research is based on a descriptive method, survey and scaling techniques, and uses a questionnaire with an assessment scale as a research instrument which was especially prepared for the needs of the research. Teachers filled in the questionnaire online, via the link that was sent to their e-mail address. The questionnaire included various aspects of online teaching in higher education, and the paper presents the results related to the identification of challenges encountered by university teachers in the implementation of online teaching during the COVID-19 pandemic, as well as their personal perceptions of online teaching. Therefore, the task of the teachers was to: (1) identify what distracted them the most in the implementation of online teaching by choosing one or more answers (with the possibility to write their own answer); (2) answer to the open-ended question - *What was the biggest challenge/difficulty for you during online teaching?*; (3) express their views on the challenges of online teaching (general impressions and feelings) on a scale from 1 (strongly disagree) to 5 (strongly agree) in relation to the following items: i1- I am satisfied with online teaching and will continue to actively implement it in the future, i2- I believe that online teaching has a negative impact on the quality of education; i3 - I believe that online teaching has a negative impact on student achievement; i4 - I believe that online teaching deepens the “gap” between professors and students; i5 - Online teaching has been exhausting for me; i6 - Online teaching was extremely stressful for me; i7 - Online teaching was a challenge for me; i8 - I didn’t feel ready to “switch” to the online teaching system; i9 - I enjoyed online classes more than the classroom teaching; i10 - Classroom teaching is more student-centered than online teaching; i11 - My general impression is that online teaching is better than classroom teaching; i12 - Online teaching will replace traditional classroom teaching in the future.

The research sample structure with regard to the set independent variables (academic rank, length of service and previous training in the field of ICT) is presented in Table 1.

Table 1: Research sample structure

academic rank			**length of service**	up to 10 years	28 (27.5%)
	graduate student instructor	7 (6.9%)		11-20 years	31 (30.4%)
	teaching assistant/assistant with a doctorate	14 (13.7%)		21-30 years	27 (26.5%)
	assistant professor	30 (29.4%)		over 30 years	16 (15.7%)
	associate professor	13 (12.7%)	**ICT training**	only one training	17 (16.7%)
	full professor	34 (33.3%)		few trainings	16 (15.7%)
	other	4 (3.9%)		a training organized just before online teaching	25 (24.5%)
				no training at all	44 (43.1%)

The largest percentage of teachers are full professors (33.3%) and assistant professors (29.4%), while the lowest percentage of teachers belong to the categories *graduate student instructor* (6.9%) and *other* (3.9%) – demonstrator, dean and professor of vocational studies (two respondents). The smallest number of teachers have a work experience of over 30 years (15.7%), while they are almost evenly distributed in other categories. Over 40% of respondents have never had training in the field of ICT (43.1%), while almost a quarter of teachers (24.5%) have had such training just before the implementation of online teaching during the pandemic period.

3. RESULTS AND DISCUSSION

The challenges of online teaching identified by university teachers are presented through three categories: the most common distractions in the implementation of online teaching; the biggest challenges/difficulties in the implementation of online teaching; challenges of online teaching - general impressions and feelings of teachers.

3.1. Online teaching distractions

When it comes to identifying the most common distractions in the implementation of online teaching, the task of the teachers was to mark everything that interfered with online teaching (predefined categories). Fugure 1 shows which category was selected how many times (one teacher had the opportunity to choose a number of categories).

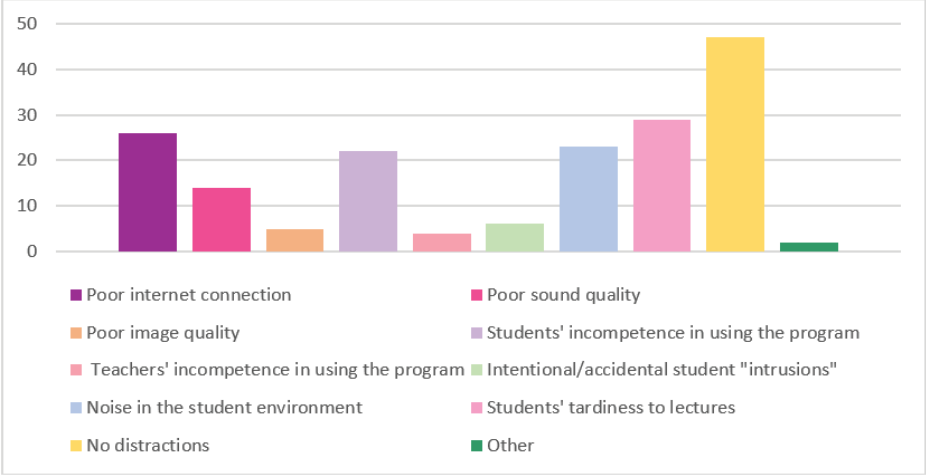

Figure 1: The most common distractions in the implementation of online teaching

Most teachers did not encounter any distractions in the implementation of online teaching (the category "there were no distractions" was selected 47 times). Other teachers had encounters with various distractions in the online environment. Online classes were most disrupted by students' tardiness to online lectures (selected 29 times); poor internet connection (selected 26 times); noise in the student environment (selected 23 times), students' incompetence in using the program (selected 22 times) and poor sound quality (selected 14 times), while teachers had less trouble with intentional/accidental student "intrusions" (selected 6 times), poor image quality (selected 5 times) and their personal incompetence in using the program (selected 4 times).

Teachers were also given the opportunity to write what else distracted them in online teaching. Two teachers supplemented the given categories with the following answers: "Inability of students to register when the presentation slides change"; "Disconnection, platform bugging". It can be concluded that both answers refer to obstacles in the functioning of the platform/program used for online teaching.

3.2. Online teaching challenges/difficulties

Figure 2 shows the biggest challenges/difficulties faced by teachers in the implementation of online teaching during the pandemic period. The task of the teachers was to answer an open-ended question: *What was the biggest challenge/difficulty for you during online teaching?* Their responses were analyzed and grouped into several categories.

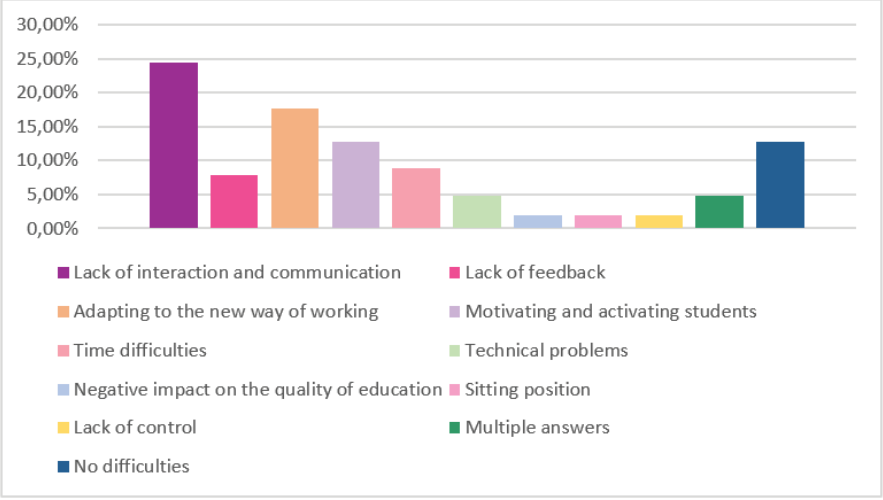

Figure 2: The biggest challenges/difficulties in the implementation of online teaching

The largest percentage of teachers (24.5%) singled out "lack of direct interaction and communication with students" as the biggest challenge/difficulty in online teaching. This is followed by "adapting to the new way of working (teaching materials, organization of classes, inability to demonstrate content)" (17.6%), as well as "motivating and activating students and maintaining their attention" (12.7%). The same percentage of teachers (12.7%) stated that there were no difficulties in their online work. Slightly lower percentage of teachers singled out "time difficulties (preparation, duration, lack of free time)" (8.8%), "inability to follow students' facial expressions and get feedback" (7.8%) and "technical problems" (internet connection, program issues, etc.)" (4.9%), while two teachers (2%) pointed out difficulties such as: negative impact on the quality of education and student achievement", "inability to move during lectures (sitting position)" and "lack of control".

Several teachers (4.9%) mentioned a number of challenges/difficulties. These are combinations of previously identified categories: technical problems, lack of interaction and communication with students, lack of feedback and students' passivity, as well as adapting to new ways of working.

Similar challenges/difficulties have been identified in another research. A study conducted in the Netherlands [7] highlighted the lack of interaction as the biggest negative aspect of online teaching in pandemic conditions, but also the fact that teachers faced challenges such as time pressure and increased workload. The research conducted in China [8] highlighted the following difficulties: inability of students to apply self-study skills, relative instability of the Internet connection and online platforms, teachers' unfamiliarity with relevant technology and techniques, difficulty controlling the progress of the course, as well as the limited interaction with students in class. Similar difficulties were recognized by students in a study conducted in Romania [9] - the greatest issues were technical problems, followed by teachers' lack of technical skills and the maladjustment of the teaching style to the online environment, as well as poor commmunication and interaction with teachers.

3.3. Challenges of online teaching – teachers' impressions and feelings

Table 2 shows teachers' general impressions and feelings about the challenges of online teaching and differences in teachers' attitudes based on their academic rank, length of service, and previous training in the field of information and communication technology (ICT).

Table 2. Differences in teachers' impressions and feelings about the challenges of online teaching

	Strongly disagree		Disagree		Neither agree, nor disagree		Agree		Strongly agree		X^2 test (p-value)		
	N	%	N	%	N	%	N	%	N	%	academic rank	length of service	ICT training
i1	11	10.8	21	20.6	43	42.2	14	13.7	13	12.7	0.121	0.055	0.043
i2	4	3.9	11	10.8	23	22.5	37	36.3	27	26.5	0.130	0.745	0.168
i3	5	4.9	10	9.8	28	37.5	33	32.4	26	25.5	0.026	0.481	0.010
i4	5	4.9	12	11.8	27	26.5	33	32.4	25	24.5	0.122	0.638	0.354
i5	12	11.8	16	15.7	32	31.4	28	27.5	14	13.7	0.489	0.536	0.296
i6	31	30.4	26	25.5	23	22.5	14	13.7	8	7.8	0.183	0.316	0.372
i7	6	5.9	10	9.8	29	28.4	27	26.5	30	29.4	0.336	0.188	0.329
i8	34	33.3	29	28.4	23	22.5	13	12.7	3	2.9	0.019	0.000	0.462
i9	31	30.4	27	26.5	32	31.4	9	8.8	3	2.9	0.162	0.744	0.018
i10	0	0.0	2	2.0	11	10.8	26	25.5	63	61.8	0.003	0.427	0.304
i11	49	48.0	24	23.5	21	20.6	8	7.8	0	0.0	0.874	0.448	0.116

i12	33	32.4	21	20.6	21	20.6	20	19.6	7	6.9	0.738	0.042	0.328

note: due to limited space, only p-values are given in the table

The largest percentage of teachers (42.2%) show insecurity when it comes to their personal satisfaction with online teaching and its future implementation. Almost a third of teachers (20.6% of teachers who disagree and 10.8% of teachers who strongly disagree) show dissatisfaction with online teaching and state that that they will not actively implement it in their future teaching. In the case of this item, there is a statistically significant difference in the attitudes of teachers depending on their length of service (p=0.055) and previous training in the field of ICT (p=0.043). This is quite understandable because teachers who have had previous training in the field of ICT are probably more open to new ways of working and opportunities of online teaching. Also, the difference may be conditioned by the fact that teachers who have a longer work experience tend to stay in their "comfort zone", i. e. strive for a traditional ex-cathedra lecture.

Considering the percentage of teachers who agree and strongly agree, it can be concluded that more than a half of teachers believe that online teaching has a negative impact on the quality of education (62.8%) and student achievement (57.9%), as well as that it deepens the "gap" between professors and students (56.9%). Also, more than a half of teachers say that online teaching was a challenge for them (55.9%).

There is a statistically significant difference in the attitudes of teachers regarding the item *I believe that online teaching has a negative impact on student achievement*, depending on their academic rank (p=0.026) and previous training in ICT (p=0.010).

Almost a third of teachers (31.4%) are not sure whether online teaching was exhausting for them, while 27.5% of teachers agree that online teaching was exhausting.

When added up, the percentages of teachers who disagree and strongly disagree show that more than a half of teachers experienced online teaching as extremely stressful (55.9%), they did not feel ready to "switch" to online teaching system (61.7 %), they did not enjoy online classes more than the classroom teaching (56.9%), nor do they think that online teaching will replace classroom teaching in the future (53%).

There is a statistically significant difference in teachers' attitudes in the case of the item *I did not feel ready to "switch" to the online teaching system* depending on their academic rank (p=0.019) and length of service (p=0.000). It is possible that this difference is due to the fact that teachers with shorter work experience and lower academic ranks (younger teachers) are more skilled in modern technology and more willing to work online, given that they were more likely exposed to teaching content on ICT during their studies, in relation to older teachers (associate and full professors with longer work experience). A statistically significant difference depending on the length of service was also found in the case of the item *Online teaching will replace traditional classroom teaching in the future* (p=0.042). This

difference may also be related to the attitudes of younger teachers who are more open to innovation, who have acquired their own education in the digital age and to whom the field of ICT is "closer", in relation to older teachers accustomed to the traditional teaching mehods.

A statistically significant difference depending on the previous training in the field of ICT was identified in the case of the item *I enjoyed online classes more than the classroom teaching* (p=0.018) which is quite logical – teachers who have never had training in the field of ICT probably faced a number of challenges and could not enjoy as usual.

The majority of teachers (who agree and strongly agree) believe that classroom teaching is more student-centered than online teaching (87.3%). However, in the case of this item, there is a statistically significant difference in the attitudes of teachers depending on their academic rank (p=0.003).

Also, the majority of teachers do not think that online teaching is better than traditional classroom teaching (71.5%). In the literature, there are similar findings that are usually associated with the financial and organizational flexibility that accompanies these forms of teaching and learning.

4. CONCLUSION

In the Covid-19 era, online courses and education have become extremely popular. During the previous two years, it became a vital tool to educate students. The courses and the curriculum have been transformed virtual, simplified and streamlined to make learning easier on people and to aid them in practicing social distancing [10].

However, despite the numerous advantages and safety conditions provided by the online teaching during the pandemic period, it is evident that such form of teaching is accompanied by many challenges and problems.

The results of the research showed that the most common distractions in the implementation of online teaching are students' tardiness to online lectures, poor internet connection, noise in the students' environment and students' incompetence in using the program. Teachers singled out that the lack of direct interaction and communication with students is the biggest challenge/difficulty of online teaching. In addition, the teachers expressed the attitude that online teaching deepens the "gap" between them and students. For teachers, online teaching was extremely stressful and challenging, and they felt unprepared to "switch" to an online environment. Therefore, they did not enjoy their work as usual and do not perceive online teaching as better, and as a future replacement for the traditional classroom teaching.

The challenges encountered must inspire teachers to be reflective, open, creative, and adaptive to dynamic changes. It reminds teachers to keep exploring technology for enhancing teaching and learning. Teachers need to identify applications and use

them based on the objectives [11]. To select and utilize suitable applications timely, teachers need practical preparation and learning on recognizing applications, organizing activities, maintaining students' engagement, and evaluating students' learning. Teachers are encouraged to have active participation in professional development opportunities to develop their competency on technology integration in teaching. Training should be given to make them well prepared to carry out online learning in emergency incidents [12].

The Covid-19 pandemic encouraged the digital transformation of higher education as a complex organizational, programmatic and pedagogical process in which online teaching should be perceived only as one of the features of the digital transformation of higher education institutions.

According to El-Azar and Nelson [13], higher education should take this chance to innovate and reconsider their education strategies. In post-pandemic conditions, higher education seeks to return to traditional forms of work. However, the sustainability of higher education requires new approaches in the context of the changes brought by Industry 4.0. which will maximize the technology-related efficiency gains and develop strategies to better interact with the latest digital trends.

ACKNOWLEDGEMENTS

This research was published with the support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, following the Agreement on Realization and Financing of Scientific Research of the Scientific Research Organization in 2022, Agreement Registration Number 451-03-68/2022-14 /200148.

REFERENCES

[1] Rashid, S.: Impact of Covid-19 Pandemic on higher education and research, *Indian Journal of Human Development*, 2020, pp. 1-4, https://doi.org/10.1177/0973703020946700

[2] Killian, J.: College students, professors adjust to COVID-19 life, *Available from* http://www.ncpolicywatch.com/2020/04/01/college-students-professors-adjust-to-covid-19-life *Accessed:* 2022-06-04.

[3] Gonzalez, D. & St.Louis, R.: Online learning, In *The TESOL Encyclopedia of English Language Teaching*, 2018, https://doi.org/10.1002/9781118784235.eelt0423

[4] Sun, S. Y. H.: Learner perspectives on fully online language learning, *Distance Education*, **Vol. 35** (2014) No., 1, pp. 18-42.

[5] Velavan, T. P. & Meyer, C. G.: The COVID-19 epidemic, *Tropical Medicine and International Health*, **Vol. 25** (2020) No. 3, pp. 278-280.

[6] Cao, W.; Fang, Z.; Hou, G.; Han, M.; Xu, X.; Dong, J. & Zheng, J.: The psychological impact of the COVID-19 epidemic on college students in China, *Psychiatry Research*, **Vol. 287** (2020), pp. 1-5.

[7] van der Spoel, I.; Noroozi O.; Schuurink, E. & van Ginkel, S.: Teachers' online teaching expectations and experiences during the Covid19 pandemic in the Netherlands, *European Journal of Teacher Education*, **Vol. 43** (2020) No. 4, pp. 623-638.

[8] Yang, X.: Teachers' perceptions of large-scale online teaching as an epidemic prevention and control strategy in China, *ECNU Review of Education*, **Vol. 3** (2020) No. 4, pp. 739-744.

[9] Coman, C.; Tîru, L. G.; Mesesan-Schmitz, L.; Stanciu, C. & Bularca, M. C.: Online teaching and learning in higher education during the coronavirus pandemic: students' perspective, *Sustainability*, **Vol. 12** (2020) No. 24, https://doi.org/10.3390/su122410367

[10] Kruger, K.: Using information technology to create communities of learners, In *Involving Commuter Students in Learning. New Directions for Higher Education*, Jossey-Bass, San Francisco, (2020), pp. 59-70.

[11] Green, P.: How to succeed with online learning, In *The Wiley Handbook of Learning Technology*, John Wiley & Sons, ISBN 9781118736432, West Sussex, UK, (2016), pp. 261-286.

[12] Moorhouse, B. L.: Adaptations to a face-to-face initial teacher education course 'forced' online due to the covid-19 pandemic, *Journal of Education for Teaching*, **Vol. 46** (2020), No. 4, pp. 609-611.

[13] El-Azar, D.; Nelson B.: How will higher education be different in 2030?, *Available from* https://www.britishcouncil.org/voices-magazine/future-higher-education *Accessed:* 2022-06-04.

CRISIS MANAGEMENT IN THE HOTEL INDUSTRY DURING THE COVID-19 PANDEMIC

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Abstract: *Crisis management, as an integral part of managing every business entity should be an ongoing process driven by a dynamic environment. Its importance is evident in particular in circumstances such as the COVID-19 pandemic. Instead of short-term interventions in time of crisis, ongoing crisis management ought to be established and crisis acknowledged as a driver for renewal of business entity itself. While sources of some crises could be stemming from the past decisions, other crisis can be caused by the risks stemming from an environment itself of business entity. An analysis of causes of certain conditions is of utmost importance, for it identifies areas (such as processes, phenomena, events), which effects must be minimized. Recognizing thus crisis management as an important aspect of successful business entities, the aim of the paper is to review the literature on the topic of crisis management in the hotel industry with special focus on the timeframe of the COVID-19 pandemics, and to provide a theoretical framework for further research on this topic.*

Keywords: *crisis management, hotel industry, COVID-19 pandemics*

1. INTRODUCTION

Crises of various manifestations and causes are present in everyday environment, some of which are caused by internal whereas others are caused by external circumstances of business entities. Given the occurrence, a crisis can be perceived both as a threat and opportunity for survival and further development of business entity. The current COVID-19 pandemic (hereinafter Covid crisis) has brought global shift in perception and reaction to crisis in general and in particular by inability to predict the duration of this particular crisis, thus adding to already complex enough business situation. Hospitality industry has been affected by the Covid crisis, developing a greater interest in business models that would be sustainable during crises. Therefore we deemed a literature review of crisis

management in the hotel industry to be of a particular importance, providing starting points for further research on the subject.

2. HOTEL INDUSTRY AND COVID-19 CRISIS

Business crisis can be identified as "an unplanned and unwanted process of limited duration and potential impact, detrimental to primary goals, with an ambivalent outcome", occurring when an unexpected problem threatens the stability of a business system or an organization [9]. These problems are caused by either or both external and internal influences [2]. Outcome performance and financial performance are two principal areas of crisis symptoms occurance, where financial performance is reflected through decreased turnover, decreased profitability, increased indebtedness, decreased cash flow, and decreased liquidity, whereas outcome performance is manifested in reduced sales, high turnover rates, supply chain problems, reduced production capacity and an increased business process inefficiency [7].

The Covid-19 pandemic has been one of the greatest contemporary crises, impacting business and society in general. A rapid spread of virus introduced many restrictive measures worldwide, known as *lock-down*, resulting in closing down a wide range of business entities. With Covid-19 pandemic crisis management became even more challenging, tackling with technological, market, political and organizational uncertainties. A key to addressing many challenges imposed by the Covid pandemic is a well established quality crisis management. The hotel industry was one of the first business activities affected by the Covid-19 pandemic [1]. General data indicate that in March 2020 as compared to 2019, occupancy decreased by 96% in Italy, 68% in China, 67% in the UK, 48% in Singapore, and 59% in the US [1]. In Europe the occupancy rate plummeted on average from 61.5% to 26.3% since WW II. The highest occupancy rates in March 2020 were recorded in Sydney with 48.5%, Los Angeles with 42.5% and New York with 34.5% [1].

Given the geographical and climate features of Croatia, the hotel industry has been recognized in Croatia as an industry with a potential for further development, because of which numerous investments took place during 2021 and 2022 [4]. In 2021 in Croatia there were 13.8 million arrivals and 84.1 million overnight stays, and compared to 2019 as a base year, in 2021 there were 67% arrivals and 77% overnight stays mostly in family-owned accommodation, campsites and hotels registering the highest turnover increase [8]. This leads to an issue of utmost importance of contemporary management, i.e. crisis management, recognizing crisis manifestations early on and promptly intervening in all phases of crisis management with intention of its prevention, and if not possible, than minimizing its negative effects.

3. CRISIS MANAGEMENT IN THE HOTEL INDUSTRY AND COVID-19 PANDEMIC

The Covid-19 pandemic negatively affected the hotel industry internationally, with up to 90% loss of reservations in accommodation just during the first month of lock-down [3]. Due to the specifics of the hotel industry, hotel business systems are particularly sensitive to crisis situations, making even a seemingly incident a potential threat to and cause of drop in demand, thus emphasizing even more the importance of crisis management implementation.

Table 1 presents researches regarding crisis management principles implementation in the hotel industry prior to the Covid-19 pandemics. The purpose is to gain an insight into the application of crisis management in the hotel business systems before the pandemics that has caused havoc both in businesses and society alike.

Table 1: Crisis management literature review in the hotel industry before Covid-19 pandemic

Author(s)	Subject and aim of the research	Sample	Method	Findings
Čevra (2016)	The ways of overcoming crisis situations and methods used for preventing the occurrence of the same crisis situations in the Split-Dalmatia County in the Republic of Croatia.	59 hotels	Questionnaire	Almost all hotels have a prepared framework for managing crisis situations and procedure actions.
Ivandić (2016)	Determining the need for crisis management implementation in the hotel entities. Author explored if the hotels used strategic crisis management correctly and successfully. The research was conducted in the Dubrovnik-Neretva County in the Republic of Croatia.	32 hotels	Questionnaire	To a great extent all surveyed the hotels did manage to cope with previous crisis situations. Majority of the hotels do not have crisis management plans nor devised crisis management, despite having already

Author(s)	Subject and aim of the research	Sample	Method	Findings
				encountering some type of crisis.
Škegro (2021)	How crisis situations and catastrophes can affect the hotel business systems and their reaction to the threats; example of the Olympia hotel (in Vodice) and Palace hotel (in Zagreb)	2 hotels	In-depth interview	Both hotels are ready and do use crisis management tools to mitigate the effects of the crisis.
Sawalha, Jraisat, Al-Qudah (2013)	To identify the main risks that could potentially lead Jordanian hotels to risks; exploring the adopted concepts of crisis management; to investigate the cultural differences affecting the adoption of crisis management principles.	16 hotels	Questionnaire	Jordanian hotels face a wide range of risks. Strategies are limited and are reducing the possibility of responding to threats and recovering effectively.
Niininen (2008)	To examine which crisis management principles do hotels implement and at what level.	12 hotels (3 in Hong Kong, 6 in London, 2 in Helsinki)	In-depth interview	All 12 hotels have an excellent level of crisis preparation and are a great example of a good practice

Source: authors

As presented in Table 1, all of the hotels have faced some form or shape of crisis. Some hotels do have a well established crisis management, whereas others (mostly small hotels) do not but did manage to cope with crises. Four out of five papers showed that hotels do have implemented crisis management principles; one research discovered that there are come hotels that do not have prepared strategies for crisis management. Some researches have shown that although effective plans, education and employee training do not have a great impact on overcoming crisis, it is necessary to identify and take needed actions as soon as possible in order to harvest positive effects of crisis.

Table 2 presents researches on crisis management in the hotel industry during the Covid-19 pandemics.

Table 2: Crisis management literature review in the hotel industry before Covid-19 pandemic

Author(s)	Subject and aim of the research	Sample	Method
Vučić (2021)	To analyze the application of crisis management in the hotel industry in order to reduce the impact of crisis.	20 hoteliers in Croatia (9 hotels, 4 appartments, 4 camps, 3 holiday homes)	In-depth interview
Petrović (2021)	To establish how has the Covid-19 pandemic affected the hotel industry, what actions has management taken in mitigating the impact of the Covid-19 pandemic.	3 hotels in the Split-Dalmatia County in Croatia	Structured interview; data comparison with previous years
Waller, Abbasian (2021)	To gain an understanding of whether and how senior managers in London and Stockholm	30 senior hotel managers in London and Stockholm	Qualitative questionnaire research; thematic analysis comparison of crisis management implementation pre- and during pandemic
Zhong, Sun, Law, Yang, Yang (2022)	Examining perceptions, reactions and further development from the perspective of hotel and tourism professionals with aim of investigating the impact of Covid-19 pandemic on the hotel and tourism industry in general in China.	58 experts in the tourism field (10 hotel managers, 10 hotel management experts, 22 tourism attraction experts, 16 tourism experts)	In-depth interview by phone and video calls and e-mail.
Cobarm Ozel (2022)	To investigate the management techniques that have been applied in the hotels in Eskişehir in Turkey.	13 hotel managers in in Eskişehir in Turkey	In-depth face-to-face and Zoom interview

Source: authors

The most prevalent factor influencing crisis management is regulation-based as determined by the state government. In determining steps in resolving the crisis, hotels first had to follow relevant and volatile government regulations regarding border closures, new hygiene routines and social distancing. Oher factor influencing the process of crisis management were plans for crisis management adopted by business entities. Many hotels did have an established crisis management plans, but had never dealt with pandemic situation. The hotels that possessed a pandemic plan had dealt with SARS and/or MERS.

As an inevitable consequence of lock-down causing a drop in demand for hotel accommodations, many hotels had to close down at least temporarily. One speculation was that those hotels closing at the beginning of the Covid-19 pandemic might remained closed longer than expected. Other speculation was that permanent closure may affect smaller hotels, whereas larger hotel chains would have higher cash flows in order to sustain the business. This permanent closure of smaller hotels would reduce competitiveness level overall even when the Covid-19 pandemic subsides. The effects of these closures would become particularly noticeable for smaller hotels might merge [6].

4. CONCLUSION

Nowadays it is not questionable whether the business system will face a crisis during its existence, but to what extent it is prepared to a timely respond to manage crisis. This is the reason of utmost importance for hotels in general, and in particular those hotels not having crisis management implemented, to establish it in a near future in order to prevent the crisis. Effective tools in this process are plans and protocols to be followed in a state of crisis as well as continual improvement of quality internal communication skills. Recovery of both tourism and hotel industry will largely depend on upcoming measures. In the recovery phase it is of utmost importance to regain the trust of the tourists, promote destinations, adjust tourism offers, evaluate the strategy effectiveness, etc.

REFERENCES

1. Choi, K.: Hotels After Coronavirus: What Happens After a Pandemic, *Available from*: https://plugandplaytechcenter.com/resources/hotels-after-coronavirus-what-happens-after-pandemic/ , *Accessed* 2022-06-10
2. Dubrovski, D., Handling Corporate Crises Based on the Correct Analysis of its Causes. *Journal of financial risk management*, 2016., 5, pp. 264 – 280, ISSN Print: 2167-9533

3. Gossling, S., Scott, D., Hall, CM.: Pandemics, tourism and global change: a rapid assessment COVID-19, *Journal of Sustainable Tourism*, 29:1, 1-20, 2020., pp. 110., DOI: 10.1080/09669582.2020.1758708,
4. Hotelske investicije 2021-2022, *Available from*: https://www.turizaminfo.hr/novosti/hotelske-investicije-2021-2022/, *Accessed* 2022-06-12
5. Hrvatski turizam, izdanje 2020., *Available from*: https://www.htz.hr/ *Accessed* 2022-06-12
6. Kenny, J., Dutt, CS.: The long-term impacts of hotel's strategic responses to COVID-19: The case of Dubai, *Tourism and Hospitality Research* 2022;22: pp 71-85, DOI: 10.1177/14673584211034525
7. Krummenacher, A.: *Krisenmanagement*, Industrielle Organisation, Zurich, 1981., pp 13
8. U 2021. godini Hrvatsku posjetilo gotovo 14 milijuna turista, *Available from*: https://www.htz.hr/hr-HR/press/objave-za-medije/u-2021-godini-hrvatsku-posjetilo-gotovo-14-milijuna-turista, *Accessed* 2022-06-10
9. Osmanagić Bedenik N.: *Kriza kao šansa*, Školska knjiga, Zagreb, 2003., pp 12

DEVELOPMENT OF TRAINING FOR EMPLOYEES TESTING HIGH PERFORMANCE PROTOTYPE ELECTRIC VEHICLES

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Abstract: *Through this case study and presentation, main aim is to present the approach that we used to arrange all minimum requirements, procedures and equipment for employees that are necessary to do validation and all other tests with electric vehicles on road or race/test track. Key solution was to implement numerous solutions because it is a field that is not covered by Croatian laws. It presents all steps of the process, from Rulebook to implementing levels for test drivers, implementing law regulation, medical exams, trainings with NAVAK, personal protective equipment, risk assessments, etc. In this way, we want to draw attention to new developing fields of work that is not covered by local laws, especially if you are working in an automotive industry that does not exist in Croatia. With this paper we will try to show other Health and safety experts that a high level of safety can be achieved nevertheless.*

Keywords: *test driver, levels, Navak training, electric vehicles, safety*

1. INTRODUCTION

Rimac develops, produces, evaluates and test prototype and pre-series vehicles. In the early and mid-phase of development these vehicles are equipped with systems that are not mature enough to be handed to non-experienced and non-trained drivers.

To ensure safety of employees, test engineers, proto and assembly technicians, as well as test drivers and passengers, driver training must be provided. Drivers are ranked regarding their skill, experience but also needs of their position.

1.1. Purpose of the document

This document defines:

- driver levels and training for each driver level
- constrains for each driver level

- health and safety rules for safe handling and conduct.

1.2. Source

The whole concept is based on previous experience in testing C_Two prototype vehicles and inputs from company Lead Test Driver; assessment and training for Bosch and Industriepool drivers; inputs from NAVAK trainers, from Occupational Safety and Environmental Protection at Rimac and inputs from other factory test drivers such as Ferrari, Porsche, Pininfarina & Pirelli.

The Permits ranking and grading system is developed to prevent accidents with heavy consequences (severe injury, death) and that the Company provides everything needed, so the employees are prepared and equipped for the job. Also, the Permits and ranking system is setup to prevent all unnecessary project delays and/or financial drawbacks that can seriously endanger any project. There is a necessity of a broad company awareness that all Test engineers, Proto and Vehicle assembly technicians and other company employees must be aware of the responsibility when in charge of the vehicle and to be trained to safely use the vehicles.

1.3. Grading system

Each driver is evaluated by minimum of two (2) instructors. If you see the picture below, you can see the explanation of the grading system.

GRADING SYSTEM

Each driver gets evaluated by minimum 2 instructors

Exercise	Score Instructor 1	Score Instructor 2	Average	Exercise difficulty factor	Total Score
Braking	5	6	5,5	1	5,5
Lane change	6	6	6	2,0	12
Lines	6	5	5,5	1,5	8,25
Car control	6	7	6,5	2,0	13
Attitude	7	8	7,5	2,0	15
GRADE					53,75

D	C	B	A	MINIMUM GRADE
3	4	7	9	
6	8	14	16	
6	7,5	10,5	13,5	
6	10	14	18	
12	14	14	14	
33	43,5	59,5	70,5	

Figure 1: Grading system explained

2. THE PROCESS OF TRAINING

Groups are up to 10 employees. Drivers should renew their Permits through entire training process every 4 years. Next, we will explain the training requirements through levels.

2.1. Level D

Coordination meeting:

- seating position, steering
- basic vehicle operation training (turning on/off, safety switches, issue reporting)
- basic vehicle limitations (ground clearance, body, and interior damage avoidance)
- rules of conduct introduction

Authorizations and responsibilities:

- handling of the vehicle in proto assembly or assembly area and in company premises
- load and unload the vehicle for transport
- handling of the vehicle in testing areas for servicing purposes
- vehicle speed limited to 5km/h indoors and up to 10 km/h outdoors

Coordinator:

- Internal coordinator - employee with an A level permit

2.2. Level C

Training program:

- seating position, steering & tight slalom
- braking with and without ABS (low and high speed)
- braking with and without ABS lane change (low and high speed)
- weight transfer, ESP lane change, ESP off lane change, double lane change (high and low speed)
- braking and cornering, understeer/oversteer control, lines, basics of track driving

Authorizations and responsibilities:

- Mule and Proto vehicles that have already been through initial shakedown
- Serial production vehicle functionality testing

- Low intensity vehicle testing,
- Soft handling track testing, soft handling road testing (bellow 0,8 g),
- Functionality testing, system engineering, EA&PWRT, NVH measurements, style and usability feedback, IVI testing, data collection, control engineering, trims and body testing, IVI functionality tests, sensor calibration, HVAC calibration, static cooling tests, regen tuning, regen-brake blending, EOL driving tests, soft handling track testing, soft handling road testing

Trainer:

- External trainer - on track with trained instructors

2.3. Level B

Training program:

- Includes C Level training
- basics of vehicle dynamics, basics of tire pressure influence
- basics of vehicle assessment for safety, compliance, and alignment
- vehicle control on low and high mu surfaces
- track driving, performance driving, hard handling

Authorizations and responsibilities:

- C level clearance plus, Mule and Proto shakedown testing and safety assessment
- Track & Road testing
- Objective measurement vehicle characterization
- Vehicle safety check, vehicle shakedown, performance tests, low mu testing, durability testing, brake calibration, objective vehicle measurements, special pavements testing, road testing, marketing events

Trainer:

- External trainer - on track with trained instructors. Hard handling training (training with Rimac prototype/pre-series or series production vehicle)

2.4. Level A

Training program:

- Includes B Level training
- subjective evaluation training
- tire testing and evaluation
- performance testing
- high speed limit handling

Authorizations and responsibilities:

- B level clearance
- Subjective vehicle assessment
- Performance testing
- Tire testing
- Vehicle assessment, tire testing, high speed testing, hard handling, EPS tuning, ESC tuning, damper testing, vehicle sign off

Trainer:

- External trainer - on track with trained instructors. Highest level of training (training with Rimac prototype/pre-series or series production vehicle)

Candidate needs to meet the minimum requirements for achieving the needed driving level. He will acquire the permit if his score level is adequate, candidate needs at least 42 points for B level or at least 38 points for C level. If a candidate that attended the A or B Level training, did not get a sufficient number of points, he/she is automatically transferred to a lower level, depending on the number of points he scored. This rule does not apply to C level, as there is no need to issue a permit for D level.

2.4. Driver's code of conduct

All drivers must obey following rules:

1. Vehicles must not be driven by unauthorized personnel.
2. Employee must care about his/her own safety and safety of others while using the vehicle. Usage of defined PPE is mandatory for drivers and passengers.
3. Employee must ensure that he/she is using the vehicle in a safe and controlled manner and that he/she is using necessary equipment to protect the interior and exterior of the vehicle.
4. Employee must inform others if he/she notices possibility of damage due to improper use of the vehicle.
5. In case of doubt or not defined task – employee must talk to his/her superior or higher-level Permit driver.
6. Vehicles are property of Rimac and/or Rimac customers and employee must treat it with respect, care, and mindfulness to avoid any kind of damage or misuse.
7. Employee using the vehicle is responsible for its state and dynamics.
8. Usage of mobile phones, eating, drinking or any kind of distraction to the driver while operating the vehicle or around the vehicle is forbidden.

9. Safety assessment of testing and safety preparation must be done before any kind of action with the vehicle. Neglecting safety risks is dangerous and person responsible for the test will be held responsible if the required measurements were not done.
10. Performance tests are to be done by performance drivers. It is forbidden to break any speed records or lap time records if not instructed to do so.

3. PROCESS OF ISSUING THE PERMIT

All drivers must obey following rules:

1. A department has a need to conduct test with the Vehicle
2. They send the request to Occupational Safety and Environmental Protection department (HSE) with a brief description what kind of testing this employee needs to do
3. HSE department agrees with Vehicle testing department there is a real need, and Vehicle testing department cannot spare one of their engineers for the future needs of the department in question
4. HSE & Vehicle testing dept. gives their OK and schedules the training
5. Employee goes through a full medical examination
6. Employee does the training
7. He/she passes the training evaluation
8. HSE department communicates this further to Vehicle testing department
9. HSE through coordination with the Vehicle testing dept. issues Internal driving Permits
10. Employee can start the activities with the vehicle

3.1. Training schedule

D level is conducted at the HQ in Ljubljanska 7, Sveta Nedelja by the Lead Test Driver. For A, C and B level by outsourced company. Exceptions for Fast Lane permits for B or C level can be done by a holder of A level permit with obligated training that has to happen maximum 3 months since the permit is issued. It can be done only after A level permit holder has spent at least one test session as a passenger with a person in question.

3.2. Budgeting process

1. Department that needs the driving permit appoints the person who will attend the training

2. HSE and Vehicle testing approves the need and proposes the training date
3. Department manager approves the budget
4. After budget approval, manager informs HSE department
5. HSE books the training, person gets the physical permit, and the process over

4. HEALTH AND SAFETY REQUIREMENTS

To create a safe environment, minimum requirements need to implement:

- **Valid driver's license for B category**
- **Official driver level refreshing**: every 4 years
- **Medical examination**: every 4 years for C, B & A Level driver is mandatory to pass the examination before the training sessions

4.1. Personal protective equipment (PPE)

A and B Level drivers are mandatory to use PPE:

- Balaclava helmet cap
- Helmet (Helmet bag)
- Neck restraining system
- Racing Shoes and Gloves
- Racing Suit

4.2. Anti-scratch policy (PPE)

For all Level drivers, mandatory is to use PPE for protection of vehicles:

- To avoid damage to the interior and/or exterior of the vehicle, jewelry, watches, zippers, hanging keys, chains or similar metal wear items that can damage the paint or fabric parts of the car's interior/exterior must not be worn
- Always use gloves or protective cover on the steering wheel
- Make sure to have clean clothes and clean hands when entering the vehicle
- Report any damages, scratches or tears to the vehicle handler Proto Assembly coordinator, Quality control manager, or other available superior at the site

C Level drivers can not to do tests of high safety risk, however protective gear can be provided on demand. Fire extinguisher **must** be installed in a secure way and

easy to reach by the driver/passenger in case of an accident. Proto assembly personnel mount fire extinguisher. Fire extinguisher must not be free installed and must have a designated restraint system to secure it falling out in case of hard cornering/braking or accident.

5. OBLIGATIONS AND RIGHTS

Employees and their representatives are obligated to cooperate with the employer and to act in accordance with the employer's instructions to prevent, eliminate or reduce stress at work or in connection with work. Employees and their representatives have the obligation to get acquainted with the Risk assessment the identified hazards and risks at the workplace where they perform work, as well as for the work they perform in the company.

5.1. Duties with due care

The employee is responsible to perform his duties with due care and to take care of his safety, as well as other employees, who may be endangered by his actions or omissions at work. **An employee is working with due care** when performing work in accordance with the knowledge and skills acquired during training to work in a safe manner and when working under the instructions given by his authorized representative, or his immediate supervisor, so that:

- before starting to work, inspect the place of work and report any shortcomings to the authorized representative or immediate supervisor
- use the means of work correctly
- correctly use the prescribed Personal protective equipment (PPE), which he is obliged to return to the designated place after use if necessary
- correctly use, does not personally switch off, make modifications, or remove protection on the means of work
- immediately informs authorized representative, immediate supervisor, or occupational safety expert of any situation he considers to be a significant and imminent risk to health and safety, the absence or absence of instructions for such a situation, and any observed shortcoming in the organization and implementation of occupational safety
- performs work in accordance with the rules of safety at work, the rules of the profession and the written instructions of the company
- before leaving the place of work, leave the means of work he used in such a state that they do not endanger other employees or means of work

- cooperates with authorized representative, occupational safety expert, occupational medicine specialist and they are performed according to the deadline indicated on the certificate issued by occupational medicine commissioner for occupational safety.

5.2. Employees rights in health and safety

An employee has the right to refuse to work and leave the workplace if he or she is directly at risk for life and/or health, until the company takes corrective measures and must not suffer harmful consequences because of such actions. An employee has the right to refuse to remain at the workplace while there is a direct and serious risk to the life and health of the employee. While not working, because of exposure to direct and serious risk for life and health, the employee is entitled to pay and other employment rights in accordance with the Labor Law.

5.3. Alchohol

In accordance with the decision of the company it is considered that the employee is under the influence of alcohol if there is more than 0.0 g/kg of alcohol in the blood, or more than 0.0 milligrams per liter in exhaled air. If the employee refuses the check ordered by the company or another by the company authorized person, he will be considered to be under the influence of alcohol. The company shall remove an employee from the workplace if under the influence of alcohol. If employee refuses to leave the place of work, the employee will be removed by the service of the police.

5. CONCLUSION

All have been done to improve the safety of our employees. Where there were no law-abiding directions, we have lean to best practices. We spoke to all companies that had similar issues in the past and we made our conclusion but also do a step up to not making the same mistakes the did. After the first process was defined, we try, asses and then analyze and upgrade the model of training. From that we came to this full bullet proof training rulebook that provide us with a tool to provide our employees with all that they need to conduct their work in a safe manner.

REFERENCES

[1] Health and safety act NN 71/14, 118/14, 154/14, 94/18, 96/18, *Available from* https://www.zakon.hr/z/167/Zakon-o-za%C5%A1titi-na-radu *Accessed:* 2022-06-07.

[2] Internal Health and safety Rulebook, *Accessed:* 2022-06-07.

[3] Internal Driving permits rulebook, *Accessed:* 2022-06-05.

[4] Ordinance on conducting alcohol testing and determining the presence of other addictive substances in the workplace, *Accessed:* 2022-06-05.

[5] Risk Assessment, *Accessed:* 2022-06-06.

RELIABILITY OF INSULATION DEVICES

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Abstract: *Insulation devices used when performing works or interventions in dangerous and harmful zones have a very important role in protecting their users. The reliability of individual modules in these devices has a special impact. This is especially true of the protective mask and the lung automaton. If they do not function according to the prescribed rule, the life and health of the user are endangered. This is especially true for the health of users. However, since the causes of damage to health are invisible during the intervention and use of these devices, users pay very little attention to the causes that affect the reliability of these modules of insulation devices. The main reason is ignorance and the implementation of prescribed procedures to make these devices reliable in their application.*

Keywords: *reliability, danger, harmfulness, insulating mask, lung automaton*

1. INTRODUCTION

The reliability of insulation devices is the probability that with proper use and maintenance they will perform their function within the prescribed period [1]. It also depends on the frequency of use over time. If the devices are not maintained according to the prescribed procedures, their reliability is reduced. In accident situations, insulation devices must be used according to the manufacturer's recommendations, but this depends not only on the device but also on the user. In possible unfortunate situations, dangers can be predicted, but all damages are difficult to identify because in most cases they are "invisible" and cannot be felt. The consequences of their action can be assumed after a long period, and in most cases, their impact has not been discovered. The subject of this paper is insulation devices used by firefighters. Firefighters should use them in almost all cases of fire, regardless of whether the intervention is in the open or indoors. During combustion,

there is a concentration of various dangerous and harmful gases and suspended particles. Possession of various detectors for the detection of dangerous gas levels does not reduce the impact of harm on the health of firefighters whose impact manifests itself after a long time. Many hazards during a fire are unknown, there are no simple methods and devices that can identify them all, known hazards are assumed based on the substances burning in accident situations. The main subassemblies of fire insulation devices are air accumulators with high-pressure control valves, pulmonary automaton, and insulation masks. Due to their impact on the reliability and safety of the use of insulation devices, all countries prescribe mandatory control in the envisaged annual or semi-annual period. However, the users and owners of these insulation devices themselves have a far greater impact on their reliability in application. Regular and timely maintenance significantly affects the reliability of insulation devices. Their basic functionality should be checked before each use. However, in the moments of the accident situation, the user's attention is focused on access to the intervention in the accident situation, so this check is omitted in most cases.

2. INSULATION APPARATUS FOR FIREFIGHTERS

There are a number of manufacturers of fire insulation devices in the world. The reliability of these devices affects the safety of users and potential future users purchase from already known and renowned manufacturers, two renowned manufacturers are known in our area. However, their reliability depends not only on the name of their manufacturer but also on the real procedure and the quality of their maintenance. Manufacturers provide procedures on what and when to check, change, and regularly carry out reflection procedures during the use of their product. It is up to the user whether to abide by it or not. Deadlines for the replacement of individual essential elements of subassemblies and assemblies have been defined. However, very few users adhere to these recommendations, which is one of the major shortcomings in the emphasis when using insulating fire extinguishers. Furthermore, there is no written documentation of problems that occur during the use of this equipment. Most of them try to meet only the legal regulations for these devices at the level of the required paper documentation confirming that the insulation devices are functional and correct. A realistic quality check with quality test equipment would lead to devastating results because there are numerous deviations from the prescribed functionality characteristics that affect the health and safety of their users.

In the accumulator (bottle for medical air) are accumulated the medical air. Medical air must not contain harmful pathogenic microorganisms. Therefore, the system for the preparation and accumulation of air must be of high quality in the sense that it does not introduce harmful pathogenic elements into the accumulator. The usefulness of that air is directly endangered because it uses that air without purification and enters it directly into its lungs. If the compressed air stays longer in the accumulator (bottle), there is a probability of the development of pathogenic

elements, and almost no one checks the quality of that air. The impurities that can be found in compressed air can be found in paper [5]. Therefore, medical air accumulators should be disinfected at certain times. In addition, if the battery is mechanically damaged, it can pose a danger to the user and his environment, as it compresses the air at a pressure of 20 MPa to 30 MPa. The material from which the bottle is most often made is steel and composites. Due to the high pressure in the bottle, the material of its walls is exposed to high voltages that can cause an accident when using the bottle in case of damage. Legal regulations define the so-called cold testing of the tightness of these bottles is usually a period of 5 years with a pressure of 50% greater than the nominal pressure. The question is what impact this test has on the integrity of the bottle material. Control of dilatation intensity on the bottle wall can be identified using strain gauge tapes in the appropriate measuring chain. Display of installed strain gauge strips on bottles made of steel and composite material [2], Figure 2. Theoretically, stresses in the walls in the axial and tangential directions on the cylindrical part of the bottle have the same values in that direction, there are differences. Based on the measured dilatations and material characteristics, the voltage states on the outer surface of the bottle are defined.

Figure 2. Detection of dilatations on a medical air accumulator

The pulmonary automaton is the next important subassembly for the reliable operation of the isolation apparatus. Its task is to reduce the inlet pressure, which ranges from 0.6 to 1 MPa to the outlet pressure, which is slightly higher than atmospheric pressure and to open and close the supply of this air in the function of proper breathing. One of the very important elements of the pulmonary automaton is the diaphragm, which must be cleaned and disinfected after each use and checked according to the procedure prescribed by the manufacturer, and if not used, it must be disinfected once a year. Its replacement is mandatory after three to four years from the date of manufacture. Therefore, the year of manufacture is printed in color on the supporting part of the diaphragm, Figure 3. However, its failure can be at any time, regardless of its permitted durability. If the diaphragm is not correct, the insulating device will not function and put the user of the insulating device in a dangerous state. Its damage can be determined only on devices recommended by the manufacturer of the lung machine. It is made of special rubber that loses its elastic properties over time. Another important subassembly of insulation devices is the protective mask. Its main function is to prevent the inhalation of polluted air from

the environment, when used in accident situations, and to enable the safe operation of the user of the insulation device. Two components are very important for its proper functioning, the speech membrane and the membrane for releasing exhaled air into the environment. These membranes are made of a special type of rubber and need to be maintained and replaced according to the manufacturer's recommendations. Floating particles are deposited on them, which during the user's intervention cause the inhalation of harmful and dangerous gases from the environment.

Figure 3. Indication of the year of manufacture of the diaphragm of the pulmonary automaton, manufacturer MSA

In this case, the user inhales the air from the environment that was polluted during the accident with various harmful substances, and can also inhale the concentration of hazardous substances. In the research, one human hair with a diameter of 60 μm was intentionally placed, but the mask could not perform its function. [3]

3.0 TESTING AND CONTROL OF FUNCTIONING

3.1 Testing and control of insulating masks

The main task of the insulating mask is not to allow the inhalation of air from the environment and to allow the exit of air that is exhaled into the environment. Therefore, an impermeability test is performed, which lasts 1 minute at the pressure prevailing in its interior in the range from -1100 MPa to -900 MPa. Presentation of the correct functioning of the seal, Figure 4, and the characteristic numerical values, Table 1,[4].

Figure 4. Sealing of a quality insulation mask

Table 1. Values of tested sizes for the mask

Type of check	min. value	max. value	value 1	value 2	unit	deviation
Facemask tightness test	-11	-9	-10.06	-9.45	mbar	0.61
Open. pressure ex. val.	4.2	6	5.2	5.2	mbar	not

In the event that floating particles are deposited on the exhaled membrane, the bearing surface is damaged, the speech membrane is damaged, the tightness diagram has the shape as in Figure 5, and the numerical values in Table 2.

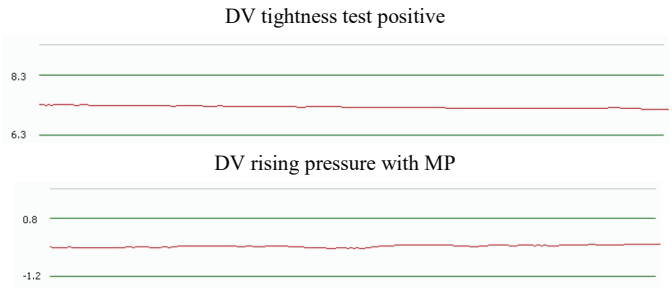
Figure 5. The insulating mask does not provide tightness

Table 2. Values of tested sizes for the mask

Type of check	min. value	max. value	value 1	value 2	unit	deviation
Facemask tightness test	-11	-9	-9.61	-8.58	mbar	1.03
Open. pressure ex. val.	4.2	6	4.31	4.31	mbar	not

3.2 Examination and control of the pulmonary automaton

The pulmonary automaton is tested for four essential characteristics. In the case of damaged membranes or internal mechanisms in the pulmonary automaton, the test values are outside the defined permissible limits and the service of that pulmonary automaton is required. This lung machine is not reliable for further use and may endanger the user. Diagrams of testing of quality and reliable lung automaton, Figure 6. Table 3 gives numerical limit values of the tested characteristics, [4].



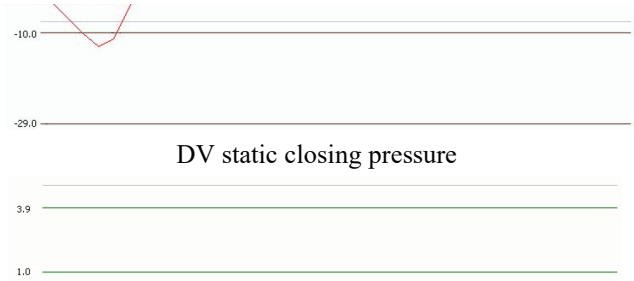


Figure 6. Diagrams of testing the proper functioning of the pulmonary automaton

Table 3. Measured values for a quality lung automaton

Type of check	min. value	max. value	value 1	value 2	unit	deviation
DV tightness test positive, 60 s	6.5	8.5	7.25	7.13	mbar	-0.12
DV rising pressure with MP, 60 s	5	9			bar	
DV rising pressure with MP	-1	1	-0.16	-0.07	mbar	0.09
DV activation pressure,10 s	-29	-10	-12.94		mbar	
DV static closing pressure, 0 s	1	3.9	3.38		mbar	

4.0 CONCLUSION

The reliability of the device's subassemblies and elements is very important for the reliability of its operation, and this is especially true for vital subassemblies. Because their failure can inevitably put the user of the device in a dangerous situation. However, if vital devices do not function as intended, the user of the device is exposed to harmful elements during the intervention. Unfortunately, harmful effects are rarely or almost never monitored in real conditions because it is a long-term job. Some harmful effects are detected after several decades, and only then are legal procedures prescribed for what to do in specific accident situations. There are no analyzes in the available research on the consequences of harm to users not only of these devices but also of others used in accident situations (due to their accuracy and proper functioning). The manufacturer improves the reliability of insulation devices after learning about the shortcomings of his device from use in a number of accident situations. Based on this knowledge, he makes improvements to his product and gives recommendations on the maintenance procedure and application of their devices. However, if the user does not implement these recommendations and procedures, there are consequences that cannot be eliminated. During the research, it comes to the fact that the use of isolating devices only

psychologically protects the direct users in accident situations, and the consequences will occur after many years of use. Fire brigades regularly use these devices during interventions, while for other users the cycles of use are almost insignificant.

The maintenance of these devices is at a low level, mostly due to the ignorance of the consequences that direct users of these insulation devices can have. There are no studies available that have investigated the consequences for long-term users of this type of protective equipment. Different profiles of experts should be involved in this research.

REFERENCES

[1] Mijović, B.; *Održavanje strojeva i uređaja*, Veleučilište u Karlovcu, ISBN 978-953-7343-74-3, Karlovac, (2019)

[2] Majstorović, A., Todić, M., Latinović, T., Babić. V; Surname, N.: *Examination of dilatation with cold water testing in steel and composite SCBA bottles*, University of Banja Luka, Faculty of Mechanical Engineering and Polytechnic University of Timisoara Faculty of Engineering Hunedoara, ISBN 978-99938-39-99-6, ICAS 2022 Banja Luka, Book of abstracts, (2022)

[3] Todić, M., Latinović, T. , Vranješ, B. A. Majstorović, *A.: Security applications of insulation mask,* 13th International Conference on Accomplishments in Mechanical and Industrial Engineering, Banja Luka, pp. 841-846, (May 2017),

[4] Todić, M.: *Ispitivanje i kalibracija Izolacionih aparata Vaterogasne jedinice Banjaluka,* Banjaluka, (2019).

SUSTAINABLE TOURISM SATELLITE ACCOUNT AS A TOURISM MANAGEMENT TOOL

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Abstract

Tourism is more vulnerable to environmental degradation than other economic activities. On the one hand, the environment is its primary resource and it needs quality and preserved space for its development. On the other hand, if the appropriate technical communal infrastructure is not implemented, tourism can be a major polluter of the environment. In addition to the environment, tourism has a significant impact on the socio-cultural authenticity of the destination and economic activities. Current strategic documents of the World Tourism Organization and the European Union envisage the management of tourism development and the direction of tourism policies in the direction of sustainability, which is manifested in three pillars: environmental, social and economic. Within the Recovery and Resilience Plan of Croatia in measure C1.6. The key phase is the development of the Satellite Account of Sustainable Tourism of the Republic of Croatia, which should create conditions for the management and monitoring of tourism development using defined indicators of tourism sustainability at the national and regional level. The paper explains the difference between the existing Satellite Tourism Account showing the contribution of tourism to Croatian GDP (including indirect effects) and the future Sustainable Tourism Satellite Account which will monitor other aspects in addition to the economic aspect, and thus indicators of sustainability such as well-being and prosperity. local communities, social justice, cultural wealth, biodiversity conservation, resource efficiency, cleanliness..

Key words*: sustainability, satellite account, tourism*

1. INTRODUCTION

The subject of the work is the establishment of the Satellite Account of Sustainable Tourism of the Republic of Croatia as a scientific tool for monitoring the development of tourism and its impact on economic, ecological and social sustainability, and, finally, the use of these results for the creation of public policies and decisions on private investments. The aim is to inform about the planned project and to link its implementation with the strategic documents of tourism development at the national and European Union level.

The data was collected by desk research of published strategic documents and project documentation, using methods of analysis, synthesis, compilation and description.

The final work is structured in seven chapters. The first chapter contains the introduction, the subject, the aim of the work. The second chapter describes and analyzes the state of tourism in Croatia today. The third chapter covers the definition of sustainable tourism and its features. In the fourth chapter, the concept of a satellite account is explained, and in the fifth, it is analyzed which content should be included in a satellite account of sustainable tourism in order to fulfill the expected functions. In the sixth chapter, the project of establishing a satellite account of sustainable tourism for Croatia is presented. The final paper ends with the seventh chapter with concluding remarks.

2. TOURISM IN CROATIA TODAY

Tourism in the Republic of Croatia represents one of the most important economic branches, whose impact on BPD is extremely high. Tourism represents 11.4% of the direct share in the GDP of the Republic of Croatia, but it is also linked to numerous other economic activities, therefore the total (direct and indirect) share of tourism is estimated at 19.5% of GDP (2019), which is the largest share compared to other member states of the EU. The share of employees directly employed in tourism is 8.2% (2019) [1]

At the same time, tourism is not only a fast-growing branch of the economy, but also a branch of the economy that represents a great burden on the resource base. The danger of excessive tourism (so-called “overtourism”) and the need for a new orientation of tourism development in the direction of sustainability have been the subject of academic debates for past several decades at the national and global level.

For example, Ph.D. Branko Blažević, professor emeritus criticized the appearance of excessive tourism in Adriatic region at the 28th traditional consultation Economic policy of Croatia in 2021 - Croatia after the pandemic [8]. He finds causes for this excessive tourism in: the economic theory that, due to the understanding of the economic process that takes place between production and consumption, ignores the consumption and valuation of the resource base, and especially space as a resource with which tourism is defined. He points out the signs of overtourism in Croatia detected by a comparative research of the indicators of Croatian and Slovenian tourism in relation to Austrian tourism and the challenge that arises at the micro level of tourist destinations in Adriatic Croatia, where, based on the analysis of five economic indicators of sustainability, the results show that Adriatic tourist destinations that achieve the highest economic indicators are threatened by greatest risk of overtourism. It indicates that the challenge is created by the wrong perception of success in tourism, which is defined through the constant growth of an increasing number of tourists. [2]

Scenario analysis that precedes the creation of the Sustainable Tourism Strategy of the Republic of Croatia until 2030 by the Ministry of Tourism and Sports [1], concludes that, in the event of an increase in the intensity of tourist traffic (Negative scenario (increase in intensity)), if the future state tourism policies are insufficient or inadequate involvement, the result would be:

- Increasing pressure on tourist infrastructure and destination resources, with increasing amounts of municipal waste and increased greenhouse gas emissions from the tourism sector as a result of the intensification of traffic and tourist offer that is not in line with the green transition.

- An increase in various types of load on natural resources and ecosystems and on infrastructure, which reduces the capacity of tourism for adequate adaptation to climate change, which ultimately results in negative impacts of climate change on the attractiveness of the destination.

- Insufficient investments in the green and digital transition, without implementing the reform, along with investments in quick earnings.

- Rising costs of living and real estate prices, as well as pressures on local infrastructure and the destruction of the authenticity of the local community, negatively affect the population in burdened destinations.

Therefore, in the proposal of the implementation decision of the Council on the approval of the evaluation of the plan for the recovery and resilience of Croatia, in measure C1.6. Creation of the Sustainable Tourism Satellite Account of the Republic of Croatia is defined as a milestone for 3Q 2023. Thus, the Republic of Croatia will reach the aim of creating the conditions for managing and monitoring the development of tourism using defined indicators of tourism sustainability at the national and regional level.

The satellite account should become a tool for public policy management. It is very important that the collection and compilation of data is harmonized with the European Tourism Indicator System (ETIS) and the concepts, definitions, classifications and accounting rules of the System of Environmental Economic Accounting (SEEA).

At the same time, the establishment of a regional satellite account of sustainable tourism is foreseen. For regional satellite account od sustainable tourism it will be possible to add special indicators of tourist activity at the destination level adapted to indicate the possible occurrence of excessive tourism. Data and analysis will serve as a basis for public and private strategic planning and a relevant tool for policy management.[3]

3. SUSTAINABE TOURISM

Sustainable tourism is defined as "Tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities" (definition by United Nations World Tourism Organization (UNWTO)) [11] .

Sustainable tourism development guidelines and management practices are applicable to all forms of tourism in all types of destinations, including mass tourism and the various niche tourism segments. Sustainability principles refer to the environmental, economic, and socio-cultural aspects of tourism development, and a suitable balance must be established between these three dimensions to guarantee its long-term sustainability.

Thus, sustainable tourism should:

- Make optimal use of environmental resources that constitute a key element in tourism development, maintaining essential ecological processes and helping to conserve natural heritage and biodiversity.

- Respect the socio-cultural authenticity of host communities, conserve their built and living cultural heritage and traditional values, and contribute to inter-cultural understanding and tolerance.

- Ensure viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed, including stable employment and income-earning opportunities and social services to host communities, and contributing to poverty alleviation.

- Sustainable tourism development requires the informed participation of all relevant stakeholders, as well as strong political leadership to ensure wide participation and consensus building. Achieving sustainable tourism is a continuous process and it requires constant monitoring of impacts, introducing the necessary preventive and/or corrective measures whenever necessary.

Sustainable tourism should also maintain a high level of tourist satisfaction and ensure a meaningful experience to the tourists, raising their awareness about sustainability issues and promoting sustainable tourism practices amongst them.[11]

The question arises whether “sustainable” should merely be based on the perception of local community or is it an ecological and social issue of highest state interest?

The local population to the greatest extent perceives the negative effects of tourism (research result, rating: 3.59 out of 5) related to the overloading of the tourist destination, the increase in the cost of living, the rise in real estate prices, traffic problems and the endangerment of space due to uncontrolled construction. [1] However, the perception of negative effects is directly related to the involvement of

the local population in the provision of services and work in the tourism sector, so in areas that are more dependent on income from tourism, this perception is milder. There remains the question of demarcating the decision-making of the local community and the state level on the intensity of tourist activity, the receiving capacity of the destination and the prerequisites in terms of infrastructure and requirements in terms of environmental protection and the controlled negative impact on the climate.

4. SATELLITE ACCOUNTS

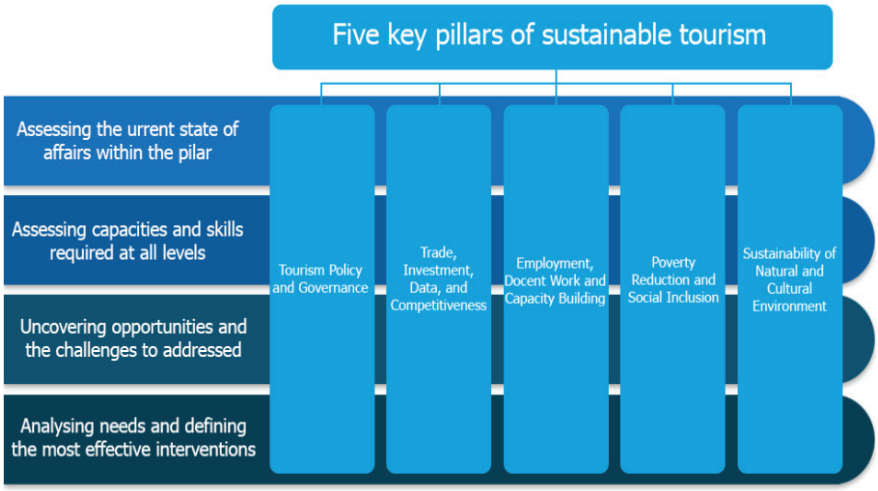
The purpose of satellite accounts is to provide a framework linked to the central (national or regional) accounts, allowing attention to be focused on a certain field or aspect of economic and social life in the context of national accounts. Satellite accounts are one way in which the System of National Accounts may be adapted to meet differing circumstances and needs. Common examples are special purposes such as monitoring the community's health, state of the environment, unpaid household work, or, important for this paper – tourism.

They are closely linked to the main system but are not bound to employ exactly the same concepts or restrict themselves to data expressed in monetary terms. Satellite accounts can meet specific data needs by providing more detail, by rearranging concepts from the central framework or by providing supplementary information. So, they may also be used to explore new methodologies and to work out new accounting procedures that, when fully developed and accepted, might become absorbed into the main system over time. They can range from simple tables to an extended set of accounts in special areas like for e.g. tourism. [5]

5. SATELLITE ACCOUNTS FOR TOURISM SUSTAINABLE DEVELOPMENT

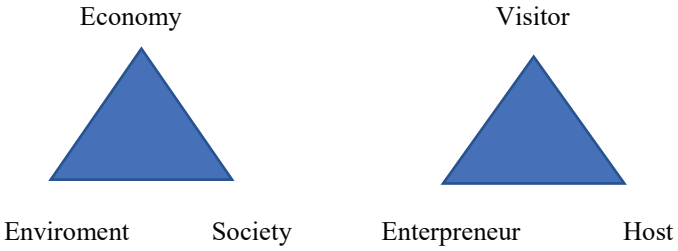
To develop appropriate data and methodology it is important to define goals of sustainable tourism development. United Nations formed an agency responsible for the promotion of responsible, sustainable and universally accessible tourism - United Nations World Tourism Organization (UNWTO). By its definition sustainable tourism is tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and the host communities.

United Nations World Tourism Organization (UNWTO) defines sustainable tourism as series of measures in different areas of activities, shown as five pillars [4]:



Picture 1: source, UNWTO

It can be simplified shown as balance:



Picture 2: source, own

6. CREATING SUSTAINABLE TOURISM SATELLITE ACCOUNT FOR CROATIA

According to news from April 28, 2022, the Ministry of Tourism and Sports launched the creation of the first Sustainable Tourism Satellite Account for Croatia (SAT_ROT RH) within the framework of the reform of the National Plan for Recovery and Resilience under the measure "Development of sustainable, innovative and resilient tourism". [7]

According to the National Plan for Recovery and Resilience, the project was started in cooperation with the Institute for Tourism of the Republic of Croatia, which is

already involved in monitoring the sustainable development of tourism on various projects, among which the CROSTO project should be highlighted. In CROSTO project development, measurement and monitoring of tourism sustainability indicators started in 2018 under the leadership of Ph.D. Izidora Marković Vukadin at the regional and at the local level. As part of that project, tourism sustainability was measured for the NUTS2 region of Adriatic Croatia for 2017 with the aim of encouraging local self-government units and tourist communities to apply ETIS indicators, i.e. monitoring the sustainable development of tourism at the local/destination level. A set of 15 basic indicators was established on which the monitoring of the sustainability of tourism development is based within the CROSTO observatory. [9]

According to the general guidelines of the National Plan for Recovery and Resilience [9] for the collection, processing and analysis of data for the management of public policies and investments, which plans to include relevant scientific institutions in the relevant areas, the Tourism Institute is included in the field of tourism, which is the only public scientific institute in In Croatia, specialized in research and advisory services in tourism, implementation of development, applied and other scientific and professional research. The Institute for Tourism gathers a multidisciplinary team of experts who have the knowledge to develop and implement the project of creating a satellite account of sustainable tourism.

The Institute of Tourism, as one of the authorities and key bearers of tourism statistics in the Republic of Croatia, previously participated in the creation of the Satellite Account of Croatian Tourism 2019 [10] and the Index of Tourism Development, which is already used as a measure of investments in touristic underdeveloped areas and the continent from funds from the Fund for tourism undeveloped areas I continent [6]

The Institute for Tourism developed, in addition to the already mentioned project, Croatian Observatory of Sustainable Tourism Development (CROSTO) as one of twenty such observatories in the world that act as members of the international network INSTO (International Network of Sustainable Tourism Observatories), which was founded by World Tourism Organization (UNWTO).

Croatia, as well as most European countries. Already has have a well-established system of statistics to track tourism and its economic impact. Moreover, the World Tourism Organisation (UNWTO), the United Nations Statistics Division (UNSD), the Organisation for Economic Cooperation and Development (OECD) and the Statistical Office of the European Union (Eurostat) developed a harmonised system of tourism satellite accounts (TSA). It uses the same concepts, definitions and classifications as national accounts and is the internationally recognized framework for measuring tourist activity and the importance of tourism to national or regional economies. [12] [13]

But, this TSA data need to be expanded with other data that can show significant indicators and help implement sustainable tourist politics to achieve responsible, sustainable and universally accessible tourism on national and regional level. First step will most certainly be linking TSA and SEEA (environmental accounts) in the context of measuring sustainable tourism (MST). Integration of the TSA and System of Enviromental Economic Accounting (SEEA) Sustainability accounts and measurements – water flowsm energy flows, GHG emissions, solid waste is important, but it will be just a part of the process of establishing fully functional Sustainable Tourism Satellite Account for Croatia (SAT_ROT RH) as well as regional sustainable tourism satellite accounts.

All impacts of touristic activities must be taken in consideration: social and economic benefits to the local community, relation towards cultural heritage, protecting and conserving the environment and ecosystem, getting community and tourists to both participate and lead.

In that process it is important for this tool to be grounded on relevant indicators, to give all important information for creating public policies as well as to direct private investments. This Sustainable Tourism Satellite Account has to also be in alliance with EU Tourism Dashboard and the EU Tourism Transition Pathway and sufficiently harmonized for the data to be fully comparably across countries.

7. CONCLUSION

Croatia needs to strengthen the evidence base on tourism and support reforms to develop the frameworks, tools and capacity to better spread and manage the impact of tourism, and steer the transformation of the tourism development model. The Ministry of Tourism and Sport in collaboration with The Institute for Tourism began the project of building Sustainable Tourism Satellite Account for Croatia (SAT_ROT RH) through which Croatia will develop indicators to measure and monitor the sustainability of tourism at national and regional level, and to establish a data collection system to enable dana-driven decisions.

Within the Recovery and Resilience Plan of Croatia in measure C1.6. Coratia's Recovery and Resilience Plan Ministry of Tourism and Sport and the Institute for Tourism will proceed with the development and implementation of Sustainable Tourism Satellite Account for Croatia (SAT_ROT RH).

The Ministry of Tourism, the Institute of Tourism and other stakeholders will actively utilize the outputs of this project to use the most of the benefits of such scientific statistic tool to create public policy and to direct private investments towards sustainability, economical, environmental and social.

REFERENCES

[1] Analiza scenarija,Ministarstvo turizma i sporta Republike Hrvatske, službene stranice, *available from* https://mint.gov.hr/root/razvoj-odrzivog-inovativnog-i-otpornog-turizma/glavni-izbornik-22719/vijesti-22724/analiza-scenarija/22874 *accessed* 6.7.2022.

[2] Blažević, Branko: Overturizmom protiv turizma i društva, *available from* http://www.hde.hr/ekonomskapolitikahrvatske/publikacija/eph2001/011_Blazevic.pdf str. 321-344, *accessed* 6.7.2022

[3] Council implementing decision on the approval of the assessment of the recovery and resilience plan for Croatia 10687/21,Council of the European Union, *available from* https://data.consilium.europa.eu/doc/document/ST-10687-2021-INIT/en/pdf *accessed* 6.7.2022

[4] EU guidebook on sustainable tourism for development, The World Tourism Organization (UNWTO) official site, *available from* https://www.unwto.org/EU-guidebook-on-sustainable-tourism-for-development, *accessed* 6.7.2022.

[5] Glossary:Satellite account, Eurostat official page, *available from* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Satellite_account, *accessed* 6.7.2022.

[6] Indeks turističke razvijenosti, Institut za turizam, službene stranice, *available from* http://www.iztzg.hr/hr/itr/ *accessed* 10.7.2022.

[7] Ministarstvo turizma i sporta pokrenulo izradu prvog Satelitskog računa održivog turizma, Ministarstvo turizma i sporta Republike Hrvatske, službene stranice, *available from* https://mint.gov.hr/vijesti-22984/ministarstvo-turizma-i-sporta-pokrenulo-izradu-prvog-satelitskog-racuna-odrzivog-turizma/23008, *ccessed* 6.7.2022.

[8] Professor emeritus Branko Blažević sudjelovao na Interdiscplinarnom znanstvenom kolokviju "Turistički time out – Trenutak za novo promišljanje turizma i prostora",,Fakultet za menadžment u turizmu i ugostiteljstvu Opatija, službene stranice, *available from* https://www.fthm.uniri.hr/novosti/professor-emeritus-branko-blazevic-sudjelovao-na-interdiscplinarnom-znanstvenom-kolokviju-turisticki-time-out-trenutak-za-novo-promisljanje-turizma-i-prostora, a*ccessed* 6.7.2022.

[9] Projekti – znanstveni projekti, Institut za turizam, službene stranice, *available from* http://www.iztzg.hr/hr/projekti/znanstveni-projekti/?tid=131, *accessed* 6.7.2022.

[10] Satelitski račun turizma za Republiku Hrvatsku u 2019., Državni zavod za statistiku, Priopćenje 2022/12.1.7. ISSN 1330-0350 *available from* https://podaci.dzs.hr/media/urxntbqj/12-1-7_satelitski-racuni-turizma-2019.pdf, *accessed* 10.7.2022.

[11] Sustainable development, The World Tourism Organization (UNWTO) official site, *available from* https://www.unwto.org/sustainable-development *accessed* 6.7.2022.

[12] Tourism Satellite Accounts in Europe, Eurostat official page, *available from* https://ec.europa.eu/eurostat/web/products-statistical-reports/-/KS-FT-17-002, *accessed* 10.7.2022.

[13] Tourism Satellite Accounts in Europe 2019 edition, Publications Office of the European Union, , ISBN 978-92-76-12188-6, *available from* https://ec.europa.eu/eurostat/documents/7870049/10293066/KS-FT-19-007-EN-N.pdf/f9cdc4cc-882b-5e29-03b1-f2cee82ec59d, *accessed* 10.7.2022.

Picture 1: source, UNWTO
Picture 2: source, own

TANK WAGON DEFORMATION DUE TO NEGATIVE PRESSURE IN TRANSPORTING DANGEROUS SUBSTANCE

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ABSTRACT

The transportation of hazardous materials takes place in road, sea, air and rail transport. Hazardous materials are a special category of substances that are classified into classes in accordance with international regulations. For the transport of hazardous materials, persons must be specially trained and qualified, because hazardous materials due to an accident or mishap can cause serious damage to human health and environmental pollution. For the transport of hazardous materials, it is necessary to have the legally prescribed documentation, which is a necessary segment of the transport of hazardous materials. In addition, safety equipment has to be in technically correct and regulary checked to avoid accidents.

This paper describes the firefighting intervention of JVP Karlovac due to the accident during transport of flammable liquid. Tank car deformed due to the vacuum caused by the defective relief valve.

Key words: *hazardous substances, transportation of hazardous materials, damage to health, environmental pollution, relief valve*

1. INTRODUCTION

Hazardous substances are substances that can endanger human health, cause environmental pollution or cause material damage to the environment. Based on their nature or properties and condition, and in connection with transportation, they can be dangerous for public safety and are therefore defined by laws, regulations and international agreements. Raw materials from which various products are produced that may or may not be dangerous are also considered hazardous substances. Waste is also considered a hazardous substance if it has the properties of a hazardous substance.[1]

2. CLASSIFICATION OF HAZARDOUS MATERIALS

Classification of hazardous materials, and in accordance with Art. 4 of the Act on the Transportation of Hazardous Materials, they are classified as follows:

- *Class 1* – explosive substances and objects with explosive substances
- *Class 2* – gases
- *Class 3* – flammable liquids
- *Class 4.1.* – flammable solids, self-reactive substances and solid desensitizing explosives
- *Class 4.2.* – substances subject to spontaneous combustion
- *Class 4.3.* – substances that create flammable gases in contact with water
- *Class 5.1.* – oxidizing substances
- *Class 5.2.* – organic peroxides
- *Class 6.1.* – toxic substances
- *Class 6.2.* – infectious substances
- *Class 7* – radioactive material
- *Class 8* – corrosive substances
- *Class 9* – other dangerous substances and objects [2]

Since the subject of this paper is a railway accident during the transport of flammable liquids, Class 3 of hazardous materials, i.e. flammable liquids and the transport of hazardous materials in rail traffic, will be described in more detail.

Flammable liquids are substances or mixtures of liquids that are liquid at a temperature of up to 20°C, and at 50°C their vapor pressure is up to 300 kPa (3 bar). They have a flash point of up to 61°C. Based on the degree of danger, flammable liquids are divided into three groups: a) very dangerous flammable liquids with a boiling point of up to 35°C or flammable liquids with a flash point below 23°C (they are highly toxic or highly corrosive, various organic compounds, some pesticides, etc.); b) dangerous substances are flammable liquids with a flash point below 23°C, which are not in the first group (ether, kerosene, gasoline, acetone, alcohols, ...); c) less dangerous substances are flammable liquids with a flash point of 23 to 61°C.

Examples of class 3 hazardous substances are: gasoline, paint, fuel oil and alcohol. The danger of this class is: flammability, toxicity and risk of corrosion.

3. TRANSPORTATION OF HAZARDOUS MATERIALS

As hazardous materials are an indispensable raw material in industry, an energy source, and therefore an indispensable part of everyday life, the transportation of hazardous materials is the subject of research from a geotraffic, economic, ecological and safety point of view. Hazardous materials must be properly prepared for transport, i.e. secured against unwanted spillage or unwanted reaction of substances with other materials in contact. Hazardous materials must be

secured for safe handling, loading, unloading as well as protected from external influences. The transportation of hazardous materials should be given special attention, their properties and characteristics should be carefully studied, the means of transport should be selected and people who are in direct contact with dangerous substances should be educated. At the same time, in any branch of transport, the legal regulations that prescribe the conditions for the transport of those dangerous substances must be followed. All vehicles transporting dangerous materials must be technically correct, manufactured, equipped and marked in accordance with the prescribed norms. The legal regulations also prescribe the equipment that every means of transport that transports dangerous substances must contain. Also, the procedure in the event of an accident or mishap is described.

In addition, there are additional risks in transport, such as the action of changing forces, climate changes and possible traffic accidents that can cause real disasters caused by the action of dangerous substances. Therefore, as stated above, there are many international regulations on the transportation of dangerous goods, which determine the classification, marking method and conditions that must be followed during transportation.

Transportation of dangerous goods takes place in road, sea, air and rail traffic and inland waterways.

Transportation of dangerous goods by rail means of transport is carried out in accordance with the provisions of the Act on the Transportation of Dangerous Goods (NN 79/07) and the provisions of the Convention on International Carriage by Rail (COTIF), Appendix C, Rulebook 4 on the International Transport of Dangerous Goods by Rail (RID – Regulations concerning the International Carriage of Dangerous Goods by Rail).[3]

3.1. Procedure in the extraordinary event

Due to an extraordinary event on the railway (technical failure, deterioration of materials or a strong impact during maneuvering), there may be waste, leakage or spillage of dangerous substances. Depending on the type of hazardous substance, the workers who directly participate in the transportation of the hazardous substance, i.e. in the intervention during the elimination of irregularities, as well as the environment into which the hazardous substance flows, are at risk. In the extraordinary event, employees in all Croatian Railways offices are obliged to take all measures to protect people and ensure the environment. When irregularities in the transportation of dangerous goods are rectified, efforts should be made to eliminate the malfunctions first at the station, whereby all prescribed protective measures should be taken. An extraordinary event that occurs during the transportation of dangerous goods in the station must be immediately reported to the traffic officer, the head of the station or any station employee, and an extraordinary event on the open railway to the traffic officer in the nearest station. Verbal notification of an extraordinary event must contain the most necessary

information, including who and from where is informing, the location and type of the extraordinary event, whether there are injured or dead persons, and temporarily taken security measures. The State Administration for Protection and Rescue (112), the security advisor for RID, Croatian Railway regional traffic operational, competent fire department and the nearest police station must also be informed about the extraordinary event. The official notification of an extraordinary event during the transportation of dangerous substances, which is forwarded to the relevant institutions, must contain the name and surname of the person notifying, the place where the extraordinary event took place (railway station or kilometer position of the track), time of the extraordinary event, the type of dangerous substance, the amount spilled liquids (flow rate – drops per minute), the cause of the flow (type of irregularity or event) and data on weather conditions.[3]

3.2. Tank safety equipment

Bulk transport containers used for flammable, corrosive and toxic liquids and gases will normally have a pressure/vacuum relief valve fitted to prevent damage to the tank from changes in the internal pressure. The valves prevent the build up of excessive pressure or vacuum which can unbalance the system or damage the storage vessel. So, their primary purpose is to protect the tank against rupturing or imploding. These valves should be inspected and maintained in line with the manufacturer's instructions.

4. TANK WAGON ACCIDENT DURING THE TRANSPORTATION OF DANGEROUS SUBSTANCE

On November 4, 2019., from the INA Refinery in Rijeka, a composition carrying a highly flammable liquid called "Raw material for reformer" which belongs to class 3, flammable liquids, left for Zagreb. The raw material contains the following ingredients that contribute to the hazard of the product: heavy naphtha (petroleum), gasoline, benzene, toluene and n-hexane. The raw material was poured into a tank wagon at a temperature between 10 and 15°C and was transported through Gorski kotar where the temperature was around 0°C. The difference in temperatures is normally not a problem, however, due to a defective venting system on one of the wagons, a negative pressure was created that deformed the formwork of the tank wagon (figture 1). Since the relief valve on the top of the tank was defective, the created negative pressure also deformed the shaft of the discharge valve that passes through the body of the tank, and is located on the lower part of the tank car. As the amount of vacuum increased, atmospheric pressure on the outside of the tank was no longer balanced by pressure inside the tank, caused the tank walls to collapse inward or was squeezed in. This event is referred to as an

implosion. In short, the tank needs to breathe in order to eliminate the possibility of rupturing or imploding.

Figure 1: Deformed tank wagon due to the negative pressure (vacuum). [4]

JVP Karlovac firefighters who arrived at the scene of the intervention shortly before 9 p.m., the auxiliary track of the Main Railway Station in Karlovac, employees of the Croatian Railways reported that due to the negative pressure in the 50,000 L tank car, which transports highly flammable liquid, the wagon's formwork was deformed. Upon inspection of the Safety Data Sheet, it was found that the liquid in it was classified as UN number 1268, while the wagon was marked UN 1203. The commander and deputy commander of JVP Karlovac measured the presence of flammable gases using an explosiometer and found that there were no flammable gases. The commander agreed with the the Croatian Railways employees to move the tank wagon approx. 200 m due to easier access to the wagon and ordered that fire protection be carried out at the scene of the intervention with the combined vehicle D-053 with 2 firefighters and the deputy shift commander Ivan Brozović. After that, 2 liquid containers were placed under the tank wagon due to possible leakage of its contents, the fire engine was positioned and protective jets were prepared. After the completion of the preparatory actions, fire protection of the tank was carried out until the arrival of the replacement. The deputy commander of JVP Karlovac, Robert Hranilović, took over the management of the intervention until the end of transferring the dangerous substance from one tank car to another (figure 2). Employees of the Croatian Railways directed the full tank to further transport, while the damaged tank remained in the same location with further securing of the place. Since about 2 L of flammable liquid leaked out of the damaged tank, the firemen repaired the soil, which was taken away for further

disposal after the repair was completed. Since it was not possible to turn off the voltage on the track, the damaged tank was towed to another track to pump the remaining liquid. After that, the firefighters returned to the unit.

Figure 2: Pumping flammable liquid. [Slike iz arhive JVP Karlovac]

5. CONCLUSION

Transportation of hazardous materials is an important segment of everyday life. Hazardous materials represent a special danger for people, property and the environment, therefore the transport of those substances is defined by international regulations for the transport of hazardous materials in a particular transport branch, which in turn prescribe a whole series of duties and obligations for all participants in the transport. In order to reduce the risks when handling hazardous materials to a minimum, it is necessary to know the basic properties of dangerous substances and to familiarize all participants in the transport process with the type of substance being transported, the dangers that could occur during transport and the ways in which the participants in the transport process can protect themselves from those dangers. Besides that, all vehicles transporting dangerous materials must be technically correct, manufactured, equipped and marked in accordance with the prescribed norms. In addition, safety equipment has to be in technically correct and regulary checked to avoid accidents.

In the previously described accident during the transport of dangerous substance in rail traffic, flammable liquid that was tranported was marked with the wrong UN number and relief valve was defected which caused the formation of negative pressure which caused implosion, deformation of wagon formork respecitvely.

Regardless of the above described accident, transportation of hazardous materials is the safest way because there is a little risk of accidents. Rail traffic offers the possibility of transporting large quantities of goods at relatively low costs, it is independent of weather conditions and time of day, and it is relatively fast, but of course that all participants during the transport process have to be extremely careful and follow the prescribed regulations.

REFERENCES

[1] Prijevoz opasnih tvari u cestovnom prometu (ADR), 2015.
[2] Benković Š., Mulić Š.: Sigurnost i zaštita zdravlja pri prijevozu opasnih tvari, *Goriva i maziva*, 49, 2, (2009), 204-217.
[3] HŽ Cargo – Prijevoz pošiljaka opasnih tvari, bez dat.
[4] Personal photo collection of JVP Karlovac

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