9th International Professional and Scientific Conference

BOOK OF PROCEEDINGS

OCCUPATIONAL SAFETY AND HEALTH

OCCUPATIONAL SAFETY AND HEALTH

KARLOVAC UNIVERSITY OF APPLIED SCIENCES

ISSN 2975-3139

9th 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, Slaven LULIĆ

Reviewers : Asmira BEĆIRAJ, Draženka BIRKIĆ, Marijana BLAŽIĆ, Slavica BOGOVIĆ, Marina BORIĆ, Tihana CEGUR RADOVIĆ, Ines CINDRIĆ, Sonja DAMJANOVIĆ DEŠIĆ, Tomislav DUMIĆ, Kristina DUNDOVIĆ, Sandra FLINČEC GRGAC, Tihomir FLORIJANČIĆ, Srđan GLISOVIĆ, Jasna HALAMBEK, Atif HODŽIĆ, Damir HODŽIĆ, Josip HOSTER, Anica HURSA ŠAJATOVIĆ, Rui ISIDORO, Lidija JAKŠIĆ, Lidija JOLESKA BURESKA, Evica JOVANOVIĆ, Davor KALEM, Anamarija KIRIN, Snježana KIRIN, Tihana KOSTADIN, Denis KOTARSKI, Damir KRALJ, Gorana LIPNJAK, Marijana LONTIĆ, Slaven LULIĆ, Bojan MATIJEVIĆ, Zvonimir MATUSINOVIĆ, Marija MIČOVIĆ, Ivan MIJAILOVIĆ, Budimir MIJOVIĆ, Nenad MUSTAPIĆ, Josipa NAKIĆ, Marko OŽURA, Milan PETKOVSKI, Mateja PETRAČIĆ, Nina POPOVIĆ, Andreja PRIMUŽAK, Igor SALOPEK, Nikolina SMAJLA, Nikola ŠIMUNIĆ, Ivana VARIČAK, Leon VEDENIK, Zoran VUČINIĆ, Vedran VYROUBAL, Filip ŽUGČIĆ.

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

9th International Professional and Scientific Conference
"OCCUPATIONAL SAFETY AND HEALTH"
September 18-21, 2024 • Zadar • Croatia

BOOK OF PROCEEDINGS

Karlovac, 2024

Organizers

Karlovac University of Applied Sciences

Instituto Politécnico de Beja

University of Niš, Faculty of Occupational Safety

International Slavic University G.R. Derzhavin, Faculty of Safety Engineering

Faculty of Chemistry and Chemical Technology

Organizing Committee

Ivan Štedul (president) (CRO)

Mimoza Anastasovska Jankulovska (MKD)

Sanja Belobaba (CRO)

Fátima Carvalho (PRT)

Mirjana Cibulka (CRO)

Ivana Ilić-Krstić (SRB)

Rui Isidoro (PRT)

Lidija Jakšić (CRO)

Anamarija Kirin (CRO)

Snježana Kirin (CRO)

Ivan Mijalović (SRB)

Igor Salopek (CRO)

Marko Štedul (CRO)

Ana Vukadinović (SRB)

Marinela Vulić (CRO)

Suzana Zikovska (MKD)

Manuela Žakula (CRO)

Program committee

Snježana Kirin (president) (CRO)

Slobodan Bundalevski (MKD)

Luís Coelho (PRT)

António Conceição (PRT)

Tatjana Golubović (SRB)

Damir Kralj (CRO)

Slaven Lulić (CRO)

Zvonimir Matusinović (CRO)

Budimir Mijović (CRO)

Marko Ožura (CRO)

Igor Peternel (CRO)

Mateja Petračić (CRO)

Miomir Raos (SRB)

Julijana Siljanovska (MKD)

Ivan Štedul (CRO)

Vedran Vyroubal (CRO)

Scientific Bord

Slaven Lulić (president) (CRO)

Branko Babić (SRB)

Sarajko Baksa (CRO)

Slavica Bogović (CRO)

Heiner Bubb (DEU)

Tihana Cegur Radović (CRO)

Ana Dias (POR)

Ana-Marija Grancarić (CRO)

Atif Hodžić (BIH)

Damir Hodžić (BIH)

Sung Hoon Jeong (KOR)

Shunichi Horigome (JPN)

Sabina Huč (SLO)

Anica Hursa Šajatović (CRO)

Rui Alberto da Silva Martins Isidoro (PRT)

Fadil Islamović (BIH)

Lidija Joleska Bureska (MKD)

Evica Jovanović (SRB)

Tanja Jurčević Lulić (CRO)

Anamarija Kirin (CRO)

Snježana Kirin (CRO)

Shunichi Kobayashi (JPN)

Damir Kralj (CRO)

Matija Landekić (CRO)

Yi Li (GBR)

Zvonimir Matusinović (CRO)

Marija Mićović (SRB)

Budimir Mijović (CRO)

Cvetanka Mitrevska (MKD)

Igor Peternel (CRO)

Milan Petkovski (MKD)

Mateja Petračić (CRO)

Zlatko Popović (MNE)

Uwe Reisch (USA)

Igor Salopek (CRO)

Simon Schnabl (SLO)

Rose Smileski (MKD)

Vladimir Stanković (SRB)

Bosiljka Šaravanja (CRO)

Ivan Štedul (CRO)

Anita Tarbuk (CRO)

Marinko Đ. Učur (CRO)

Leon Vedenik (SVN)

Xungai Wang (AUS)

Daniela Zavec (SVN)

Patrons

Ministry of Health

Ministry of Labour, Pension System, Family and Social Policy

Ministry of Science and Education and Youth

Foreword

Dear colleagues, esteemed participants, and partners,

It is with great pleasure that I present this collection of papers from our 9th International Professional and Scientific Conference Occupational Safety and Health which will take place in Resort Borik – Zadar, Croatia during 18-21 September 2024. This conference, organized in collaboration with prestigious institutions – Polytechnic Institute of Beja, University of Niš, International Slavic University, and the Faculty of Chemistry and Chemical Technology of the University of Ljubljana – brings together experts and researchers from various disciplines with the aim of sharing the latest information and achievements in the fields of occupational safety and health both in Croatia and internationally.

The true value of this conference lies in its multidisciplinary approach, which brings together over 250 participants, including industry experts, union representatives, occupational health specialists, and many more. With approximately 110 papers presented through oral presentations and posters, the conference will also feature two roundtable discussions addressing key topics in the field of occupational safety and health.

This collection of papers reflects the wealth of knowledge and research efforts of all participants, providing a platform for continued exchange of experiences and expertise. I believe it will serve as a valuable resource not only for professionals but also for future generations of researchers and practitioners in this field.

I extend my sincere thanks to our partners and patrons, including the Ministry of Health, the Ministry of Labour, Pension System, Family and Social Policy, and the Ministry of Science and Education and Youth, as well as to all the authors and participants for their contributions. Your dedication and engagement are key to the success of this conference and this volume, and I am confident that the results of our discussions and conclusions will shape the future direction of research and practice in occupational safety and health.

I warmly greet you all and wish you much success in your future research and professional endeavors.

Sincerely,

Dean of the Karlovac University of Applied Sciences
Ivan Štedul

Table of Contents

1

INVITED PAPERS

Slavica BOGOVIĆ
THE INFLUENCE OF DYNAMIC ANTHROPOMETRY ON THE DESIGN OF PROTECTIVE CLOTHING......................................27

Sandra FLINČEC GRGAC
DEVELOPMENT OF TEXTILES FOR USE IN THE HOSPITAL ENVIRONMENT..39

Jadranka GRBINIĆ
ENVIRONMENTAL AND HEALTH IMPACTS OF THE CLOSURE OF LANDFILLS IN THE REPUBLIC OF CROATIA.........52

Marija GROZDANOVSKA, Milena SPASOVSKA
WORKPLACE HARASSMENT (MOBBING): LEGAL FRAMEWORK AND CHALLENGES FOR THE REPUBLIC OF NORTH MACEDONIA 60

Ivan MIJAILOVIĆ
TOBACCO STALKS BIOBRIQUETTES COMBUSTION EMISSIONS – ENVIRONMENTAL IMPACT AND ENERGY EFFICIENCY..73

Uwe REISCHL, Budimir MIJOVIĆ, Alex HONN
PROTOTYPE RESPIRATORY PROTECTION SYSTEM FOR WILDLAND FIREFIGHTERS...84

2

OCCUPATIONAL SAFETY

Marijan BINIČKI, Pero ŠKORPUT, Tomislav KLJAK
WORK SAFETY AND PROTECTION IN POSTAL SYSTEM 92

Neno ČABRAJA, Diana KRALJ, Damir KRALJ
IRLEN SYNDROME AND ACCESSIBILITY OF DIGITAL MEDIA FROM THE PERSPECTIVE OF PROTECTION AT WORK 99

Alojzije GRZELJA IVETA
REMOTE WORK CHALLENGES IN OCCUPATIONAL HEALTH AND SAFETY IN REPUBLIC OF CROATIA........................106

Jelena IVANČAN, Dragica LIČKO
ENHANCING WORKPLACE SAFETY: STRATEGIES AND PRACTICAL STEPS DERIVED FROM INA GROUP'S EXPERIENCE 113

Rui ISIDORO, Luís SERRA
LIVE WORKING - ACCIDENTS IN ELECTRICAL TRANSFORMATION STATIONS 122

Marijana LEONTIĆ, Darko PALAČIĆ
OCCUPATIONAL HEALTH AND SAFETY RISKS MANAGEMENT - FUNDAMENTAL PHILOSOPHY 132

Antonio METIĆ
TRAINING AND DEVELOPMENT OF VOLUNTEER FIREFIGHTERS 139

Lada PURGAR, Maja ŠIKIĆ
IMPROVING THE QUALITY OF EDUCATION OF OCCUPATIONAL SAFETY ENGINEERS BY INTRODUCING A COMPULSORY COURSE IN ANDRAGOGY AT THE SPECIALIST STUDY OF SAFETY AND SECURITY 147

Lada PURGAR, Ana Marija BONIĆ
ANDRAGOGICAL SKILLS OF OCCUPATIONAL SAFETY EXPERTS 155

Anita STILIN, Ljerka TOMLJENOVIĆ, Ana BLAŽEVIĆ
EXPERIENCE OF FOREIGN WORKERS – SAFETY ISSUES 163

Goranka ŠKEVA, Bojana KNEŽEVIĆ, Željko OTMAČIĆ, Anamarija VONIĆ LUKINEC
TRAINING OF HEALTHCARE WORKERS TO WORK IN A SAFE WAY AND USE OF PERSONAL PROTECTIVE EQUIPMENT 169

Leon VEDENIK, Marjan LUKEŽIČ
STATISTICS OF OCCUPATIONAL ACCIDENTS IN THE REPUBLIC OF SLOVENIA FROM 2008 TO 2022 175

Suzana Z. ZIKOVSKA, Cvetanka T. MITREVSKA, Lidija Lj. BURESKA, Slobodan BUNDALEVSKI
CAUSES OF ACCIDENTS AND PROTECTION MEASURES WHEN WORKING IN WAREHOUSES 182

3

OCCUPATIONAL HEALTH

Jasmina BESLAGIC, Atif HODZIC, Esad BAJRAMOVIC
INJURY AT WORK AND OCCUPATIONAL DISEASE IN THE LEGISLATION OF THE FEDERATION OF BOSNIA AND HERZEGOVINA 192

Marijana BLAŽIĆ, Karmen MATKOVIĆ MELKI, Monika ĆUBELA, Elizabeta ZANDONA, Ines CINDRIĆ, Martina STVORIĆ
ZERO WASTE PRACTICES IN FINE DINING RESTAURANTS 199

Marina BORIĆ, Snježana ŠTEFOK
FINDINGS OF THE MINDBOT PROJECT AS GUIDELINES FOR PROMOTING MENTAL HEALTH AT WORK AND IMPROVING COBOT-WORKER WELL-BEING 206

Iva ČEHAK
IMPLEMENTATION OF TECHNICAL PROTECTION IN SAFETY AND HEALTH PROTECTION 214

Tamara FEHERVARI, Marko PRAHOVIĆ
THE IMPACT OF OCCUPATIONAL PHYSICAL ACTIVITY ON HEALTH 218

Tatjana GOLUBOVIĆ, Ana BIJELIĆ
OCCUPATIONAL EXPOSURE TO BTEX: A CONDENSED REVIEW 223

Jasna HALAMBEK, Iva PUTANEC, Ivana KOLIĆ, Sandra ZAVADLAV
PESTICIDES IN FOOD AND THE ENVIRONMENT-IMPACT ON HUMAN HEALTH 229

Renata HRŽENJAK, Ksenija DOLEŽAL, Blaženka BRLOBAŠIĆ ŠAJATOVIĆ
THE IMPORTANCE OF MONITORING THE VALUE OF BODY MEASUREMENTS IN THE FUNCTION OF HEALTH 236

Marko KRŠULJA, Dinko JURJEVIĆ, Damir KARABAIĆ
ASSESSMENT OF UNPLEASANT ODORS IN THE WORKING ENVIRONMENT 242

Bojan MATIJEVIĆ
FOOD SAFETY CULTURE: COMMON WAY OF BEHAVING AND THINKING 248

Franjo MIROSAVLJEVIĆ
FIRST AID SUPPLIES IN FIRST AID CABINETS 254

Eduard MISSONI, Marin DUGINA, Dino ŠOJAT
THE EFFECTS ON EXHAUST GAS EMISSIONS ON WORKERS IN MOTORWAY TOLL BOOTHS 260

Sandra ZAVADLAV, Petra CVETIĆ, Ivana KOLIĆ, Jasna HALAMBEK, Jasminko SALETOVIĆ
SWEETENERS AND NO SUGAR FOOD OFFER FOR THE PURPOSE OF PROTECTING HEALTH OF DIABETICS 266

Ivana ŽITKO
CHEMICAL MANAGEMENT SYSTEM IN RIMAC TECHNOLOGY AND BUGATTI RIMAC 272

4

TECHNICAL-TECHNOLOGICAL PROTECTION FACTORS

Tomislav BOŽIĆ, Zvonimir ORNIK, Tomislav ŠANČIĆ
MAINTENANCE OF INDUSTRIAL CUTTING LASERS AND THE INFLUENCE OF POOR MAINTENANCE ON MACHINE OPERATION 280

Katarina ČAVLOVIĆ, Slaven LULIĆ, Mario FANJAK
BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS 285

Tihana DEKANIĆ, Tanja PUŠIĆ, Ana ŠARAVANJA
THE RELEASE OF FIBRE FRAGMENTS FROM ARTIFICIALLY AGED POLYESTER/COTTON FABRIC DURING WASHING PROCESS......291

Josip HOSTER, Andrija BERISLAVIĆ
SAFETY ASPECTS OF STRAIGHTNESS DEVIATION OF COLUMNS ACCORDING TO EN 10034:1993......297

Josip HOSTER, Andrija BERISLAVIĆ, Antun RADEČIĆ
INCREASING STABILITY AND SAFETY OF THIN-WALLED HOLLOW SECTIONS BY PRESTRESSED INSERTS......303

Aida IMAMOVIĆ, Omer KABLAR, Mirsada ORUČ, Dragana AGIĆ
SAFETY MEASURES AT WORK WHEN TRANSPORTING AND UNLOADING STEEL SCRAP IN THE TECHNOLOGICAL PROCESS THE OF STEEL PRODUCTION 309

Anđela JEVTIĆ, Vladimir STANKOVIĆ, Evica JOVANOVIĆ
RISKS IN ELECTRICAL POWER SYSTEMS......316

Lidija Lj. JOLESKA BURESKA, Suzana ZIKOVSKA, Cvetanka T. MITREVSKA
RISKS FACED BY WORKERS DURING THERMAL POWER PLANT MAINTENANCE 322

Anamarija KIRIN, Vanesa SARVAŠ, Katarina ČAVLOVIĆ, Filip ŽUGČIĆ, Slaven LULIĆ
ULTRAVIOLET RADIATION: PROTECTION AND APPLICATIONS......330

Tihana KOSTADIN, Ana TOMAŠIĆ
PROPERTIES AND RECYCLING OF POLYMER MATERIALS....................336

Tihana KOSTADIN, Tomislav ŠANČIĆ, Nikola ŠIMUNIĆ, Matija RENDULIĆ
ECOLOGICALLY ACCEPTABLE MACHINING OF POLYMER MATERIALS....................342

Tihana KOSTADIN, Nikola ŠIMUNIĆ, Srđan MEDIĆ, Domagoj JURČIĆ
PROPERTIES OF BIOCOMPATIBLE MATERIALS....................348

Vlado KUŠEC, Martina KUŠEC RUGANEC, Igor KOVAČEV, Tomislav KOS
HAZARDS AND SAFETY MEASURES WHEN WORKING WITH PLANT PROTECTION MACHINES....................352

Bosiljka ŠARAVANJA, Selma IMAMAGIĆ, Anica HURSA ŠAJATOVIĆ, Paula MARKOVIĆ
THE CALCULATION OF THE TIME NORMS FOR A WHITE LAB COAT "LEON"....................364

Goran ŠARIĆ
SPECIFICS OF OCCUPATIONAL SAFETY IN SMALL AND MICRO BREWERIES....................372

Nikola ŠIMUNIĆ, Tihana KOSTADIN, Ivana STIPANIČIĆ, Ivana GRGURIĆ
SAFETY MEASURES IN ADDITIVE MANUFACTURING....................378

Domagoj ŠKARICA, Budimir MIJOVIĆ
DANGERS AND PROTECTIVE MEASURES WHEN WORKING WITH ACIDS AND ALKILS IN POWER PLANT EL-TO ZAGREB....................386

Anita TARBUK, Tihana DEKANIĆ, Josip MARKOVIĆ, Katia GRGIĆ
THE INFLUENCE OF WASHING WITH PERACETIC ACID BLEACH ON THE PROPERTIES OF GREEN HOSPITAL PROTECTIVE COTTON FABRIC....................395

Ana Marija ŽALAC, Budimir MIJOVIĆ
SAFETY AT WORK FOR THE CNC MACHINE OPERATOR....................402

Filip ŽUGČIĆ, Mario FANJAK, Ivan ŠTEDUL
AVERAGE DAILY SUNSHINE AND CLOUD COVER AS A GUIDE TO PRODUCTION AT SOLAR POWER PLANT "VUK"....................408

5

ERGONOMICS

Ines BAKSA, Jasminka HORVATIĆ, Sarajko BAKSA
PRESERVING THE PHYSICAL AND MENTAL HEALTH OF EMPLOYEES AT THE WORKPLACE 416

Blaženka BRLOBAŠIĆ ŠAJATOVIĆ, Renata HRŽENJAK, Ksenija DOLEŽAL
DIFFERENCE IN THE ANTHROPOMETRIC CHARACTERISTICS OF ATHLETES AND THE GENERAL POPULATION AND THEIR IMPACT ON HEALTH...423

Minka ĆEHIĆ, Hasan TALIĆ, Selma MUJANIĆ
ANALYSIS OF ENVIRONMENTAL HEAT ON A WORKER IN A SAW MILL...429

Ria HORVAT, Sandra DEBELJAK, Kristina DUNDOVIĆ
PSYCHOSOCIAL RISKS AMONG HEALTHCARE WORKERS IN LEGAL THEORY AND PRACTICE 435

Snježana KIRIN, Kristijan KALCINA, Marinela VULIĆ
EXAMINATION OF NOISE WITHIN THE WORK ENVIRONMENT DURING THE SEWING TECHNOLOGICAL PROCESS 449

Snježana KIRIN, Manuela ŽAKULA, Luka BABIĆ
INVESTIGATION OF WORKPLACE LIGHTING IN THE PROCESS OF TECHNOLOGICAL SEWING 456

Snježana KIRIN, Anica HURSA ŠAJATOVIĆ
ANALYSIS OF STATODYNAMIC LOAD IN THE TECHNOLOGICAL PROCESS OF SEWING 462

Karla KOVAČEVIĆ ČORAK, Marina MILAKOVIĆ, Dominik OROZ, Petra KOVAČEVIĆ TOTIĆ, Marija BUBAŠ, Krunoslav CAPAK
OCCUPATIONAL MUSCULOSKELETAL DISORDERS AMONG DENTISTS..470

Damir KRALJ, Snježana KIRIN, Marinela VULIĆ
MEETING THE "TEKSERGO" PROJECT..478

Bojan LATIĆ
STRESS AT WORK CAUSED BY BURNOUT SYNDROME...............485

Gorana LIPNJAK
PSYHOSOCIAL RISKS AT THE WORKPLACE CAUSES, CONSEQUENCES, PREVENTION..........491

Josipa NAKIĆ, Matija LANDEKIĆ
PRE-WORK WARM-UP ROUTINE FOR CHAINSAW WORKERS..........497

Zlatko ŠARIĆ, Sonja DAMJANOVIĆ DEŠIĆ, Tina MUDROVČIĆ
APPLICATION OF OCCUPATIONAL EXOSKELETONS..........503

Maja TREČIĆ, Željka POTOČNJAK
IMPACT OF SEXUAL HARASSMENT IN THE WORKPLACE: CONSEQUENCES ON WORK ENVIRONMENT AND PRODUCTIVITY..........507

Maja ULEMEK, Željko JOVANOVIĆ
STRESS AND CONSEQUENCES OF STRESS OF HEALTHCARE WORKERS IN ONCOLOGY DEPARTMENTS..........512

Eric ŽGELA, Filip ŽUGČIĆ, Anamarija KIRIN
THE PROCESS OF INTEGRATION OF LIGHTING FIXTURES IN THE WORK SPACE, MEASUREMENT AND SIMULATION OF LIGHTING..........525

6

ENVIRONMENTAL PROTECTION

Asmira BEĆIRAJ
ENVIRONMENTAL DAMAGE - CHOICE OF APPLICABLE LAW..........534

Draženka BIRKIĆ, Dijana BENKO
ECO-LABELLING OF HOSPITALITY FACILITIES OWNED BY HRVATSKE ŠUME d.o.o...........539

Lidija JAKŠIĆ, Marta MARKOTA
THE EFFECTS OF MICROPLASTICS ON HUMAN HEALTH AND ENVIRONMENT..........551

Filip KOVAČIĆ, Mirsada ĆEHIĆ
THE EU'S GREEN DEAL: CAN IT CURB EMISSIONS IN NEW MEMBER STATES LIKE CROATIA? 562

Nenad LORKOVIĆ, Marina TEVČIĆ, Domagoj OPAČAK
SAFETY PRECAUTIONS IN ENVIRONMENT CONTAMINATED WITH H2S...568

Mladena LUKIĆ, Tatjana GOLUBOVIĆ, Žarko ĆOJBAŠIĆ, Dragan MARKUSHEV
ADVANCING ENVIRONMENTAL AND OCCUPATIONAL SAFETY: TRACE GASES DETECTION BY PHOTOACOUSTICS AND MACHINE LEARNING IMPLEMENTATION..574

Nenad MUSTAPIĆ, Toni KRALJ
DEFINING THE STANDARD CONTENT OF THE PRE-FEASIBILITY STUDY FOR GEOTHERMAL POWER PLANTS BASED ON THE ORGANIC RANKINE CYCLE.................581

Nenad MUSTAPIĆ, Toni KRALJ
OPTIMIZATION AND ANALYSIS OF THE ORGANIC RANKINE CYCLE FOR COMBINED HEAT AND POWER PRODUCTION FROM GEOTHERMAL SOURCES..........................588

7

FIRE AND EXPLOSION PROTECTION

Dario JAVOR, Dejan KRSTIĆ, Nebojša RAIČEVIĆ
RANKING OF VEHICLE FIRE RISK BASED ON HARMFUL GAS EMISSIONS 598

Danijel KNEŽEVIĆ, Manuela ŽAKULA, Damir KRALJ
RESEARCH ON THE EXPERIENCE AND QUALIFICATIONS OF FIREFIGHTERS FOR INTERVENTIONS IN ELECTRIC AND HYBRID VEHICLES..605

Marko OŽURA, Nina POPOVIĆ, Zrinka MESIĆ
FIRE EFFECTS ON INVASIVE PLANTS IN THE AREA OF FOREST ADMINISTRATION KARLOVAC...612

Željka POTOČNJAK, Maja TREČIĆ, Zvonimir MATUSINOVIĆ
ANALYSIS OF THE GAS CRISIS IN RAB 617

Maja TREČIĆ, Željka POTOČNJAK, Zvonimir MATUSINOVIĆ
FIRE ON HYBRID VEHICLES 625

Maja TREČIĆ, Nikola RADOLIĆ, Ivan ŠTEDUL, Manuela ŽAKULA
STATISTICAL ANALYSIS OF WILDFIRES IN CROATIA APPLICATION OF DANA FROM THE GLOBAL WILDFIRE INFORMATION SYSTEM (GWIS) 633

Ivan VRABEC, Anđelko MIHOK, Zvonimir MATUSINOVIĆ
SAFETY RISKS AND EXTINGUISHING FIRES OF ELECTRIC VEHICLES 641

8

SOCIAL AND HUMANISTIC ASPECTS

Tihana CEGUR RADOVIĆ, Dijana BENKO, Lora VUCELIĆ
WHAT MOTIVATES VISITORS TO VISIT HUNTING LODGE MULJAVA? – VISITOR MOTIVATION, SATISFACTION, LOYALTY AND SUSTAINABLE DEVELOPMENT 650

Tatjana ČUMPEK
WHAT IS THE RISK? 658

Ivana ILIĆ KRSTIĆ, Danijela AVRAMOV, Anica RANĐELOVIĆ
ANALYSIS OF SOCIO-DEMOGRAPHIC CHARACTERISTICS OF INJURIES AT WORKPLACE FOR THE 2022 YEAR IN SERBIA...664

Suan ISLAMOVIĆ, Nikola FINDRIK, Fadil ISLAMOVIĆ
NORMATIVE FRAMEWORK ON OCCUPATIONAL SAFETY IN GREAT BRITAIN..675

Dubravka KRIVAČIĆ, Silvija ŠPEHAR
OCCUPATIONAL HEALTH AND SAFETY COSTS ACCOUNTING...682

Elizabeta KRSTIĆ VUKELJA
QUALITY MANAGEMENT SYSTEMS IN THE AREAS OF OCCUPATIONAL HEALTH AND SAFETY AND ENVIRONMENT USING FMEA METHOD FOR PATIENT SAFETY RISK MITIGATION....................689

Zoran MARJANOVIĆ, Marija MIČOVIĆ, Aleksandar TERZIĆ
PROTECTION AND RESCUE SYSTEM OF THE REPUBLIC SERBIA....................701

Vesna NIKOLIĆ, Srđan GLIŠOVIĆ, Ivan MIJAILOVIĆ
OCCUPATIONAL SAFETY IN THE MODERN BUSSINES CONTEXT....................708

Ana RAČKI MARINKOVIĆ
CAN PORTUGUESE TEENAGERS SUE CROATIA OVER CLIMATE INACTION? - RECENT CLIMATE CHANGE LITIGATION IN EUROPE....................714

Anamarija ŠINKOVAC, Ivana VARIČAK
ASPECTS OF CORPORATE SOCIAL RESPONSIBILITY IN THE BANKING SECTOR OF THE REPUBLIC OF CROATIA....................722

Marinko Đ. UČUR
THE COMPLEXITY AND SPECIFICITY OF THE WORK OF PORT WORKERS IN SEAPORTS REQUIRES SPECIAL REGULATIONS FOR THEIR SAFETY AND HEALTH PROTECTION AT WORK....................728

Zoran VUČINIĆ, Manuela ŽAKULA
SECURITY MANAGEMENT SYSTEMS DURING AN EARTHQUAKE....................732

Branko ZLOMISLIĆ, Zvonimir MATUSINOVIĆ, Zoran VUČINIĆ, Lidija JAKŠIĆ, Igor PETERNEL
ASSISTANCE TO PERSONS WITH DISABILITIES IN CRISIS SITUATIONS....................738

Manuela ŽAKULA, Andreja PRIMUŽAK, Nikola TURINA, Mirjana CIBULKA
THE IMPORTANCE OF INTERPERSONAL RELATIONSHIPS IN FIREFIGHTING....................745

9

MULTIDISCIPLINARY ASPECTS

Sarajko BAKSA, Misel MIHALIĆ, Ines BAKSA
ORGANIZATIONAL MAINTENANCE SYSTEM IN THE FUNCTION OF OCCUPATIONAL SAFETY AND HEALTH PROTECTION....754

Marija BATAK, Andreja CESAR SLEGOVAC, Sanela PASKAŠ DLUGOŠ
IMPACT OF THE FOURTH INDUSTRIAL REVOLUTION ON DEVELOPMENT OF PERSONAL PROTECTIVE EQUIPMENT....760

Iva ČEHAK
SAFETY ADVISER FUNCTION....767

Damir HODŽIĆ, Ermin BAJRAMOVIĆ, Emir BAJRAMOVIĆ
ARTIFICIAL INTELLIGENCE IN THE IMPROVEMENT OF SAFETY AT WORKPLACE....775

Alen KRIVAČIĆ
GREEN CROSS RECORDS:TRACKING TOOL OF WORK SAFETY STATUS IN THE COMPANY....781

Krešimir MALARIĆ, Bosiljka ŠARAVANJA, Tanja PUŠIĆ, Ivan LENIČEK, Damir ILIĆ
BLUETOOTH IN OFFICE ENVIRONMENT....787

Matija NOVOSEL, Alen ŠIMEC, Lidija TEPEŠ GOLUBIĆ
EXPLORING STRATEGIES FOR DEVELOPING SECURE AND TRANSPARENT CHAT APPLICATIONS....793

Marko OŽURA, Nina POPOVIĆ, Zrinka MESIĆ
POTENTIAL RISKS OF INVASIVE ALIEN PLANTS IN HISTORIC CENTRE OF KARLOVAC....800

Dušica J. PEŠIĆ, Darko N. ZIGAR, Srđan M. GLIŠOVIĆ, Aca V. BOŽILOV
FIRE RESEARCH USING FIRE DYNAMICS SIMULATOR SOFTWARE PACKAGES....804

Krunoslav PINTUR, Tomislav DUMIĆ, Relja BECK
THE IXODES RICINUS TICK – THE VECTOR OF HUMAN BABESIA IN CROATIA AND EUROPE....811

Marko ŠTAJNER, Kristina ŠTIMAC, Bruno ŠTAJNER
SECURITY IN THE IMPLEMENTATION OF TELECOMMUNICATIONS INFRASTRUCTURE................................819

Ivan ŠTEDUL, Mario FANJAK, Merima ARNAUT
MATHEMATICAL MODELS IN OCCUPATIONAL SAFETY 826

1

INVITED PAPERS

THE INFLUENCE OF DYNAMIC ANTHROPOMETRY ON THE DESIGN OF PROTECTIVE CLOTHING

Slavica Bogović

University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, Zagreb, CROATIA, slavica.bogovic@ttf.hr

Abstract: *The influence of dynamic anthropometry on the design of protective clothing to increase functionality is presented in the paper. Protective clothing is designed according to the purpose of the garment, using materials that provide adequate protection against external influences that may endanger a person's health or life. When designing and manufacturing protective clothing, the specific movements performed in the work environment must be taken into account to ensure adequate protection. Based on the kinematic model of the human body, it is possible to predict specific body positions and determine dynamic measures depending on the degree and type of protection the garment is intended to provide. To perform measurements in specific positions, it is necessary to digitize the human body and analyze the obtained 3D point cloud of the human body. By measuring the body in different positions, it is possible to adjust the cut from a structural point of view to increase the protective function of the garment with regard to its purpose, while ensuring comfort and safety when using the garment. The focus is on the input parameters required for the design of a protective coverall, as a large number of deficiencies have been identified in the aforementioned garment, regardless of the type of protection.*

Keywords: *dynamic anthropometry, protective clothing, protective coveralls*

1. INTRODUCTION

The primary function of clothing is to protect the human body from external influences. Depending on the final function of the garment and the protection required in the working environment or during daily activities, research is being carried out into new materials with specific properties that provide the user with safety when carrying out the required activities. The purpose of clothing plays a major role in the development of protective clothing. The rapid development of new materials and their further processing contribute greatly to better protection against various injuries that can be caused by mechanical hazards, chemicals, thermal risks, ionizing, biological agents, radioactive and non-ionizing radiation, electric shocks, entanglement and entrapment [1].

According to EN 340:2003, effective protective clothing should have the following characteristics [2, 3]:

- be universally applicable, regardless of gender
- should be manufactured in different sizes
- should be ergonomically designed according to dynamic anthropometric conditions to ensure comfort and a high degree of freedom of movement

- should be specially designed for all carrying options that may arise during use (carrying tools, accessories, breathing apparatus, etc.).

The stated standard is a reference standard that cannot be applied independently. It is therefore necessarily accompanied by at least one special standard for protective clothing, depending on the category of personal protective equipment. Regulations have been created for various protective clothing items depending on the level of protection the garment is intended to provide to the end user at work. In the production of protective clothing, high-performance materials are used to prevent the penetration of liquid, solid or gaseous agents through the clothing. Due to the properties of the materials used, it is important to apply adequate modern joining methods and techniques [2, 3].

In addition to the types of materials used in the manufacturing of protective equipment, the regulations also define the types of clothing used in different occupations. In addition to the special characteristics of protective clothing or clothing systems, the regulations may also include measurement tables alongside clothing sizes. According to EN 340:2003, which specifies that protective clothing must ensure unrestricted movement of the body, it is possible to define exactly to which segment of the garment this refers [4].

Manufacturers of protective clothing come up with their own innovative solutions to ensure unhindered movement when using protective clothing that does not fully meet the needs of the user. An additional problem arises from the small number of sizes in which protective clothing is manufactured, as different body constitutions are not covered. As certain movements are performed during the work process, it is necessary to know the dynamic anthropometry based on the most common and frequent movements performed when using protective clothing to ensure unhindered body movement. This requires you to know the characteristic movements of the body and their influence on the movement of parts of the garment during wear. Different garments are used for protection during the work process. Therefore, it is necessary to foresee characteristic areas for each type of garment that must ensure unhindered body movement [5-8].

2. PROTECTIVE CLOTHING FROM THE POINT OF VIEW OF CLOTHING CONSTRUCTION

Protective clothing is divided into aprons, vests, T-shirts, coats, blouses, jackets, trousers, work suits, coveralls and clothing systems. Protective clothing also includes gloves and headgear (hats, caps, hoods, etc.) [1, 9]. From the point of view of clothing construction, aprons, vests and T-shirts are simple items of clothing that are used on a daily basis or during the work process to protect against self-assessed hazards. Coats, work blouses, work trousers and work suits are structurally more demanding, but as garments or parts of clothing systems they are relatively adaptable to certain postures and constitutions. Clothing systems are a combination of several items of clothing that work together to provide the user with complete protection against external influences. They are designed so that a combination of different garments provides complete protection, whereby each element of the system can be adapted to the needs of the user. Clothing systems are used to protect against high-risk external influences. They are used in firefighting, for protection against chemicals, thermal risks, biological agents, radioactive radiation, etc. [7-9].

Protective coveralls are garments that cover the entire body, they are made as one piece and are a very common element of a clothing system or the only protective garment. They are widely used as protective clothing. Their shape depends on the purpose, materials and the need for integrated elements. Coveralls can have built-in cooling systems, breathing systems, etc. [4].

In general, garments are designed and manufactured based on standard clothing sizes with knowledge of the anthropometry of the human body and the properties of the material from which the garments are made. For the purposes of construction, the main body measurements determined on the basis of static anthropometry are used, and during the construction of the garment, commotions are added to ensure unhindered movement of the body in performing normal movements. In the work process, it is extremely important that the protective clothing item is designed and manufactured in such a way that it is purpose-built to protect against expected risks and that its use does not cause further risks for the safety and health of workers, and that it corresponds to the general conditions of the workplace, ergonomic needs, and that it is made and designed in such a way that the worker can adjust it in a simple way [1]. For the design of protective clothing, the sectors in which the clothing will be used (construction, shipbuilding, mining, railways, forestry, energy production, firefighting, health, civil protection, etc.) must also be taken into account, as well as other factors that affect the design of protective clothing (Fig. 1) [1, 10].

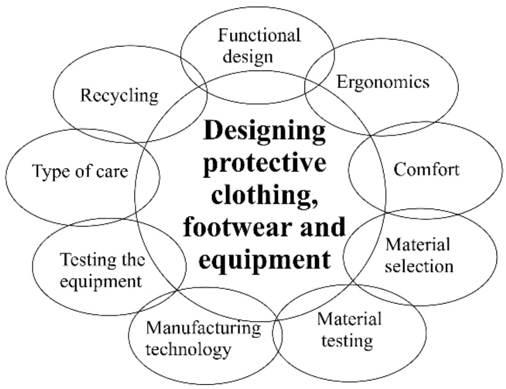


Figure 1: Factors influencing the design of protective clothing, footwear and equipment [10]

In addition to the factors mentioned above, it is necessary to take into consideration the posture in which the work is performed to ensure the necessary movement and reduce the possibility of additional injuries. Therefore, it is necessary to define the areas on the garment where the greatest strain occurs.

3. DYNAMIC ANTHROPOMETRY

Dynamic anthropometry is used to determine body measurements in dynamic positions. Workplaces, tools and clothing can be designed based on body measurements in a dynamic position. The determination of body measurements in a dynamic position is carried out without contact using a 3D scanner that digitizes the body in a specific position. With the tools used for measuring body dimensions, it is possible to determine the required dimensions very accurately. It is important to determine the specific positions of the human body when performing certain activities [5-9].

The specific positions of the human body are highly dependent on the type of work and the working environment, so research into dynamic anthropometry in specific positions is of particular importance. Measurements related to the length of body parts such as arms and legs are determined based on the length of the bones and can be calculated in advance. Based on the biomechanics of the body, comfort in a specific area of the garment can be predicted. The expected movements in the elbow or knee area must be defined to prevent the garment from moving in the wrist or ankle area, akin to the sitting position. The bending of the elbow or knee has a strong influence on the position of the garment on the body. The sitting position influences the movement of the garment in the waist area and the length of the garment, as the body bends in two places. In this case, using the example of the trousers, they are lowered in the waist area, the trouser leg is shortened, while at the same time excess material is created at the front seat seam and in the area behind the knees [5-8].

The above suggests that it is necessary to pay attention to the kinematic chains and biomechanics of the body, which play a key role in the construction of clothing [5-8, 11].

From a kinematics perspective, the human body can be visualized as a system of rods representing body segments connected by joints. The human body can be viewed as a system of levers whose muscles are the driving parts that act as levers on the bones, and the center of rotation lies within the joints. The simplest kinematic chain consists of two links connected by a joint, the kinematic pair (Fig. 2) [11, 12].

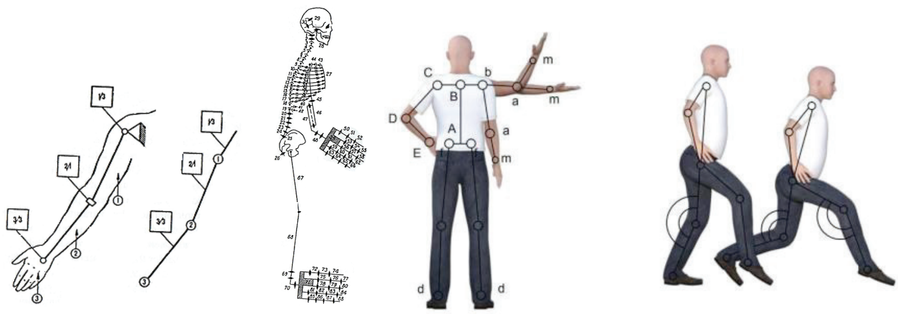


Figure 2: Kinematic chain of the hand and the human body [11, 12]

The human skeleton consists of a closed kinematic chain of the spine with the rib cage and five open kinematic chains of the head, arms and legs, which can be seen in Fig. 2. The kinematic chain shows the interlinking of several body segments [11].

There are 264 degrees of freedom in the structural diagram of the human skeleton. The arm with the shoulder has 28 degrees of freedom, while the leg has 25 degrees of freedom of movement, i.e. 40% of the total number of degrees of freedom of movement. The spine contains 20% of the total number and the remaining 40% of the degrees of freedom of movement of the human body relate to the joints of the chest, neck and head [11].

Based on the kinematic model of the human body, it is possible to define the maximum movements of body parts and their rotations in advance. This knowledge has been used for many years in the construction of clothing for everyday use. In this way, a clothing construction technique is defined that allows unhindered movement during daily activities. [5-9].

By using 3D technologies, it is possible to study the influence of body movements on the fit of a garment. The segments of the garment that are exposed to the greatest stresses can be precisely defined. For garments that cover the upper or lower body, the loads on the garment segments are compensated for by moving the garment in the form of a shortening, as described above. When coveralls are used, there is no way to move the garment in such a way that the body movements, which are the result of complex kinematic chains, can be carried out unhindered. When the movement is carried out, the garment is strained because it cannot follow the dynamics of the body. This can restrict the movement of other parts of the body and thus the inability to perform the movement, which can lead to injury. For this reason, users often choose larger clothing sizes, which can have the same negative effects [5-9].

4. METHOD

To solve the problem of fit and functionality of the protective coverall, tests were carried out in different body positions, including the position of the body when standing. Figure 3 shows the stress areas of the garment that occur during body movements.

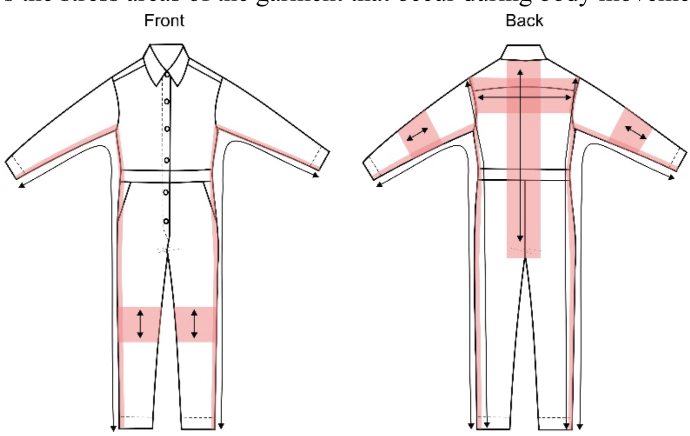


Figure 3: Stress on parts of the coverall during body movements

The VitusSmart 3D body scanner was used to digitize the bodies of men in the same age group. With a 3D scanner, it is possible to digitize the human body in 12 seconds, resulting in a point cloud of the human body. The point cloud contains 500 000 spatial points. The VitusSmart 3D scanner is a laser scanner equipped with a modular system with four guides, each containing two CCD cameras. The CCD camera records the distance between the points and covers a recording space of 1 x 0.95 m and a height of 2.03 m.

Figure 4 shows specific body positions divided into 3 groups: static positions, asymmetric and symmetric body positions. In this way, 14 body positions were defined and digitized. The positions depicted show the main areas of body extension that directly affect the design of the garment.

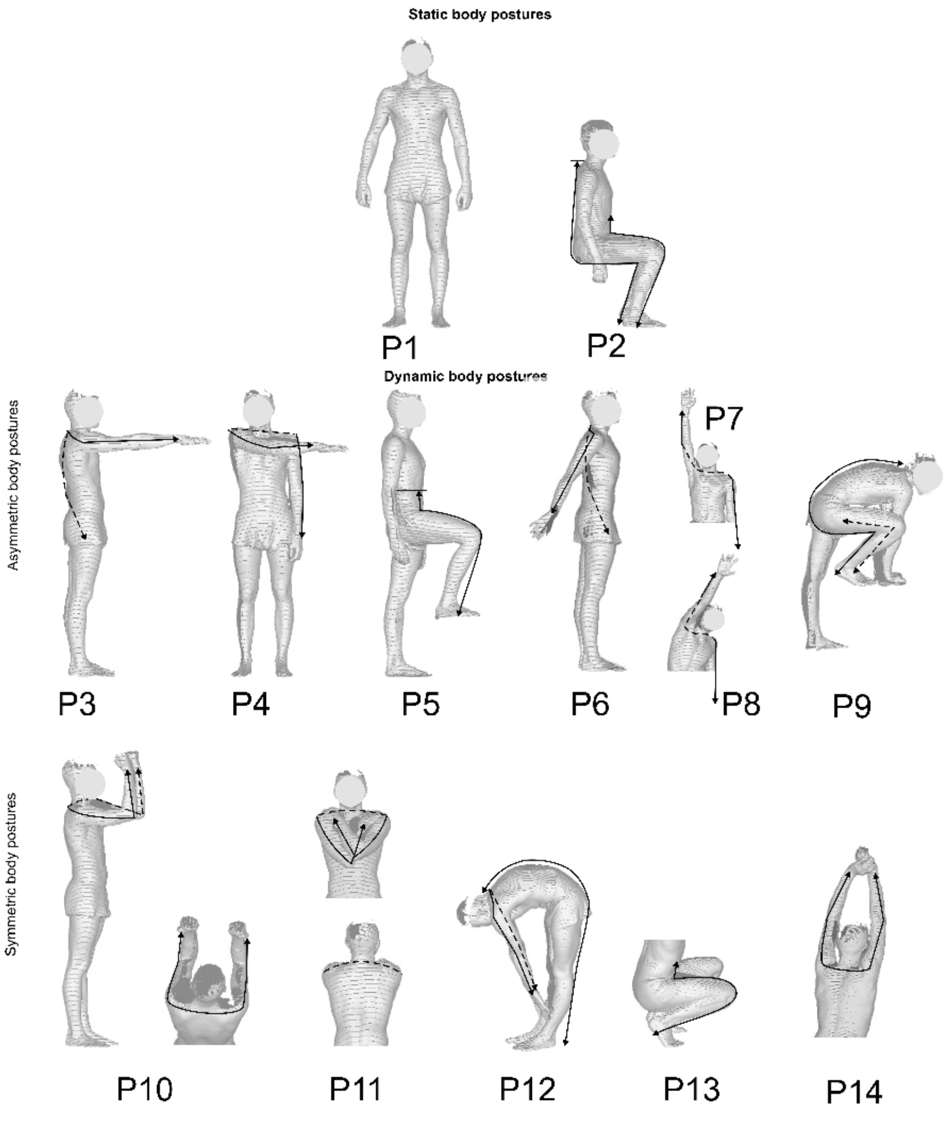


Figure 4: Body positions to investigate the effects of dynamic anthropometry on the fit and functionality of protective clothing

The measurement positions of the human body are shown in Fig. 5 while the person is in a static position. The measurement was carried out according to anthropometric principles. Fig. 5a shows the positions of the measurements that have a direct effect on the wearing comfort of the protective clothing. Fig. 5b shows the definition of the measurements in the areas where the seams of the garment or the greatest strain of the garment are located. For different body positions, only the segments in which the movement of the body part was realized were measured.

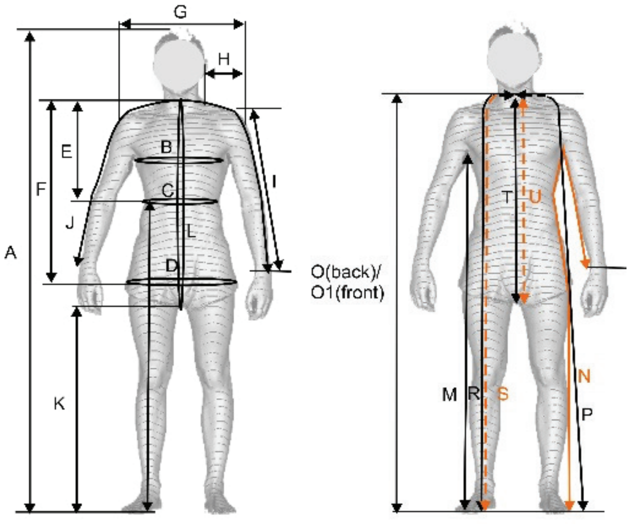


Figure 5: Measuring positions: a) body measurements, b) garment measurements (seam lengths and strain positions of the garment)

3. RESULTS AND DISCUSSION

Based on the methodology presented, the measurements for asymmetric body positions shown in Table 1 and the measurements for symmetrical positions shown in Table 2 were determined.

Tables 1 and 2 show the body measurements that directly affect the fit of the garment when certain movements are performed. The body position P1 is the basic position on which the garment is constructed. Garments made based on measurements in the P1 position will fit well while performing simpler movements. Asymmetrical movements of body parts, which occur frequently in the work process, change the body measurements. The measurements defined with the marking J refer to hand movements in positions P3, P4, P6, P7, P8, P10, P11 and P14, whereby it is obvious that the sleeves only need to be extended for position P11. The specified position has a strong influence on the length of the sleeves, as the arm is bent in two joints.

From the results presented, it can be concluded that the hand movements only affect the upper body, i.e. only the length of the sleeves, because the rest of the body is static and identical to the measurements in position P1. Since the effects of certain body movements on the wearing comfort of the coverall are to be observed, the length of the sleeve seams and the side seam (marked N) were measured for the specified positions. It can be seen that the difference in the length of the seam is between 5 and 40 cm depending on the position. The specified difference in the seam length affects the shortening of the sleeves and the lifting of the garment if it is a jacket. In the case of overalls, lifting part of the garment results in a strain as the garment cannot be lifted due to its shape. For positions P11 and P14, the strain is partly transferred to the side seam area of the lower part of the overalls and partly to the seat seam area, causing discomfort or inability to perform movements.

Table 1: Measurements of specific positions in different asymmetric postures

Body dimension	Body asymmetric postures								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
	Measured body dimension in cm								
A	177.9								
B	100.0								
C	82.6	82.2							
D	99.9								
E	26.3								
F	49.8								
G	42.4								44.3
H	15.4						11.6	9.2	
I	61.8								
J	169.3		165.1	168.7			152.7	152.5	169.7
K	78.6	78.1							
L	167.9	162.0							
M	122.3	126.5			132.0				L 165.3 R 137.2
N	169.5	164.0	192.6	191.9	168.1	174.0	196.8	209.0	L 197.2 R 194.9
O	154.0	153.7							
O1	146.6	137.4							
P	165.9	160.4	165.2	165.4	165.0	166.6	164.4	170.4	
R	161.9	152.7			151.9				L 146.3
S	152.4	154.5			160.4				L 181.0 R 169.5
T	67.6	63.2							49.2
U	84.0	89.4							90.5

The sitting position (P2), raising the legs (P5) and the squatting position (P13) influence the measurements of the lower part of the garment. The length of the side seam (P) was measured, with a difference of 5.5 to 6 cm compared to position P1. If the front and back parts are measured from the 7th cervical vertebra over the knee area on the front part (R) and on the back (S), the length is up to 10 cm less on the front part compared to position P1, whereas it is up to 8 cm longer on the back.

The amounts given do not exactly indicate the problematic area at the lower part of the garment, as the bending of the leg at the knee and the bending of the body at the hip are compensated for as they go in different directions. The body bends forwards and the leg in the knee area bends backwards. For this reason, additional measurements were taken in the knee and hip area, where the markers were positioned as shown in Fig. 6.

Table 2: Measurements of specific positions in different symmetrical positions of the body

Body dimension	Body symmetric postures					
	P1	P10	P11	P12	P13	P14
	Measured body dimension in cm					
A	177.9					
B	100.0					
C	82.6					
D	99.9					
E	26.3					
F	49.8					
G	42.4	42.9				
H	15.4					9.2
I	61.8					
J	169.3	161.5	172.5	166.3		135.9
K	78.6					
L	167.9				161.3	
M	122.3			130.9	136.0	
N	169.5	190.2	189.4	195.0		202.0
O	154.0			175.9		
O1	146.6			122.9		
P	165.9			159.9	157.8	
R	161.9				152.6	
S	152.4				150.1	
T	67.6					
U	84.0					

Figure 6: Marker positions on the body to determine the dimensional change in the hips and knees when performing positions P2, P5, P9, P12 and P13 compared to position P1

The measurements showed that there was a difference of 5 cm in the knee area when bending the leg, while there was a difference of 8.5 cm in the buttock area.

Position P12 with the corresponding measurements shows the difference in the measurements when bending the torso. The length of the side seam with the sleeve seam

(N) differs by 25.5 cm compared to position P1. The rear part from the 7th cervical vertebra (O) is 21.9 cm longer than in the static position P1, whereby 8.5 cm should be provided for the rear seat seam, while 13.5 cm relate to the bending of the torso from the 7th cervical vertebra to the waist. The front part (O1) is 23.7 cm shorter in position P12 and has no influence on the load on the garment in this area of the body.

The P9 body position is a climbing position in which the dynamics of the upper and lower body parts are pronounced. There are visible differences in the measurements in relation to the left and right sides of the body. The side seam (N) of the left and right side differs by 2.3 cm, while it differs by 27.7 cm compared to the P1 position. The back section, measured from the 7th cervical vertebra to the floor, is 29 cm larger compared to the P1 position. In this position, the flexion in the hip and knee area should also be separated according to the measurements obtained.

When measuring the torso from the 7th cervical vertebra to the neckline on the front, it was found that the differences in the measurements in the different body positions have no influence on the design of the overalls, as the amounts are smaller than in position P1, according to which the basic structure is made.

All the above data on body measurements in certain positions is of crucial importance for the design of functional coveralls. From the aforementioned results of body measurements and the garment's load range, it is clear that it is necessary to correct the design of the coveralls. Different body positions require a significant lengthening of certain segments of the cut to allow unrestricted movement and full functionality of the coverall in terms of protection.

Sometimes elastic materials are used to adapt the cut to specific positions, which is often not possible with protective clothing, as protective clothing is usually made from materials with specific properties of minimal elasticity.

4. CONCLUSION

It can be concluded from the above that dynamic anthropometry has a major influence on the design of protective clothing. Due to the specific positions of the body in the working environment, it is necessary to design structural solutions that ensure comfort and the necessary protection. Protective coveralls are garments that have a wide range of applications and are extremely complex in terms of adapting to different constitutions and specific body positions.

The previous solutions for adapting coveralls to specific postures did not show satisfactory results, as the design solutions were based on the segments of the garment where the strain of the garment occurred. In many cases, comfort in certain segments of the garment lead to movement restrictions in other parts of the body. In this way, protective clothing does not have the function of complete protection because the person adapts to the clothing instead of the clothing adapting to the needs of the person.

The studies presented show that it is necessary to know the kinematics of the human body, the dynamic anthropometry, the position of strain on the garment and the construction of the garment in order to determine the necessary movements on the segments of the garment. It is important to determine the mutual influence of the individual body segments, the movements and the garment as a whole.

From the above results of the body measurements indicate that it is necessary to find structural solutions when designing a protective coverall to ensure comfort and safety, regardless of the type of protection the suit is intended to provide.

REFERENCES

[1] Pravilnik o uporabi osobne zaštitne opreme, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2021_01_5_111.html *Accessed:2024-05-15*

[2] Pejnović, N. (2015). Osobna zaštitna oprema za zaštitu tijela, *Sigurnost*, **57** (2015),3, 229-242 ISSN 1848-6347, *Available from* hrcak.srce.hr/153090 *Accessed:2024-05-15*

[3] HRN EN 340:2004: Zaštitna odjeća –opći zahtjevi, Hrvatski zavod za norme, Zagreb, 2004

[4] Hrvatski zavod za javno zdravstvo - služba za medicinu rada: Zaštitna odjeća, *Available from* http://www.hzzzsr.hr/wp-content/uploads/2016/11/Zaštitna-odjeća.pdf *Accessed:2024-05-15*

[5] Bogović S., Stjepanovič Z., Cupar A., Jevšnik S., Rogina-Car B., Rudolf A.: The use of new technologies for the development of protective clothing: comparative analysis of body dimensions of static and dynamic postures and its application, *AUTEX research journal*, **19** (2019) 4; 301-311 ISSN 2300-0929

[6] Rudolf A., Bogović S., Rogina-Car B., Stjepanovič Z., Jevšnik S., Cupar A.: Virtual prototyping of special protective clothing for sport aircraft pilots, *Inovattions in protective and e-textiles in balance with comfort and ecology*, Frydrich I., Bratkowiab G. & Pawlowa M. (Ed.), pp. 84-96, ISBN 978-83-7283-855-1, Lodz, 2017, University of Technology, Lodz(2017)

[7] Bogović S., Dragčević Z., Hursa Šajatović A.: Ergonomic design and construction of protective clothing based on dynamic anthropometric, Proceedings *12th World Textile Conference AUTEX 2012, Innovative Textile for high Future Demands*, Volume I, Mijović B., Ujević D., Petrak S., Grancarić A. M., Glogar M. I., Salopek Čubrić I. (Ed.), pp. 995-1000, ISBN 978-953-7105-44-0, Zagreb: University of Zagreb Faculty of Textile Technology, (2012)

[8] Domjanić J., Bogović S.: The Impact of Dynamic Anthropometry on the Pattern Construction of One-piece Suit, *Proceedings of the 15th World Textile Conference AUTEX 2015,* Blaga, M. (Ed.), ISBN 978-606-685-276-0, Bukurešt: "Gheorghe Asachi" Technical University of Iasi, Faculty of Textiles, Leather and Industrial Management (2015)

[9] Bogović S.: Construction of Functional Protective Clothing, *Functional Protective Textiles*, Bischof Vukušić S. (Ed.), Zagreb: University of Zagreb Faculty of Textile Technology, ISBN 978-953-7105-45-7, (2012) pp. 71-100

[10]Hursa Šajatović, A.; Dragčević, Z.; Zavec Pavlinić, D.: Oblikovanje zaštitne odjeće, obuće i opreme s ergonomskog stajališta, *Available from* https://hrcak.srce.hr/file/276053, *Accessed:2024-05-15*

[11]Kirin, S.: *Uvod u ergonomiju*, Veleučilište u Karlovcu, ISBN 978-953-8213-03-8, Karlovac, (2019)

[12]Horvat, M. : Kinematika ljudskog gibanja, *Available from* https://repozitorij.fsb.unizg.hr/islandora/object/fsb%3A141/datastream/PDF/view *Accessed:2024-05-15*

DEVELOPMENT OF TEXTILES FOR USE IN THE HOSPITAL ENVIRONMENT

Sandra Flinčec Grgac

[1] University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, 10 000 Zagreb, CROATIA, sflincec@ttf.unizg.hr

Abstract: *The paper provides an overview of the successes to date in the development of protective hospital textiles with reduced textile dust generation. Textile dust is one of the causes of problems on the wards and in the extremely clean conditions of operating rooms and public facilities because it can be a carrier of infections, but also because its accumulation leads to the failure of modern, sophisticated equipment. Current findings on the influence of yarn, weave and fabric construction on the share of textile dust generation before and after care cycles are presented. In addition, the methods developed for textile pre-treatment, preparation and application of environmentally friendly antimicrobial agents are presented with regard to the use of conventional and innovative technological processes with the aim of achieving a durable antimicrobial finish. The methods and results of testing the structural, mechanical, physico-chemical and morphological properties as well as the toxicological effect of the samples before and after the care cycles are presented.*

Keywords: *cotton and cotton/PES, textile dust generation, environmentally friendly antimicrobial agents, care processes, sample characterization*

1. INTRODUCTION

Regardless of the developments in science, medicine and technology, we can see and witness durable material and health problems caused by various substances and particles around us [1]. Exposure to fine dust particles has been regarded recently a cause of numerous health problems (allergies, respiratory disease, asthma, etc.). A part of dust generated in closed areas has its origin in textiles [2, 3]. Textile dust has been a topic in scientific literature for more than 50 years. The problems caused by textile dust are not only present in textile manufacturing plants in extreme working conditions, but in wearing and application of newly developed textiles as well. Additionally, it is a hazard in hospitals, where it transmits bacteria and fungi, causing nosocomial infections, although it is not a cause of specific diseases itself. Numerous investigations in the field of textiles have been aimed at preventing the growth, development and transfer of microorganisms by textiles of natural origin. Thanks to their chemical composition, physico-chemical and mechanical properties, cotton cellulose materials have most often been applied in various branches of human activities. However, due to their chemical composition they are quite prone to the impact of microorganisms [4]. Cotton is susceptible to the impact of microorganisms because of its porous hydrophilic structure that retains water, oxygen and nutrients. In the case of microbiological attack, enzymatic degradation of cellulose to glucose occurs and glucose is used by microbes as a source of carbon necessary for their growth [4]. Although the investigations on the impact of hospital textiles on the proliferation of pathogens were done as early as the sixties of the last century [5], the problem has not been solved until present days. The solution implemented in surgery theatres is the use of disposable nonwoven textile suits with reduced particle release, with durable control and sterilisation. However the problem occurs at hospital wards, where patients are highly sensitive to germs and where cotton bedwear, reusable protective clothing (smocks), towels and curtains are used, creating larger amounts of textile dust that increase the probability of transferring pathogens [5, 6]. The above mentioned facts, as well as the need to create textile materials which generate lower amounts of textile dust, were the basis for the project investigation goal of investigating yarn and fabric parameters with the aim of creating cotton (CO) and cotton/polyester blend (CO/PES) fabrics with lower amount of textile dust generated throughout their use, primarily intended for hospital use and environment. Apart from reducing the dust generated from the material itself, it is of key importance to pay much more attention to durable antimicrobial finish in order to prevent proliferation of contagious diseases through textile materials by improving protective and hygiene properties of the textiles used in the hospital environment. World market has exhibited, due to higher awareness of the need to protect from the impact of various microorganisms, a double-digit growth of demand for antimicrobial textiles. However, numerous chemicals that are used to attain antimicrobial properties on textiles are also toxic for people and environment. These chemicals include inorganic salts, organometal compounds, iodophores, phenols and thiophenols, antibiotics, heterocyclic compounds with anionic groups, nitro compounds, urea, formaldehyde derivatives, amines, as well as various synthesised nano particles, the harmful impact of which has not been properly investigated so far [7]. Textile industry is still aimed at finding more environmentally-friendly processes and compounds to obtain efficient antimicrobial properties on cellulosic materials and their blends, especially those used in public and hospital premises. Durable antimicrobial properties of fabrics and their structures also impact the efficiency of barriers for microbes, preventing their proliferation, which results in better protection for the patients and hospital staff alike [8]. Textile industry was not able until 1975 to develop efficient fabrics for surgical gowns and covers, when speaking of antimicrobial and barrier function. Until present days, despite clinical investigations and developments in textile technology, researchers interested in infection control have been faced with a number of unanswered questions regarding the issue of evaluating the efficiency of the “barrier” fabrics used. The Hospital Protective Textiles project, co-financed by the Croatian Science Foundation, investigated the possibility of manufacturing fabrics from cotton fibers (CO) and their blends with polyester (CO/PES), focusing on observing the influence of yarn construction and weave fabrics (plain, twill, satin weaves and their derivativesand) on textile dust generation before and after the multiple care cycles and functionalization of selected samples to achieve antimicrobial and wellness effect for targeted use in the hospital environment.

2. INFLUENCE OF FABRIC CONSTRUCTION AND WASHING CYCLE ON TEXTILE DUST GENERATION

The development of textiles with reduced textile dust generation for use in the hospital environment is a challenging process. The geometric structure of fabrics is very complex and each part of it can be considered as a separate entity that influences the physical and mechanical properties of the fabric to a certain extent. Over the last few decades, a lot of research has been carried out, which can be divided into three categories depending on the level at which the material is viewed: The macro level (> 10^{-2} m) refers to the construction of the fabric, which is analyzed as a homogeneous continuum obeying a certain constitutive law [9]. Mezo level (10^{-3} do 10^{-2} m) includes the description of basic, representative element of weave, i.e. weaving point. The analysis of a basic element offers the possibility to evaluate the behaviour of the whole structure. Micro level includes interactions of fibres in yarn structure (< 10^{-3} m). Yarn inner structure consists of fibre bundles (10^{-6} m) which can but need not be torsionally twisted. The description of yarn structure behaviour and behaviour of the fibres themselves can offer a basis for the prediction of yarn behaviour and interaction among the yarns in the woven structure, i.e. to describe the property of yarn compacting it is necessary to investigate the interaction among the fibres constituting the yarn. Fabrics are exposed to various stresses in use. This results in yarn displacements within the structure, causing wear and release of coarse and fine particles from the material, such that could cause various problems in public and hospital areas. Pathogens are largely transmitted by airborne dust, which can be inhaled, or by deposited dust, which can serve as a breeding ground for bacteria and fungi.

It is well known that it is precisely for the reasons mentioned above that carefully prepared nonwovens are used in large quantities in the clean rooms of operating theatres, which have been tested for the possibility of textile dust formation in accordance with the EN ISO 9073-10 [10]. The large quantity of nonwovens that are used only once poses the problem of waste accumulation, and from this knowledge an attempt was made to investigate the possibility of producing textile fabrics with reduced generation of textile dust, which find their application not only in the hospital environment and in public spaces, but also as a valuable material for conservation and art restoration. In order to investigate the influence of the fabric weave and the care cycle on the generation of textile dust, a textile dust test was carried out using a modification of the standard method for testing nonwovens EN ISO 9073-10 [10]. For this purpose, the test time was extended from the prescribed 5 min to the optimal 30 min, and more reliable results were obtained [11].

As previous studies have shown, dust formation in textiles increases after several washes. For a large-scale investigation into the possibilities of producing fabrics with lower textile dust generation, it was necessary to carry out a study on fabrics currently used in the hospital sector for the production of protective clothing in operating theaters and bed linen. It has been proven that washing processes have a negative effect on the strength of the fabric, i.e. with an increasing number of washing cycles, the fabric is mechanically damaged and in correlation with this, more particles are released from the surface of the fibers. The distribution of particle release is interesting: for particles of 0.3 µm, 0.5 µm, 5 µm and 10 µm, the number of particles released increases with the number of wash cycles, while for particles above 25 µm the number of particles released decreases. The lower release of particles larger than 25 µm can be explained by the fact that these particles originate from fibers separated from the yarn and correspond to the average diameter of a mature cotton fiber, which is 25 to 30 µm. The amount of particles released with a size of 1 µm shows no significant differences depending on the number of washing cycles [12].

In addition, the problem of textile dust generation is approached trough process of weaving. As already known, textile dust is mainly caused by the friction between the threads. Since different weaves have a different arrangement of the intersection points within the weave unit cell and thus a different contact area between the threads, it stands to reason teth particle generation and its release can be manipulated by adjusting the weave parameters. The research was carried out on 100% cotton fabrics in tree basic weaves: plain, satin and twill. Fabric densitie for every weave was 24 threads per cm in the warp and weft direction. In addition, the number of intersections and the surrounding intersection points as well as the number of warp and weft yarns per unit length have a decisive influence on the amount of friction. These factors can be summarised in a firmness factor (φ, %), calculated according to the following equation:

$$\varphi = \sqrt{\frac{12}{\pi}} \cdot \frac{1}{P_1} \cdot \sqrt{\frac{T_{average}}{\rho}} \cdot S_2^{\frac{1}{1+2/3\sqrt{T_1/T_2}}} \cdot S_1^{\frac{2/3\sqrt{T_1/T_2}}{1+2/3\sqrt{T_1/T_2}}}$$

(1)

where: P_1- weave factor which is 1 for plain weave, T_1, T_2, T average -warp, weft and average count, respectively (tex), S_1, S_2 - warp and weft density (per 10 cm), ρ -fibre density

A higher firmness factor for plain weaves results in a lower amount of particles, because even with tough plain weaves there are the most intersection points and thus a large number of contact points between warp and weft, the fabric structure is more compact and does not allow as much movement between the threads as other weaves. Twill and satin, on the other hand, have lower firmness factor, which means a looser structure where floating threads rub more easily against tangent threads. This leads to higher friction and therefore a higher particle count. It is also possible that some of the generated dust does not release from more compact structures such as plain weave , but remains in the fabric structure [13].

All of the above was investigated through the examination of cotton (100%) and cotton/polyester (50%/50%) fabric in plain weave of three different weft densities (17, 20, 23 threads per cm) with the same other properties. The samples prepared in this way were washed up to 50 times. The influence of the strength parameters of the fabric on the topographical properties of the fabric surface and the release of textile dust under low mechanical stress (comparable to the stress in daily use) before and after 3, 10 and 50 washing cycles was investigated. The analyzes showed a positive correlation between the strength factor of the fabric and the generation of textile dust particles. If the active area of the fabric is smaller due to the higher density of the fabric, the internal structures of the fabric generate more friction and therefore more particles than a fabric with a looser structure. The results obtained indicate the possibility of using the DinoLite digital microscope and imaging software as one of the faster and non-destructive methods for determining surface roughness in order to estimate the ability of fabrics in terms of the tendency to form textile dust [14, 15].

In view of the increasingly stringent requirements for determining environmental quality, much of the research focuses on the presence of particles of polymeric origin in the air and water. For this reason, the study of the influence of 3, 10 and 50 washing cycles on the properties of cotton fabrics and cotton/polyester blends in plane weaving has been deepened. In addition to the analysis of the tensile properties in weft and warp direction and thickness, the number of particles formed in the dry state after 3, 10 and 50 washes was also measured, as well as the effluents after washing, which were analyzed by determining the total suspended solids (TSS), total solids (TS), pH and conductivity. The increased strength of cotton/polyester fabrics after 3 and 10 wash cycles in the weft direction is the result of fibrillation and shrinkage. The changes in fabric properties, expressed as total wear in the warp direction after 50 wash cycles compared to the unwashed state of 41.2 % for cotton and 30.9 % for cotton/polyester blended fabrics, can be attributed to the synergy of process parameters, fabric structure and raw material composition. The number of particles > 25 um released in the dry state is significantly lower than the number of particles released in the size range from 0.3 to 5 µm. In all size categories, the quantity of particles released in the dry state is significantly greater for washed cotton fabric than for washed cotton/polyester fabric. As the detergent contains water-soluble components, the TSS values determined confirm the degree of contamination of the effluent with particles from the textile materials tested. Based on the spectral bands of the CO and CO /PES samples before and after 3, 10 and 50 wash cycles, no significant changes were detected at the physicochemical level within the polymers of the tested samples. According to the hierarchical cluster analysis [16] (HCA) dendrograms, particle release in the first wash cycles is mainly controlled by the material structure. Future washing cycles are influenced by chemical, mechanical and thermal interactions. The research results underline the need for an analytical approach to categorise and quantify particles released from textiles both in the dry state and during washing to reduce the potential for harmful effects on humans and the environment [16, 17].

In addition to the effects on the environment and the user's health, the requirements for textiles that come into direct contact with people relate primarily to comfort. To evaluate the comfort and the generation of textile dust, a cotton/polyester fabric (50%:50%) in satin weave (A1/4 (A)) with a warp density of 36 threads per cm and a weft density of 26 threads per cm and a surface mass of 183.9 g/m2 was subjected to several washing cycles in accordance with the standard EN ISO 15797:2017 [18] with the application of the standard detergent WFK 88060 and ε-(phthalimido)peroxyhexanoic acid (PAP). Measurements were taken on the samples prepared in this way before washing and after the third and tenth wash cycle using the Fabric Touch Tester (FTT M293, SDL Atlas) to assess the hand feel of the fabric.The samples were also tested for the release of textile dust according to the standard EN ISO 9073-10 [10] with measurement conditions adapted to the fabric, and the effects of certain hand feel properties on the quantity and size of the textile particles generated were evaluated. Results measured using FTT showed that washing cycles affect fabric properties, including surface roughness profile, average wavelength and amplitude, bending stiffness and roundness of the profile, coefficient of friction and thermal permeability and conductivity. The roundness of the profile fabric surface varies with wash cycles, being higher after three cycles and decreasing after ten wash cycles. This can also be seen in the coefficient of friction [19], which is related to the morphology of the surface of the cotton/polyester sample, which becomes smoother after 10 washing cycles. The surface friction coefficient correlates with the number of larger textile dust particles released. Surfaces with a higher coefficient of friction offer greater resistance to sliding and tend to retain larger particles, while smaller particles are more easily released from the surface. The results show that due to the reduced friction caused by the change in the morphology and structure of the fabric, which was permanently altered by exposure to mechanics, chemistry and heat after 10 wash cycles, the number of particles released was reduced compared to the sample after 3 wash cycles [19]. The evaluation of thermal comfort shows a non-linear decrease in the transfer of thermal energy through the fabric after the wash cycles. This is probably due to the shrinkage of the fabric and the increasing thickness, which leads to a lower porosity of the fabric. Fabric samples in satin weave show improved thermal conductivity during compression and recovery after three wash cycles. The reason for this could be that the contact points between the threads enable better heat transfer through the material, while air gaps increase the resistance to heat transfer. The textile material (fibres/yarns) acts as a heat conductor and the air as an insulator. Although satin weave fabric is comfortable to wear due to its smooth surface and high pliability, it tends to deform with frequent care, which limits its lifespan. Irrespective of this, such a fabric can be used for various purposes in the hospital sector, e.g. for bandages, dressings, bed linen, etc. with a limited service life [19].

In general, the information gained through the above-mentioned research on fabrics at the micro, macro and meso levels is a valuable contribution to further development aimed at replacing non-woven textiles with woven ones wherever possible, thus helping to reduce waste and improve environmental and economic sustainability.

2. ANTIMICROBIAL TREATMENT COTTON AND COTTON/PES FABRICS AND ITS CHARACTERIZATION

In addition to reducing the textile dust generated by the material itself to prevent the spread of infection through textiles, greater attention is being paid to durable antimicrobial treatment to improve the protective and hygienic properties of textiles used in hospital environments. World market has exhibited, due to higher awareness of the need to protect from the impact of various microorganisms, a double-digit growth of demand for antimicrobial textiles. However, numerous chemicals that are used to attain antimicrobial properties on textiles are also toxic for people and environment. These chemicals include inorganic salts, organometal compounds, iodophores, phenols and thiophenols, antibiotics, heterocyclic compounds with anionic groups, nitro compounds, urea, formaldehyde derivatives, amines, as well as various synthesised nano particles, the harmful impact of which has not been properly investigated so far. Textile industry is still aimed at finding more environmentally-friendly processes and compounds to obtain efficient antimicrobial properties on cellulosic materials and their blends, especially those used in public and hospital premises. Antimicrobial agents used in protecting textiles often contain more than one active component and need aggressive conditions for the treatment or modification to become durable which causes damage to the material [20-23]. Besaid to commercial products with antimicrobial activity based on quaternary ammonium compounds, which have shown sustained antimicrobial efficacy, and the ability to apply small amounts during the wash and add afterward to improve efficacy [24] the possibility of using environmentally friendly antimicrobial agents such as various essential oils with confirmed antimicrobial activity has been investigated encapsulated inside β-cyclodextrin (b-CD) and chitosan.

Cyclodextrine (CD) consists of glucopyranose units, interconnected with α-1,4-glycoside links. Their key characteristic is the ability to create complexes with various hydrophobic compounds. The hollow of the β-CD molecule plays the role of a "host", while the complexing hydrophobic molecule plays the role of a "guest". The creation of a complex does not change the β-CD characteristics. However, the physical and chemical properties of the "guest" molecule are considerable changed: solubility of hydrophobic compounds is increased, degradation impacts of oxidation, hydrolysis, high temperature and UV radiation are reduced, together with the rate of evaporation and sublimation. The complex is not durable what depends upon a number of factors, such as the size of the "guest" molecule, van der Waals forces, water molecule release, hydrogen bonds, and others [25], which will be systematically investigated in the course of the project, when the Laboratory for Controlled Monitoring of Crosslinking Processes is established.

Part of the research focuses on monitoring the influence of ultrasonic waves on the stable binding of inclusion complexes β-cyclodextrin-peppermint oil (β-CD_PM) to cellulose in cotton and cotton/polyester material in the presence of 1,2,3,4-butanetetracarboxylic acid (BTCA) as crosslinking agent and sodium hypophosphite monohydrate (SHP) as catalyst [26]. The treatment was carried out at room temperature in an ultrasonic bath with a frequency of 80 kHz for 10 minutes. After sonication, the samples were left in the bath for 24 hours and then dried. Fourier transform infrared spectroscopy with attenuated total reflectance technique (FTIR ATR) (PerkinElmer Inc., Waltham, MA, USA, Spectrum 100 software) with unit wich can heated up to 300 °C (Golden Gate FTIR-ATR). The treated samples were analyzed by an FTIR-ATR Golden Gate at temperatures of 150 °C to determine the optimal time for crosslinking the -β-CD_PM with the cellulosic material using BTCA as crosslinking agent. According to the obtained results, a thermocondensation time of 5 minutes at 150 °C was selected. The samples were subjected to a series of washing cycles in the Wascator FOM71 CLS (Electrolux, Sweden) according to ISO 6330:2012 [29], with 20 g of standard detergent added. The samples were washed at 60 °C for 66 minutes. After washing, the samples were dried, ironed and analysed. The FTIR-ATR method applied in monitoring physico-chemical properties of the samples clearly indicates spectral band changes and the binding of _β-CD_PM inclusion complexes to cellulose by ester bonds, whereas the presence of peaks at 1721 cm^{-1} confirms the persistence of changes after 10 cycles of maintenance. A peak at 1710 cm^{-1} indicates the presence of an ester group characteristic of polyester fibers, with significantly increased intensity after treatment (CO/PES_β-CD-PM_H). The peak at 1575 cm^{-1} is present in the untreated sample, with very low intensity. In the treated sample, the peak disappears at the same wave number, but then after one wash cycle the appearance of peaks is visible, confirming the presence of carboxylate anions, indicating the crosslinking of inclusion complexes of β-cyclodextrin peppermint oil with the cellulose component in CO/PES blends by 1,2,3,4-BTCA. Also, effectiveness of the treatment is confirmed by the absence of microorganisms on the treated cotton sample before (CO_β-CD-PM_H) and after the 1st, 3rd and 10th maintenance cycles indicate the absence of an inhibition zone, but bacteria were also not found on and below the sample , which indicates antimicrobial action, we assume the slight release of peppermint essential oil from the inclusion complex. From the obtained results after the 1st, 3rd and 10th wash cycles at 60 _C, it is evident that the binding of β-CD-PM inclusion complexes was successfully performed using ultrasound. Moreover, further research will be focused on the achievement of good mechanical properties using a less acidic medium [28].

Flinčec Grgac et al. investigated the influence of pretreatment of cellulose material in a NaOH solution of different concentrations in the stretched state on the mechanism of crosslinking of β-cyclodextrin and its inclusion complexes with essential oils on the cellulose polymer of cotton and cotton/polyester fabrics with or without the application of microwave radiation. For better crosslinking, polycarboxylic acids and Na-hypophosphite monohydrate were used as catalysts. The persistence of β-CD on treated cellulose fabrics was tested by performing one or more washing cycles in accordance with the ISO 6330:2012 [27]. The properties and structure of the processed materials were characterized by FTIR-ATR and FE-SEM. Breaking forces and mechanical damage of the materials were determined in accordance with EN ISO 13934-1:1999 [28]. Morphological characterization of the surface of the treated cotton sample was performed using a high-resolution scanning electron microscope, MIRA, LMU Tescan (FE-SEM) and the successful binding of the β-cyclodextrin particles with the cellulose before and after the washing cycles was demonstrated. The best results were obtained with the sample exposed to microwave energy at a power of 80% and with the surface uniformly covered with β-CD (Figure 1). In order to quantify the behavior of the sample treated with the inclusion complex β-CD-essential oil in releasing the odor of cellulose fabrics, a subjective method of olfactometric determination of odor intensity was performed for some samples. [29, 30]

Cationization of β-CD was carried out with the aim of achieving permanent bonding with the cellulose material, and the processing of standard cotton fabric was carried out by the process of impregnation, aging and heating with microwave energy. Considering the fact that the process of binding cationized β-CD prepared in this way to cellulose material is stable to several washing cycles and does not require additional chemicals, and that the treated materials have good mechanical properties, i.e. minimal damage, an attempt is made to further investigate the possibility of using samples prepared in this way as carriers for various active substances with antimicrobial and wellness effects [31].

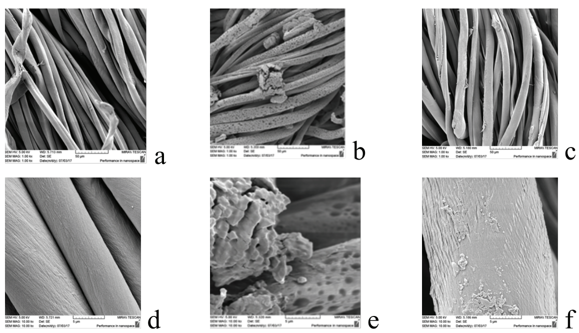


Figure 1. Representative FE-SEM images of cotton sample (a, d), and sample treated in microwave over on the power of 80% at 4 minutes before (b, e) and after washing processes (c,f.) at different magnifications: a, b,c 1000x; d, e, f 10000x [30]

Numerous scientific investigations have been aimed at reaching durable treatment of cellulose textiles using chitosan, which possesses physical and chemical properties of biodegradability, biocompatibility, and antimicrobial effect and is not toxic. It is well known that chitosan is obtained from chitin by deacetylation (approximately 60% is needed to become soluble in an acid). It is predominantly built of 2-amino-2-deoxi-D-glucopyranose units, linked with ß-1,4- links. Various factors are important for the treatment of textile materials, such as raw chitine source, degree of polymer deacetylation, arrangement of the molecular mass, the concentration of the acids applied, pH, ionic character, as well as the temperature [32]. Primary (C-6) and secondary (C-3) hydroxyl groups at each repeating unit are responsible for its reactivity, together with amino (C-2) groups at each deacytilated unit prone to chemical modifycations. Mechanical and physical properties that impact chitosan properties can be varied, while its derivatives are used in various field. Chitosan is well known in medicine as an efficient material to prevent bleeding, when used as a chitosan film on bandages, as an efficient antimicrobial agent, and as a material that can transfer medicines through skin. Therefore, its application is being investigated to achieve durable antimicrobial properties with minimal damage to CO and CO/PES fabrics.

The durability of chitosan functionalization of textile substrates made of cellulose, cotton and cotton/polyester blended fabrics was investigated. Chitosan functionalization was carried out with maleic acid (MA) and 1,2,3,4-butanetetracarboxylic acid (BTCA) as crosslinking and chitosan activating agents and sodium hypophosphite monohydrate as catalyst. To determine the durability, the fabrics were subjected to 10 care cycles according to ISO 6330:2012 [27] using reference detergent 3 and drying according to Procedure F. The properties were monitored after the third and tenth cycle. The crosslinking ability of chitosan with cellulose fabrics was monitored by FTIR-ATR. The changes in mechanical properties, whiteness and yellowing as well as antimicrobial properties were determined using standard methods AATCC TM 147-2016 [33]. Both acids showed good crosslinking properties, independent of the cellulose fabric (cotton or cotton–polyester blend). The mechanical damage of the cotton fabric was greater than that of the cotton–polyester blend, which is due to the sensitivity of cotton to acids compared to polyester, but also to the greater number of free groups over which chitosan crosslinking could occur. Maleic acid caused a higher percentage of mechanical damage compared to 1,2,3,4-butanetetracarboxylic acid as a crosslinking agent, regardless of concentration.

Maleic acid and 1,2,3,4-butanetetracarboxylic acid proved to be good, environmentally friendly crosslinking agents, as cotton or cotton–polyester blend fabrics showed good durability even after 10 care cycles. All treated samle no activity against bacteria was observed, but activity against the microfungus Candida albicans was present after 10 care cycles. Compared to maleic acid, BTCA proved to be a better crosslinking agent for chitosan considering all tested properties [34, 35]

The group of authors investigated the possibility of successfully attaching chitosan to cotton and polyester/cotton materials using 2,3-dihydroxybutanediolic acid and SHP as a catalyst. All samples were pre-treated in 8% NaOH in the stretched state before treatment in the bath. During processing, the samples were treated with microwave energy. The IR spectral curves of the two treated samples before and after the washing cycle indicate permanent physico-chemical changes in the treated samples. In all tested samples, due to processing in an acidic medium and high condensation temperature, there was a reduction in tensile strength towards the warp and weft yarns, but the material still retained its useful properties. The antimicrobial efficacy was confirmed in the treated cotton samples after 1 and 3 washing cycles on E.coli, where an inhibition zone of 1 mm is visible around the sample, while in the other samples there is efficacy as there is no growth of bacteria (E.coli) on the surface of the samples and below [36].

With the aim of a better implementation of chitosan in the structure of cotton and cotton/polyester fabrics, the influence of a pretreatment of the fabric in 20% NaOH and a subsequent treatment with chitosan dissolved in citric acid with SHP as catalyst was investigated. Since the cotton cellulose structure was opened during pretreatment and the polyester was hydrolyzed, the chitosan was able to penetrate the structure more easily during treatment was performed in two-step procedure on jigger (Konrad Peter Lab.) [37], and after drying and thermocondensation, the chitosan was crosslinked with the cellulose and polyester polymer. To determine the persistence of the binding of chitosan in the fabric structure, five wash cycles were performed according to ISO 6330:2012 [27] using ECE reference detergent 98. The fabrics were washed in the Wascator FOM71 CLS, Electrolux, for 30 minutes at 60 C. Morphological analysis on the FE-SEM, physico-chemical characterization with the spectrometer FTIR-ATR, determination of the surface charge of the sample, i.e. the zeta potential with the electrokinetic analyzer (EKA, Anton Paar GmbH, Graz, Austria), measurement of tensile properties according to EN ISO 13934-1:1999 [28] on a TensoLab Strength Tester (Mesdan S.p.A., Puegnago del Garda, Italy) and the determination of antimicrobial activity according to AATCC TM 147-2016 [33] confirmed that chitosan particles are present in the fabric sample even after five washes. It emphasized that the fabric treated in this way exhibits good antimicrobial and structural properties even after washing cycles. The technological treatment process represents a step forward in the development of fabrics for use in the hospital environment, which can be further developed and applied in industry [38].

Considering all the findings related to the use of chitosan in finishing cellulose fabrics, the influence of crosslinkers (maleic acid) and catalysts (SHP) on the possibility of obtaining stable bonds by hydrothermal *in situ* synthesis between cellulosic material in plain and satin weave and chitosan with and without tea tree essential oil was investigated. The coverage of the sample with a thin chitosan film in the form of a larger amount of agglomerates in the plain and satin weave fabric samples are comfirmd with FE-SEM. Covering the fibres with tine film of chitosan are still visible in all the samples after care cycle, which indicated stability of the treatment for all samples which the process of *in situ* hydrothermal synthesis definitely contributed. The stability of the treatment was also confirmed by the spectral curves of the treated samples before and after washing, recorded with an FTIR -ATR which indicate physicochemical changes in the polymer of the fabric after treatment compared to the spectral curve of the untreated samples. All samples showed good hydrophilicity according to the goniometer results, regardless of the presence of a chitosan film around the fibers in the fabric. In addition, all treated samples showed an increase in mass before and after washing compared to the untreated samples. Antimicrobial efficacy against bacteria and fungi was confirmed in all the treates samples before and after the care cycle. In view of the results obtained, the authors point out that the application of in situ hydrothermal synthesis for the purpose of processing textile materials is a method that provides excellent results, with the stability of the properties obtained being the main focus [39].

Monitoring of the effect of antimicrobial treatments on the formation of textile dust particles was only carried out on samples treated with citric acid [40], which gives the material crease resistance and extremely good antimicrobial properties, and the material treated in this way can be used more widely in the hospital environment. Tests are currently being carried out on the effect of selected antimicrobial treated fabrics before and after several wash cycles on the generation of textile dust to determine their application in a hospital environment.

3. CONCLUSION

An overview is given of previous research on the development of fabrics with reduced textile dust formation and their functionalization to achieve durable antimicrobial properties. From all that has been presented, it can be concluded that considerable efforts have been made to develop value-added fabrics that are primarily guided by ecological, economic and sustainable principles. A major advantage in terms of maintenance stability in the development of functional antimicrobial fabrics for hospital use was observed in the developed samples that were treated with microwave energy during processing. Development and testing is continuing and efforts are being made in collaboration with industry to start production.

REFERENCES

[1] Luce, D. et.al.: Sinonasal cancer and occupational exposure to textile dust, *American Journal of Industrial Medicine*, 32 (1997) 3, 205-210, ISSN 1097-0274.
[2] Pope, C.A.; Bates, D.V.; Raizenne, M.E.: Environmental health issues, *Environmental Health Perspectives*, (1995) 103, 472–480, ISSN 1552-9924.
[3] Afshari, A.; Matson, U.; Ekberg, L.E.: Characterization of indoor sources of fine and ultrafine particles: a studyconducted in a full-scale chamber, *Indoor Air*, (2005) 15, 141–150, ISSN 1600-0668.
[4] Szostak-Kotowa, J.: Biodeterioration of textiles, *International Biodeterioration & Biodegradation,* 53 (2004) 3, 165-170, ISSN 0964-8305.
[5] Rubbo, S.D. et.al.: Transmission of airborne bacteria in hospital wards, *Lancet*, 2 (1960). 397-400, ISSN 0140-6736.
[6] Wilkoff, LJ.; Westbrook, L.; Dixon, G.J.: Factors affecting the persistence of Staphylococcus aureus on Fabrics, *Applied Microbiology,* **17** (1969), 268-274, ISSN 2673-8007.
[7] Rauert, C. et.al.: Direct contact between dust and HBCD-treated fabrics is an important pathway of source-to-dust transfer, *Science of the total environment*, 545-546 (2016), 77-83, ISSN 0048-9697. doi: 10.1016/j.scitotenv.2015.12.054.
[8] Rogina-Car, B.; Flinčec Grgac, S.; Katović, D.: Physicochemical characterization of the multiuse medical textiles in surgery and as packaging material in medical sterilization, *AUTEX research journal*, **17** (2017) 3, 1-7, DOI: 10.1515/aut-2016-0029 © AUTEX.
[9] Vassiliadis S, Kallivretaki A, Domvoglou D, Provatidis C (2011). Mechanical Analysis of Woven Fabrics: The State of the Art. Advances in Modern Woven Fabrics Technology, doi:10.5772/25255
[10] EN ISO 9073-10 Textiles - Test methods for nonwovens.
[11] Malinar, R.; Flinčec Grgac, S.; Katović, D.: Textile particle generation: test method for nonwovens modified for use on woven materials, *Textile research journal*, **90** (2020), 19-20, 2284-2291. doi: 10.1177/0040517520915840
[12] Malinar, R. et al.: The influence of the maintenance process of hospital textiles on the generation of textile dust, *7th International Professional-Scientific Meeting "Occupational Safety and Health Protection" Proceedings*, Kirin, S. (Ed.), Karlovac: University of Karlovac, 2018. p. 502-506
[13] Malinar, R.; Brnada, S.; Flinčec Grgac, S.: Effect of constructional characteristics and sample preparation of fabric on textile dust generation, *Book of proceedings*

ITC&DC, Dragčević, Z., Hursa Šajatović, A., Vujasinović, E. (ed.). Zagreb: Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, 2018., 240-245

[14] Malinar, R.; Brnada, S. ; Flinčec Grgac, S.: The influence of fabric structure properties on surface roughness and textile dust generation, *Book of proceedings ITC&DC*, Dragčević, Z., Hursa Šajatović, A., Vujasinović, Edita (Ed.). 2022. str. 243-248

[15] Brnada, S. et. al.: Impact of weave on topographic characteristics of polyester/cotton fabrics before and after washing, *Book of proceedings ITC&DC*, Dragčević, Zvonko; Hursa Šajatović, Anica; Vujasinović, Edita (Ed.), Zagreb: Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, 2022. str. 213-218.

[16] Pušić, T. et. al.: Particle Shedding from Cotton and Cotton/polyester Fabrics in the Dry State and in Washes, *Polymers*, (2023)15; 3201-3217, ISSN 2073-4360

[17] Brnada, S. et. al.: Influence of textile care processes on the mechanical properties of the woven fabric, Autex 2019, *19th World Textile Conference*, Ghent, Belgija, 2019. 1-3.

[18] EN ISO 15797:2017 Textiles — Industrial washing and finishing procedures for testing of workwear

[19] Palčić, A.; Flinčec Grgac, S.; Brnada, S.: Sustainable Aspects of Multiple-Use Woven Fabric in the Hospital Environment: Comfort and Textile Dust Generation Perspectives, *Sustainability*, **15** (2023), 15364 -15379, ISSN 2071-1050

[20] Bischof Vukušić S. et. al.: Cotton textiles modified with citric acid as efficient anti-bacterial agent for prevention of nosocomial infections, *Croatian Medical Journal,* **52** (2010), 68-75, ISSN 0353-9504

[21] Budimir, A., Bischof Vukusic, S., Flincec Grgac, S..: Study of antimicrobial properties of cotton textiles treated with citric acid and dried/cured by microwaves, Cellulose, **19** (2012) 1, 289–296, ISSN 0969-0239

[22] Flinčec Grgac S. et al.: Antimicrobial Funcionalisation of Knitted Fabrics, *Book of Pproceedings of the 3rd International Textile, Clothing & Design Conference,* (Ed.) Dragčević, Z., (2006), Zagreb, A & C Design, 270-276.

[23] Grancarić A.M., Tarbuk A, Ujević D (2010). The Fabric Hand of Antimicrobial Protected Cotton Fabrics Using Antibiotics and Antiseptics, *Buletinul Institutului Politehnic din Iasi*, **56** (2010) 4, 39-47.

[24] Palčić, A. et. al.: Functionalization of cotton/polyester fabric with dimethyltetradecyl (3-(trimethoxysyl) ammonium chloride, *Book of proceedings ITC&DC*, Dragčević, Z., Hursa Šajatović, A., Vujasinović, E. (ur.). 2022.,136-141

[25] Vončina, B., Vivod, V.: Cyclodextrins in Textile Finishing, Chapter 3 in Eco-Friendly Textile Dyeing and Finishing, (Ed.) Günay M, (2013). InTech, DOI: 10.5772/53777

[26] Flinčec Grgac, S. et. al.: The effect of ultrasonic treatment on the binding of the inclusion complex β-cyclodextrin-peppermint oil with cellulose material, *Materials*, **15** (2022) 2; 470, 13. doi: 10.3390/ma15020470

[27] ISO 6330:2012 Textiles Domestic washing and drying procedures for textile testing

[28] EN ISO 13934-1:1999 Textiles -Tensile properties of fabrics - Part 1: Determination of maximum force and elongation at maximum force using the strip method

[29] Flinčec Grgac, S.; Vrbić, A.; Malinar, R.: The influence of microwaves on the cross-linking of maleic acid with β-cyclodextrin and cellulose, Book of proceedings ITC&DC, Dragčević, Z., Hursa Šajatović, A., Vujasinović, E. (Ed.). 2018.,100-105.

[30] Flinčec Grgac, S. ; Kopljar, Marija ; Malinar, R.: Influence of cotton pre-treatment in an alkaline medium on binding with inclusion complex of beta-cyclodextrin- tea tree essential oil, *Proceedings of 13th Symposium „Novel technologies and economic development“*, Lazić, Miodrag (Ed.). Leskovac, 2019.,128-135.
[31] Flinčec Grgac, S. ; Krešić, Anamarija ; Vrbić, Ana ; Čorak, Ivana ; Tarbuk, A. ; Brnada, S., Dekanić, Tihana: Investigation of the possibility of binding cationized β-cyclodextrin on cotton fabric, *Book of proceedings ITC&DC*, Dragčević, Zvonko ; Hursa Šajatović, Anica ; Vujasinović, Edita (ur.). 2022. str. 94-99.
[32] Simončič B, Tomšič B (2010). Structures of Novel Antimicrobial Agents for Textiles – A Review, Textile Research Journal Vol 80(16), DOI: 10.1177/0040517510363193, 1721–1737.
[33] AATCC TM 147-2016 Antibacterial Activity Assessment of Textile Materials: Parallel Strip Method
[34] Flinčec Grgac, S. et. al.: The Durable Chitosan Functionalization of Cellulosic Fabrics // *Polymers*, 15 (2023), 18; 3829, 13. ISSN 2073-4360.
[35] Flinčec Grgac, S. et. al.: The influence of maleic acid concentration on the binding of chitosan with cotton cellulose, *Textile Science and Economy Chinese-Croatian Forum Book of Proceedings*, Petrak, S. (ed.), Zagreb: Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, 2020, 51-55.
[36] S. Flinčec Grgac, Valentina M., Ana V.: Influence of pre-treatment in an alkaline medium on binding chitosan and 2,3-dihydroxy butandionic acid on cotton and polyester/cotton substrate, *AUTEX 2022 Conference Proceedings*, Tokarska, Magdalena (ed.). Łódź: Politechnika Łódzka, 2022. str. 363-367 doi: 10.34658/xxxxxxxxx
[37] Flinčec Grgac, S., et. al.: The Chitosan Implementation into Cotton and Polyester/Cotton Blend Fabrics, *Materials*, **13** (2020) 7, 1616, 18. doi: 10.3390/ma13071616
[38] Tarbuk, A. et. al.: The Influence of Cotton/Polyester Blend Fabric Pre-treatment on Chitosan Functionalization // Engineering power : bulletin of the Croatian Academy of Engineering, 18 (2023), 1; 6-12
[39] Flinčec Grgac, S. et. al.: Hydrothermal Synthesis of Chitosan and Tea Tree Oil on Plain and Satin Weave Cotton Fabrics, Materials, **15** (2022), 14, 5034, 17. doi: 10.3390/ma15145034
[40] Flinčec Grgac, S.; Malinar, R.; Inić, S.: Generiranje tekstilne prašine s celuloznog materijala obrađenog limunskom kiselinom, *7. Međunarodni stručno-znanstveni skup "Zaštita na radu i zaštita zdravlja" ZBORNIK RADOVA*, Kirin, S. (ed.). Karlovac: Veleučilište u Karlovcu, 2018., 470-475

ENVIRONMENTAL AND HEALTH IMPACTS OF THE CLOSURE OF LANDFILLS IN THE REPUBLIC OF CROATIA

Jadranka Grbinić[1]

State Inspectorate, Šubićeva 29, 10 000 Zagreb, CROATIA jadranka.grbinic@dirh.hr

Sažetak: *Gospodarenje otpadom mora se provoditi na način da se ne dovodi u opasnost ljudsko zdravlje, bez uporabe postupaka i /ili načina koji bi mogli štetiti okolišu, posebice kako bi se izbjegao rizik onečišćenja zraka, vode, tla, pojave buke i neugodnih mirisa. Cilj je u čitavom razdoblju trajanja odlagališta otpada smanjiti štetne utjecaje na okoliš. Sanacija postojećih odlagališta u skladu sa važećim propisima uz provođenje monitoringa u propisanim rokovima preduvjet je za očuvanje okoliša i kvalitetu života. Kružno gospodarenje otpadom jedan od važnijih prioriteta u gospodarenju otpadom.*

Ključne riječi: *odlagalište otpada, monitoring, sanacija, okolišno- zdravstveni učinci, kružno gospodarenje otpadom*

Summary: *Waste management has to be carried out in a way which does not endanger human health, without using procedures and/or methods that could harm the environment, especially in order to avoid the risk of air pollution, water and soil contamination, generation of noise and unpleasant odours. The goal is to reduce harmful effects on the environment during the whole lifetime of a landfill. Rehabilitation of existing landfills in accordance with the current regulations which implement monitoring within prescribed deadlines is a prerequisite for preservation of environment and quality of life. Circular waste management is one of the most important priorities in waste management.*

Key words*: landfill, monitoring, rehabilitation, environmental and health effects, circular waste management*

1. INTRODUCTION

The generation of waste and existing waste disposal sites are one of the fundamental problems facing modern society. Namely, landfills are still one of the methods of waste disposal. Environmental pollution is faster than the natural process of purification, as a result of industrialization, economic progress, but also of neglecting the endurance limits of the ecosystem. Waste is created as a result of all our activities, and its action can cause imissions into all environmental factors. How big the impact will be, depends on the amount, type and properties of the waste, and also on the way it is managed. Waste management must be started with measures to prevent and reduce the generation of waste. For already generated waste, the optimal method of processing or final disposal should be chosen, which will produce the least risk for human health and the environment (reuse, use of material or energy properties of waste).

2. CIRCULAR WASTE MANAGEMENT

Once optimal levels of waste prevention, reuse, and waste recycling are reached, the processes of energy production from waste play an important role in realizing a circular economy.

The way of production and consumption that includes sharing, borrowing, reusing, repairing, restoring and recycling existing products and materials as long as possible so that the products have added value is called circular economy. The emphasis is on extending the life of the product and reducing the amount of waste at the same time.

Improving waste management, water protection and biodiversity in order to strengthen resilience to climate change is one of the goals highlighted in the National Recovery and Resilience Plan.

Figure 1: Circular economy

It is important to be aware that certain types of waste are generated in each of our activities and technological processes. The new i.e. amended Waste Framework Directive (Directive 2008/98/EC) brings news and complements the existing definition of waste ("*every substance and object that the owner discards, intends to or must discard*") with the following terms:

End-of-waste (EoW) - contains a precise criterion to determine when a particular waste ceases to be waste. It includes efficiency, recycling, or recovery criteria. It specifies when certain waste can be considered a (secondary) product.

By-product (product) - production residue, which is neither waste nor product and which is entered in the register of by-products, i.e. a substance or object that directly results from the production process, if acceptable utilization can be ensured and it can be used directly, without further processing.

This Directive prescribes the basic principles of waste management: "*waste should be managed without danger to human health and environment, and especially without risk of impact on water, air, soil, plants or animals, without creating noise or odour imissions, and without negative impact on the environment and places of special interest"*.
The concept of circular economy provides a path to sustainable growth and development, good health, and at the same time it is solving climate change and challenges related to environment.

New forms of work that are developing in response to climate change, the so-called "green jobs" (energy sector, waste and recycling), as well as new technologies designed for environmental protection (electric vehicles and machines that use alternative energy sources) prove that waste management policy is always ready for new challenges.

3. WASTE DISPOSAL SITES

Waste disposal sites are equipped with buildings (plants) intended for the procedure of permanent disposal of waste. As part of the waste disposal site, there are also buildings for storing and processing waste. Buildings for waste disposal (waste disposal sites) are obliged to obtain an environmental permit. An environmental permit is issued for facilities where activities are carried out and for facilities where, after construction, i.e. reconstruction and commissioning of the facility, activities that may cause emissions that pollute the soil, air, water and sea will be carried out.

3.1. Active waste disposal sites

Controlled disposal of a certain category of waste at a properly organized waste disposal site is the initial form of expressing ecological awareness, which is largely conditioned by the economic power of paying for the service, since certain systems of waste processing and disposal are determined by prescribed limit values of environmental emissions.

Regardless of all the methods of waste disposal that have been applied so far, there is still a need to dispose a certain amount and type of waste.
Success in a proper planning of a complete waste management system by building sanitary landfills depends solely on

- the choice of location
- climatic characteristics
- sociological factors
- environmental protection
- monitoring (environmental monitoring)

Figure 2: Active waste disposal site

3.1.1. Choosing a location Finding all possible locations begins with the elaboration of the data collected in the field. It is necessary to display possible locations in relation to the environment (construction zones, agricultural areas, forests) and to process geological and hydrological data, which provides us with quality data when choosing a location.

3.1.2. Climatic characteristics are made up of the elements; winds, temperature, precipitation, evapotranspiration, and special attention is needed, considering that they are associated with unpleasant odours, blowing of dust and light materials, formation of leachate, gases and erosion.

3.1.3. Sociological factors are of crucial importance, considering that the surrounding population can reject even the most favourable location, primarily due to insufficient education. The "NOT IN MY BACKYARD" syndrome and the complaints of the local population need to be minimized in an acceptable way, through education and holding of public forums (introduction of eco rent).

3.1.4. Environmental protection when choosing a location should be such that there is no impact on the ecosystem, that is, if the impacts do occur, they are within the limits of legally prescribed values. The most important conditions are surface and underground water protection, soil protection, flora and fauna protection, air protection.

3.1.5. Monitoring (environmental monitoring)

Monitoring the state of the environment plays a major role in risk assessment for landfills and for its professional management before the start of any operations. Monitoring provides information that tells us how the landfill affects the environment and ensures that the landfill is managed within controlled and prescribed standards. There are 3 key phases of landfill monitoring:

- before the start of landfill work - investigative work, preparation of documentation
- during the operation of the landfill - in accordance with the obtained environmental permits

- landfill rehabilitation - in accordance with obtained project documentation

Landfill monitoring is an interactive process that includes obtaining the results of the type of terrain, environmental impact assessments, results of environmental monitoring, risk assessment and presentation of all conclusions made on the basis of the conducted research. Supervision does not end with the closure of the landfill body, but continues even when the landfills are closed and rehabilitated (max. 30 years).

3.2. Closed waste disposal sites

After the closure of the landfill and the construction of the covering sealing layer, the rappers will be placed on the surface to monitor the landfill after its closure, and the measurement must be carried out once every year.

Once waste disposal ends, chemical-physical processes continue to take place in the body of the landfill, which reduce the volume of disposed waste and this causes the occurrence of settlement and differential settlement of waste. The size of the settlement depends on the composition of the deposited waste, the method and technology of installation, the height of the waste, the percentage of humidity during installation, etc.

Figure 3: Closed waste disposal site

When the active phase finishes, the body of the waste disposal site tries to fit into the environment as best as possible. Recultivation of the final surfaces is carried out by planting grass or plants that are characteristic of the landfill environment. The further use of the space is determined by spatial planning documentation.

4. NEGATIVE IMPACT OF WASTE LANDFILLS ON HUMAN HEALTH AND THE ENVIRONMENT

The implementation of the landfill rehabilitation process continuously reduces the negative impact of waste on the environment and natural resources. The goal is to reduce the harmful effects on the environment, especially the pollution of surface water, underground water, soil and air, including the effect of greenhouse gases, and to reduce the risks to human health that could occur as a result of waste disposal and the lifetime of the landfill, the goal is to bring waste disposal sites to an environmentally acceptable state.

4.1. Groundwater pollution

Leachates are defined as polluted wastewaters that are created as a result of biochemical processes and the different content of the waste itself, as well as the passage of precipitation through the disposed waste. The resulting leachate is a mixture of highly concentrated organic and inorganic substances including humic and fulvic acids, heavy metals, inorganic salts and many other harmful substances that can be very toxic and have a negative impact on human health and the environment, especially groundwater.

4.2. Surface water pollution

Leachates contain many pollutants and can threaten the quality of the surface recipient. Biodegradable organic substances contained in the leachate reduce the oxygen content in the recipient, affect its flora and can lead to its eutrophication, and various toxic substances in the leachate can endanger a large number of living creatures in the surface water.
If larger quantities of leachate are generated, significant pollution of the recipient is possible, considering that in such situations self-purification of the recipient is not enough, especially if chemical pollution is also present.
The main goal in remediation of waste disposal sites is to reduce the amount of leachate to a minimum, to prevent contact of leachate with underground and surface water.

4.3. Air pollution

Landfills have a major impact on air quality, the environment and human health. One of the main problems with landfills that causes environmental pollution is landfill gas, the occurrence of flames and fires, dust, and the presence of birds and pests. Each of the mentioned factors in its own specific way leads to a decrease in the quality of life and health of people who live or work in the immediate vicinity of the landfill.

4.3.1 Landfill gases

Biodegradable waste disposed of in a landfill is subject to various microbiological decomposition processes, during which various types of gases are generated. Landfill gases consist of a mixture of different gases, of which methane accounts for about 45%, carbon dioxide for about 45%, while other landfill gases account for about 10%. Methane and carbon dioxide, from the aspect of impact on the atmosphere, belong to greenhouse gases and contribute to global climate change. Landfill gases also contain small amounts of nitrogen, oxygen, ammonia, carbon monoxide, sulphide and non-metallic organic compounds (NMOC). Sulphides (hydrogen sulphide, dimethylsulphide, mercaptans) are naturally occurring gases that give landfills the unpleasant smell of rotten eggs. The mentioned gases, even in very small concentrations, affect the air quality in a narrow area around the body of the landfill. At sanitary landfills, it is necessary to ensure the collection of landfill gases for the safety and health of people, and on the other hand, for economy and reduction of negative impact on the environment.

4.3.2. Occurrence of flames and fires

One of the main problems at landfills is fire, which can be the result of spontaneous combustion of waste in the depth of the body of the landfill (deep fire) or ignition of waste on the surface of the body of the landfill (surface fire) due to the action of the human factor. A fire that is not recorded in a timely manner and not brought under controlled conditions in time poses a danger of explosion and causes environmental pollution in the form of smoke and air pollution, and depending on the composition of the disposed waste, there is a possibility of dioxin formation.

4.3.3. Pests and birds

Pests (rats and insects) and birds almost always appear at waste disposal sites, and they settle here in search of food, and can transmit diseases to people and animals. Pest control and disinsectisation must be carried out continuously, in order to prevent the emergence and spread of infection. Birds can also be carriers of infection, so it is necessary to regularly compact the waste and cover the body of the landfill with inert material, thus removing waste of organic origin that is food for birds.

4.3.4. Noise

Every facility, including a waste disposal site, produces a certain amount of noise. Noise is generated during the operation of construction machinery during transportation, handling, loading, and spreading of waste on the very body of the landfill. At some landfills, cannons have been installed for dispersing birds, which, with their sound effects, represent the imission of noise into the environment.

Figure 4: Fire on the body of the landfill

5. CONCLUSION

The process of waste management – waste disposal in landfills is considered the least desirable method of waste management. With the final closure of the existing waste disposal sites, along with previously implemented remedial measures, along with continuous monitoring (monitoring of the state of the environment), we can expect a positive impact on all components of the environment, and thus bring the health-environmental effects to the highest level.

Upon accession to the EU, the Republic of Croatia signed the Directive on landfills and the Waste Directive, from which obligations arise, and which have been implemented in national legislation, including the Waste Management Act. Compliance of national regulations in the field of environmental protection with EU directives, along with regular supervision of law enforcement institutions ensures that negative impacts from waste disposal facilities are reduced to the minimum possible extent.

References

[1] Waste Management Act (Official Gazette NN 84/21)

[2] http://www.haop.hr/hr/information-systems

[3] Directive (EU) on Waste 2008/98/EC

[4] Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018.

WORKPLACE HARASSMENT (MOBBING): LEGAL FRAMEWORK AND CHALLENGES FOR THE REPUBLIC OF NORTH MACEDONIA

Marija Grozdanovska[1], **Milena Spasovska**[2]

[1] Faculty of Law, International Slavic University
St. Marsal Tito, Sveti Nikole, North Macedonia, marija.grozdanovska@msu.edu.mk
[2] Faculty of Psychology, International Slavic University
St. Marsal Tito, Sveti Nikole, North Macedonia, milena.spasovska@msu.edu.mk

Abstract: Physical, psychological, and sexual forms of workplace harassment are all frequent and dangerous for workers worldwide. Nowadays, mobbing is regulated by national legislation in a lot of countries. One example is the Republic of North Macedonia, which approved the Law on Protection against Harassment in the Workplace in 2013. All modern countries have significant challenges when it comes to some type of harassment in the workplace. This highlights the necessity for both scientific research on mobbing and effective treatment. The purpose of this paper is to analyze the mobbing legislation and the available research literature in order to identify relevant circumstances and challenges. Based on this paper, recommendations and ideas for changes to the law will be made in order to preserve and improve a fair and healthy workplace.
Keywords: workplace harassment (mobbing), consequences, challenges, perspectives, legislation.

1. INTRODUCTION

Harassment at the workplace (mobbing) is hostile and unethical communication, a specific type of behavior at the workplace with which one or more people systematically harass and humiliate another person, with the goal of jeopardizing his/her reputation, honor, human dignity and integrity, all until elimination from the workplace. Basically, mobbing leads to a gross violation of human rights and dignity, causes damage to physical, mental and social health and hinders the professional future of the worker. The consequences of mobbing have a negative impact, multiple times, both on the worker himself, on the productivity of the work organization and on society in general.

Mobbing is a psychological-sociological phenomenon that poses a threat to employees on a global level. With the exposure to this behavior, employees find themselves in an unpleasant work environment, that is not only harmful and detrimental to their overall health, but also has a poor impact on the work results [3]. Mobbing can be applied in different ways, through preventing the progress of the employee, psychological torture and humiliation, sexual harassment, dismissal of an employee with health problems, revenge, excessive control, etc. [34] But despite the actuality of this problem and the existing legal protection, instead of decreasing, the number of workers exposed to mobbing is increasing.

As well as other countries, the Republic of North Macedonia is facing this phenomenon and is taking measures for its prevention, as well as sanctioning those who commit harassment in the workplace. In the Republic of North Macedonia, the national regulation related to mobbing is contained in the Labor Law and the Law on Protection from Harassment in the Workplace. This paper presents an analysis of various aspects of the mobbing legislation and gives a theoretical review of the effects of mobbing on individuals and organizations, as well as recommendations and suggestions for preventing mobbing in the workplace.

2. DEFINITION OF MOBBING

First of all, it is important to understand that the phenomena of „mobbing“ or „workplace harassment“, as it is called in this paper, does not have an officially accepted term in the literature. As a result, there is also no definition that applies to everyone. There is no correct or true definition.

For the International Labor Organization (ILO), workplace harassment is constituted by offensive behavior through vindictive, cruel, malicious or humiliating attempts to undermine an individual or groups of employees. It involves ganging up on or "mobbing" a targeted employee and subjecting that person to psychological harassment. Mobbing includes constant negative remarks or criticisms, isolating a person from social contacts, and gossiping or spreading false information.

According to the American Psychological Association, any use of physical force or intimidation against workers in or outside the workplace, including threats, harassment, verbal abuse, physical assault and murder, constitutes workplace violence.

The term „mobbing“ originates from 1990 when it was first introduced by prof. Heinz Leymann, PhD, MD sci, who defined it as „a hostile or unethical type of communication, originating from one or more persons, systematically directed against an individual who is therefore in a helpless and unprotected position, who cannot free himself due to the actions of the mobbing that is constantly repeated“. Due to the fact that these actions are repeated - at least once a week and over a long period of time (at least 6 months), the long duration of hostile behavior leads to consequences of a mental, psychosomatic and social nature. Within his research, prof. Leymann identified 45 mobbing behaviors, which he divided in 5 groups:

1. Behaviors that affect self-expression and communication,
2. Behaviors that attack social relationships,
3. Attacks on reputation,
4. Attacks on quality of work life and
5. Attacks on health [6].

The term mobbing comes from the English verb „to mob“, which means to rush into a crowd, a noisy attack on someone and from the noun „mob“, which means a mass, a crowd, a multitude of people, a mob with destructive and hostile behavior [33]. The term mobbing is also associated with the research of Konrad Lorenz, who described it as a way of behavior of some animals, when they unite against one of the members in the pack, attack him, drive him out of the community and sometimes lead him to death [32].

Today in different countries of the world, work harassment or mobbing is known by different names in the legal sense. The table below shows the different names that denote mobbing in some states.

Table 1. Global terminology for mobbing

GLOBAL TERMINOLOGY			
COUNTRY			TERM
Australia	UK	US	workplace bullying
Belgium	France	Spain	moral harassment
Denmark	Italy	Norway	Mobbing
Germany			mobbing / psychoterror
Sweden			victimization / mobbing
Canada (Québec)			psychological harassment

In 1993, Sweden was the first country to implement legislation specifically prohibiting work harassment. Based on the Swedish experience, many European countries followed the example and implemented it in their legislation.

In Europe today there is a comprehensive network of overlapping European and national laws dealing with the growing problem of stress and harassment in the workplace. These laws derive from a combination of European Union documents and national laws that prohibit discrimination, ensuring that employers take care of the health and safety of their employees.

Today, stress and harassment at work are widespread and costly problems for employers and employees. Research for the European Agency for Health and Safety at Work in 2009 found that:

- stress is the second most reported work-related health problem, affecting 22% of workers;
- one in twenty workers suffers from workplace harassment;
- stress is a factor that accounts for 50-60% of all lost working days in 2002 (when the EU consisted of only 15 member states instead of the current 27) the cost to businesses of stress-related absence was estimated at around 20 billion euros [12].

3. INTERNATIONAL LABOUR ORGANIZATION AND WORKPLACE HARASSMENT

The Violence and Harassment Convention, 2019 (ILO No. 190) and its associated Recommendation, 2019 (ILO No. 206) represents an important milestone in the international effort to acknowledging everyone's right to a world free from violence and harassment at work. Together they provide the first global labor standard that offers a uniform framework for preventing, resolving, and outlawing Violence and Harassment (V&H) in the workplace, including gender-based violence and harassment. Additionally, The Violence and Harassment Convention is the first global document to refer to violence and harassment as a single, integrated idea. The term „violence and harassment“ in the context of the workplace refers to a range of unacceptable behaviors and practices, whether one-time or recurring, that aim at, result in, or are likely to result in physical, sexual, or economic harm and includes gender-based violence and harassment, as stated in Article 1.1(a) of the Convention.

As one of the strategies to deal with violence and harassment in the workplace, the International Labour Conference decided to modify the ILO Declaration on Fundamental Principles and Rights at Work (1998) in 2022, adding „a safe and healthy working environment" as a fundamental principle and right at work. This decision strengthened the commitment made at the beginning. This action also illustrates the ten-year evolution of occupational safety and health (OSH) in the workplace, which began with addressing safety issues and progressed to include general concerns about protecting both physical and mental well.

Without a doubt, legislation have a symbolic and educational function in confirming that violence and harassment is a workplace problem that warrants public attention. They also provide support and credibility for workplace action.

Harassment at work is a global problem that impacts a significant number of organizations worldwide. There is increasing evidence that no industry, no individual, no business, and no community can truly declare themselves immune from violence and harassment at work. The latest statistics from the ILO show that almost one in five people in employment had come across it at some point in their working lives [31]. This phenomena can happen when traveling to and from workplace, in the digital sphere via work-related emails, on business travels, at events or social gatherings, and in home offices. It is not limited to any one type of workplace (office, workstation, factory, retail).

4. EUROPEAN UNION AND WORKPLACE HARASSMENT

Violence and harassment at work are defined as: undesirable behavior by one or more individuals that can take many various forms, some of which may be more clearly identifiable than others. This is according to the 2007 Framework agreement on harassment and violence at work signed by the European social partners.

As per the definition given by Directive 2002/73/EC harassment is any circumstance in which an individual engages in undesired behavior connected to his or her sex with the intention or result of violating their dignity and creating an environment that is dangerous, hostile, degrading, humiliating or rude. Anything that „occurs, with the intention or effect of violating the dignity of a person, particularly when creating an intimidating, hostile, degrading, humiliating or offensive environment" is considered sexual harassment. This includes unwanted verbal, nonverbal, or physical conduct of a sexual nature.

At the European level, the main responsibility to protect the health, safety, and dignity of employees gives shape to the legal framework regarding stress and mobbing, which includes important elements such as:

- Article 19 of the European Union Charter on the Social Fundamental Rights of Workers stipulates that every worker must have a right to adequate working conditions in their workplace that protect their safety and health,
- Article 31 of the European Union Charter on Fundamental Rights stipulates that every worker has the right to receive benefits that are compatible with their health, security, and dignity,
- The EU Health and Safety Framework Directive (89/391/EEC), which requires companies to take steps to "ensure the safety and health of workers in every aspect

related to work," such as preventing hazards at work, addressing them at their source, and conducting evaluations of workplace risks,

- Directives 2000/43 and 2000/78 on Equality of Treatment (broadly anti-discrimination provisions) define harassment as discrimination when the unwanted behavior is related to any protected characteristic and happens with the intention of "violating upon a person's dignity and creating an intimidating, hostile, degrading, humiliating or offensive environment." Some characteristics that are protected in this situation are: age, disability, gender identity, relationship status and marriage, childbirth and motherhood, race, religion or belief, sex and sexual orientation.

5. REPUBIC OF NORTH MACEDONIA AND WORKPLACE HARASSMENT

In the Republic of North Macedonia, the national regulation related to mobbing is contained primarily in the Labor Law [35] and the Law on Protection from Harassment in the Workplace [36], which is the lex specialis in this area.

The Labor Law is the basic law that regulates labor in the Republic of North Macedonia. It prohibits any type of psychological harassment in the workplace (mobbing). According to this law, psychological harassment in the workplace (mobbing) is discrimination. It is any negative behavior by an individual or group that is frequently repeated (at least in a period of six months), which constitutes a violation of the dignity, integrity, reputation and honor of employees and causes fear or creates hostile, humiliating or offensive behavior and the purpose may be termination of the employment relationship or leaving the workplace. The perpetrator of mobbing can be one or more persons with negative behavior regardless of their capacity (employer as a natural person, responsible person or employee).

The Labor Law contains provisions prohibiting harassment and sexual harassment. Harassment and sexual harassment constitute discrimination.

Harassment is any unwanted behavior caused on the basis of different racial or ethnic origin, skin color, gender, age, health condition, i.e. disability, religious, political or other belief, trade union membership, national or social origin, family status, property condition, gender orientation or due to other personal circumstances of the candidate for employment or the employee, which aims at or represents a violation of the dignity of the candidate for employment or the employee and which causes fear or creates hostile, humiliating or offensive behavior.

Gender harassment is any verbal, non-verbal or physical behavior of a gender nature that is aimed at or constitutes a violation of the dignity of a candidate for employment or an employee and that causes fear or creates hostile, humiliating or offensive behavior.

Mobbing in the Republic of North Macedonia has been regulated by a special law since 2013, namely the Law on Protection from Harassment at the Workplace. The subject of this law are the rights, obligations and responsibilities of employers and employees in relation to the prevention of psychological and sexual harassment at the workplace and the place of work, the measures and procedure for protection against harassment at the workplace, as well as other issues related to the prevention and protection against harassment in the workplace. The purpose of this law is to prevent and protect against psychological and sexual harassment at the workplace, i.e. the place of work and ensuring a healthy working environment.

The law applies to employers, employees, candidates for employment, as well as to persons engaged with contracts, who participate in the work of the employer. The employer, the employee, as well as the persons engaged with contracts who participate in the work of the employer, are obliged to behave in a way that respects the dignity, integrity and reputation of the employees by respecting the rules of the work order and discipline of the employer and the general rules of conduct.

During the work, the employer should:

- provide conditions in which the work will be done in an atmosphere of mutual respect, cooperation, without hostile, humiliating or offensive behavior;
- develops awareness among employees about the need for mutual respect and teamwork in the performance of work tasks;
- give the employees the right to express their views, opinions and suggestions regarding the performance of the work at the workplace, and because of this, the employees do not suffer harmful consequences.

The employee, as well as the persons engaged with contracts who participate in the work of the employer in the course of work, should:

- ✓ behave correctly, decently and with dignity towards other employees and the employer,
- ✓ contribute to the creation of a working environment in which there will be no harassment at the workplace and
- ✓ contribute to the prevention of workplace harassment.

The Law on protection against harassment in the workplace prohibits any type of harassment in the workplace and contains a definition of psychological and sexual harassment.

Psychological harassment in the workplace is any negative behavior by an individual or group that is repeated, continuously and systematically, represents a violation of the dignity, integrity, reputation and honor of the employee and causes a feeling of fear or creates discomfort, humiliation, the ultimate goal of which may be injury to physical and mental health, compromising the professional future of the employee, termination of employment or leaving the workplace.

Gender harassment is any verbal, non-verbal or physical behavior of a gender nature, which is aimed at or represents a violation of the dignity of the candidate for employment or the employee and which causes a feeling of fear or creates discomfort, humiliation.

Behaviors and activities that are not considered harassment in the workplace are:

- individual acts adopted by the employer, which decide on rights, obligations and responsibilities from the employment relationship, against which the employee has the right to protection in a procedure established by law;
- deprivation and impossibility of exercising and using rights established by law, collective agreement and the employment contract, the protection of which is achieved in a procedure with the employer and before a competent court;

- any unjustified discrimination in unequal treatment of the employee on any basis of discrimination, which is prohibited and in connection with which protection is provided, in accordance with the law and
- occasional differences of opinion regarding issues and problems related to the performance of work and work tasks, unless they are intended to injure or intentionally insult the employee.

A perpetrator of workplace harassment is one or more persons who engage in negative behavior regardless of their capacity - an employer in the capacity of a individual, a responsible person at a legal entity, an employee or a group of employees from a third party with whom the employee or the employer comes into contact while performing work at the workplace.

This Law also regulates the time and place of harassment in the workplace.

The workplace where the employee who is exposed to harassment usually works or the place where the employee is directed to work by the employer is considered to be the place of psychological and sexual harassment in the workplace. The place(s) through which the employee who is exposed to harassment passes during his/her usual arrival and departure from the workplace can be considered as a place of psychological and sexual harassment at the workplace, only in the case when the psychological and sexual harassment is carried out by an employee at the same employer or another person who works for the same employer who travels or moves together or in close proximity to the employee, that is, the other person who works for the same employer with the person exposed to harassment.

The time of psychological and sexual harassment at the workplace is considered to be the time within the working hours and the time of travel to and from the workplace, when the type and manner of behavior that is considered harassment at the workplace occured.

The Law on Protection from Harassment in the Workplace separately regulates the rights and obligations of the employer and the employee.

Rights, obligations and responsibilities of the employer are:

- taking preventive measures to protect against harassment in the workplace;
- notifying employees;
- determination of intermediary and
- liability for damage.

Rights, obligations and responsibilities of the workers are:

- protection from harassment in the workplace;
- knowledge of workplace harassment and
- abuse of rights.

6. CONSEQUENCES OF MOBBING

The occurrence of mobbing in the workplace has consequences both for the victims of mobbing and for the work organization itself. The permission for mobbing, not applying effective means to oppose it, result in numerous negative consequences in the long run [10]. Mobbing greatly affects the well-being of the victims and can cause moral, psychological, physical and material damage [11].

On an individual level, mobbing can cause consequences on physical and mental health, as well as on the quality of work. Certain signs and symptoms that may occur as a result of mobbing are:

- *Physical symptoms* – fatigue, headaches, sleep disturbances, somatization, heart palpitations, gastrointestinal problems, muscular tension, increased level of blood pressure, increased level of blood sugar, shortness of breath;
- *Psychological symptoms* – emotional: anxiety, depression, irritability, hopelessness, guilt, low self-worth, decreased self-confidence; and cognitive: loss of concentration, purposelessness, reduced ability to make decisions;
- *Behavioral and social symptoms* – avoidance from work, intentions to leave work reduced productivity, dismissal, interpersonal relationship problems, isolation, lack of interest towards everyday activities, increased use of alcohol and other psychoactive substances [33].

The causes and consequences of mobbing cannot be fully covered or generalized, precisely because of the fact that each person is an individual, with their own specific characteristics and needs. However, the consequences of mobbing basically have in common that on an individual level they impair health (occurrence of organic or mental illness) and affect the professional performance of work (due to physical, emotional and mental difficulties). The person's capacity to cope with stress and difficulties is also relevant factor in predicting the effects of the mobbing. Each person has a different threshold of tolerance, so a consequence for a certain person can be simple and for another person the same consequence can be difficult and unbearable. The severity of the consequence also depends on whether the victim of mobbing wants to find an appropriate solution or if he/she believes that he/she is in a hopeless situation, that is, even if he/she reports the mobbing, no one will take any action.

Heinz Lehmann warned many years ago about the consequences of mobbing in terms of endangering human rights, which, apart from the victim, can also have consequences for the work environment and organizations in general [34]. The emergence of mobbing can cause increased absenteeism from work, break loyalty to the organization and the same, as expected, leads to a decrease in productivity and quality in work, accompanied by frequent resignations. Mobbing has significant consequences in terms of the climate, results and achievements in the work environment. The most dominant are the following consequences: a large number of absences from the workplace, frequent use of sick leave, reduced productivity, reduced quality of work, violation of work ethics, giving resignations, loss of continuity due to the need to train new employees, job turnover, early retirement etc.[25].

There are significant costs associated with workplace harassment for individual workers' health, well-being, and livelihoods; for businesses, these costs include decreased productivity, replacement, retirement and reputational harm; and for society as a whole, these costs include the possible loss of productive workers and increased strain on social services as well welfare. A number of variables that are transforming the nature of work, including new types of employment contracts, the aging workforce, job intensification, digital surveillance, and a poor work-life balance, could make the issue worse in the future.

7. SUGGESTIONS AND RECOMMENDATIONS FOR THE PREVENTION OF MOBBING

Preventive protection against mobbing can be primary, secondary and tertiary. The main goal of primary prevention is to prevent new cases of harassment in the workplace. Secondary prevention is aimed at providing effective measures to deal with mobbing when it has already occurred, while tertiary prevention provides interventions that enable victims to reduce the consequences of mobbing on their health and well-being [23].

The suggestions and recommendations for mobbing prevention begin with documentation of the cases. Anyone who believes that he/she is a victim of mobbing, in order to prove it, it is necessary to record all the data that can be used as evidence. In order for success to be more certain, it would be desirable for the worker - a victim of mobbing - to have colleagues (allies) who will stand in his/her defense for proving the harassment.

Help within the workplace can be requested from: colleagues, line manager (immediate supervisor), human resources department (sector), social care officer, through a complaint procedure (most complaints have written rules and procedures on how to make them), harassment advisors, occupational health and safety expert, union representative, etc.

All individuals have a responsibility to behave in ways which support an inclusive and tolerant working environment. To prevent mobbing on an individual level, it is recommended to:

- Maintain professionalism;
- Build and foster positive relationships with colleagues based on trust and cooperation;
- Document incidents;
- Know the policies and rights on harassment;
- Seek support in order to solve and prevent any potential harmful situation at the workplace [4].

Employers are required to prevent mobbing, i.e. above all:

- respond to behavior that may be classified as mobbing at their companies and
- take measures to prevent the occurrence of mobbing.

Mobbing prevention strategies in the companies can include raising awareness about mobbing and fostering a culture of tolerance and respect, assessing the presence of mobbing, development of anti-mobbing policies, training, selection, performance management and reward systems, consultations with human resources personnel and school-based mobbing prevention strategies with ongoing assessment of outcome effectiveness.

Consistent efforts to prevent mobbing will benefit both employees and the organization as a whole. By taking proactive measures to prevent mobbing, organizations can create safe and inclusive environment in which the employees will realize their potentials and will participate actively in fulfilling personal and organizational goals.

8. CONCLUSION

From the given review of the available literature, as well as from the analysis of the legal national and international regulation, it can be seen that mobbing is a behavior that consists in constant or prolonged harassment or intimidation of the person in the workplace. Mobbing occurs when such behavior or actions cause an employee to underestimate his/her professional suitability and cause that person to be subjected to humiliation or ridicule, as well as to be isolated or excluded from a team of co-workers or with the intention of having the same happen. The consequences of mobbing, can be severe and far-reaching, therefore it is necessary to prevent, sanction and protect the victims when it happens.

In accordance with international regulations, the Macedonian legal system regulates harassment in the workplace in the Labor Law and the Law on Protection against Harassment in the Workplace, which as lex specialis aims to ensure prevention and protection from psychological and gender harassment in the workplace and to promote a healthy working environment. But legislation without its proper implementation in practice has only a symbolic function. This is precisely why North Macedonia faces a series of challenges in the field of workplace harassment. To deal with them, it is necessary:

- ✓ Full implementation of the legal regulation related to mobbing;
- ✓ Monitoring of the international regulation, accompanied by appropriate legal amendments for the issues related to mobbing;
- ✓ Raising the awareness of workers about the recognition, consequences and harmfulness of workplace harassment;
- ✓ Raising employers' awareness of the role and importance of creating and maintaining a pleasant and safe working atmosphere, without harassment and violence against employees;
- ✓ Providing adequate help and support to victims of workplace mobbing;
- ✓ Comprehensive and continuous education and training of professionals from all relevant institutions for recognition and appropriate action in cases of mobbing;
- ✓ Education of children and students from the youngest age about the meaning of working conditions, that is, about the right and the need for safe and healthy workplaces, which, in addition to other dangers, will exclude harassment;
- ✓ Debates that bring together several interested parties refer to workplace harassment etc.

REFERENCES

[1] Akar, N.Y., Anafarta, N., & Sarvan, F. (2011). Causes, Dimensions and Organizational Consequences of Mobbing: An Empirical Study. Ege Academic Review, 11(1), 179-191.

[2] APA Dictionary of Psychology (2018). Workplace Violence. Retrieved 14.04.2024 from https://dictionary.apa.org/workplace-violence

[3] Arnejčič, B. (2016). Mobbing in Company: Levels and Typology. Organizacija. 49. 10.1515/orga-2016-0021.

[4] Blomberg, S., & Rosander, M. (2020). Exposure to bullying behaviours and support from co-workers and supervisors: a three-way interaction and the effect on health and well-being. International archives of occupational and environmental health, 93(4), 479–490. Available from https://doi.org/10.1007/s00420-019-01503-7 Accessed: 2024-04-28

[5] Da Silva João, A. L., & Saldanha Portelada, A. F. (2019). Mobbing and Its Impact on Interpersonal Relationships at the Workplace. Journal of interpersonal violence, 34(13), 2797–2812. Available from https://doi.org/10.1177/0886260516662850 Accessed: 2024-04-23

[6] Davenport, N., Schwartz, R. D., & Elliott, G. P. (2002). Mobbing: Emotional abuse in the American workplace. Ames, IA: Civil Society Publishing

[7] Directive 2002/73/EC of the European Parliament and of the Council of 23 September 2002 amending Council Directive 76/207/EEC on the implementation of the principle of equal treatment for men and women as regards access to employment, vocational training and promotion, and working conditions. Official Journal L 269, 05/10/2002 P. 0015 – 0020. Available from https://eur-lex.europa.eu/eli/dir/2002/73/oj Accessed: 2024-04-18

[8] Directive 89/391/EEC - OSH "Framework Directive". Available from https://osha.europa.eu/en/legislation/directives/the-osh-framework-directive/1 Accessed: 2024-04-26

[9] Djurkovic, N., McCormack, D. and Casimir, G. (2003), "The physical and psychological effects of workplace bullying and their relationship to intention to leave: a test of the psychosomatic and disability hypotheses", International Journal of Organization Theory & Behavior, Vol. 7 No. 4, pp. 469-497. Available from https://doi.org/10.1108/IJOTB-07-04-2004-B001 Accessed: 2024-04-26

[10] Duffy, M. (2009). Preventing workplace mobbing and bullying with effective organizational consultation, policies, and legislation. Consulting Psychology Journal: Practice and Research, 61(3), 242-262

[11] Duffy, Maureen & Sperry, Len. (2012). Mobbing: Causes, Consequences, and Solutions. 10.1093/acprof:oso/9780195380019.001.0001.

[12] European Risk Observatory Report (2009). OSH in figures: stress at work — facts and figures. European Agency for Health and Safety at Work

[13] European Trade Union Confederation (2007). Framework agreement on harassment and violence at work. Available from https://www.etuc.org/en/framework-agreement-harassment-and-violence-work Accessed: 2024-03-14

[14] Federal Anti-Discrimination Agency (N. D.). The Directives on Equal Treatment of the European Union. Available from https://www.antidiskriminierungsstelle.de/EN/about-discrimination/order-and-law/directives-of-the-eu/directives-of-the-eu-node.html Accessed: 2024-05-01

[15] Framework agreement on harassment and violence at work. Available from https://www.etuc.org/en/framework-agreement-harassment-and-violence-work Accessed: 2024-03-14

[16] Grotto-de-Souza, J., Pohl, H. H., & Aguiar-Ribeiro, D. (2023). Mobbing as a source of psychological harm in workers. Revista brasileira de medicina do trabalho: publicacao oficial da Associacao Nacional de Medicina do Trabalho-ANAMT, 20(4), 670–675. Available from https://doi.org/10.47626/1679-4435-2022-766 Accessed: 2024-03-14

[17] Hogh, A. & Mikkelsen, E. & Hansen, Å. M. (2010). Individual Consequences of Workplace Bullying/Mobbing. Bullying and emotional abuse in the workplace: International perspectives in research and practice. 107-128. 10.1201/EBK1439804896-7.

[18] Høgh, A., Clausen, T., Bickmann, L., Hansen, Å.M., Conway, P.M., Baernholdt, M. (2021). Consequences of Workplace Bullying for Individuals, Organizations and Society. In: D'Cruz, P., et al. Pathways of Job-related Negative Behaviour. Handbooks of Workplace Bullying, Emotional Abuse and Harassment, vol 2. Springer, Singapore. https://doi.org/10.1007/978-981-13-0935-9_8

[19] International Labour Organization (1998). When working becomes hazardous. p. 2. Available from http://www.ilo.org/public/english/bureau/inf/magazine/26/violence.htm Accessed: 2024-04-10

[20] International Labour Organization (2019). Violence and Harassment Convention, 2019 (No. 190). Available from https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C190 Accessed: 2024-04-14

[21] International Labour Organization (2020). Safe and healthy working environments free from violence and harassment. Geneva: ILO 2020

[22] International Labour Organization (2022). Experiences of Violence and Harassment at Work: A Global First Survey, Geneva:ILO

[23] Kostelić-Martić, A. (2006). Prevencija mobinga i vrste pomoći žrtvama. Viktimizacija na radnom mestu. Available from https://vds.rs/File/Tem0604.pdf Accessed: 2024-03-14

[24] Lo Presti, A., Pappone, P., & Landolfi, A. (2019). The Associations Between Workplace Bullying and Physical or Psychological Negative Symptoms: Anxiety and Depression as Mediators. Europe's journal of psychology, 15(4), 808–822. Available from https://doi.org/10.5964/ejop.v15i4.1733 Accessed: 2024-04-10

[25] Magee, C., Gordon, R., Robinson, L., Caputi, P., Oades, L. (2017). Workplace bullying and absenteeism: The mediating roles of poor health and work engagement. Hum Resour Manag J. 27: 319–334. Available from https://doi.org/10.1111/1748-8583.12156 Accessed: 2024-04-10

[26] Matthiesen, S. & Einarsen, S. (2010). Bullying in the workplace: Definition, prevalence, antecedents and consequences. International Journal of Organization Theory and Behavior. 13. 202-248. 10.1108/IJOTB-13-02-2010-B004.

[27] Nielsen, M. B., Hetland, J., Matthiesen, S. B., & Einarsen, S. (2012). Longitudinal relationships between workplace bullying and psychological distress. Scandinavian Journal of Work, Environment & Health, 38(1), 38–46. Available from http://www.jstor.org/stable/41508862 Accessed: 2024-04-11

[28] Official Journal of the European Communities (2000). Charter of fundamental rights of the European Union (2000/C 364/01). The European Parliament & the Council and the

Commission. Available from https://www.europarl.europa.eu/charter/pdf/text_en.pdf Accessed: 2024-05-01

[29] Official Journal of the European Union C 303/17 - 14.12.2007 (2007). EU Charter of Fundamental Rights

[30] Sansone, R. A., & Sansone, L. A. (2015). Workplace bullying: a tale of adverse consequences. Innovations in clinical neuroscience, 12(1-2), 32–37.

[31] Trebilcock, A. (2023). 2022 Amendments to the ILO Declaration on Fundamental Principles and Rights at Work. International Legal Materials, 62(4), 605–610. doi:10.1017/ilm.2023.7

[32] Westhues, K. (2007). Mobbing a Natural Fact, Adapted and revised from „Mobbing am akademischen rbeitsplatz", a lecture given in the Society for Sociology at the University of Graz, Austria, on 23 January 2007.

[33] Белевска Д. (2009). Психологија за менаџери. Универзитет за туризам и менаџмент Скопје

[34] Гаврилова, В., Гаврилова, А. (2023). Психологија на менаџмент и лидерство (второ издание). Меѓународен Центар за Славјанска Просвета

[35] Закон за работните односи (пречистен текст). Достапно на https://mtsp.gov.mk/content/pdf/2023/trud/ZRO,%20precisten%20tekst%202023.pdf Пристапено на 2024-03-14

[36] Закон за заштита од вознемирување на работното место. Достапно на https://www.mtsp.gov.mk/content/pdf/trud_2017/pravilnici/16,,11-%D0%B7%D0%B0%D0%BA%D0%BE%D0%BD%D0%97%D0%B0%D1%88%D1%82%D0%B8%D1%82%D0%B0%D0%92%D0%BE%D0%B7%D0%A0%D0%B0%D0%B1%D0%9C%D0%B5%D1%81%D1%82%D0%BE.pdf Пристапено на 2024-03-14

TOBACCO STALKS BIOBRIQUETTES COMBUSTION EMISSIONS – ENVIRONMENTAL IMPACT AND ENERGY EFFICIENCY

Ivan Mijailović[1]

[1] Faculty of occupational safety in Niš, Čarnojevića 10a Niš, Serbia
ivan.mijailovic@znrfak.ni.ac.rs

Abstract: RES (renewable energy sources), or “green energy”, are forms of exploitable energy obtained from various physical processes. The main purpose of RES is to limit greenhouse gas emissions, diversify energy supply, and reduce dependence on unreliable and volatile fossil fuel markets, especially oil and gas. At the moment, alternative energy sources are needed more than ever; one of the solutions is consumption of biomass, and particularly the agricultural waste. In the Republic of Serbia, one of the agricultural waste sources are tobacco stalks, the byproduct of tobacco industry. Tobacco production in Serbia in 2021, by the record of Statistical Office of the Republic of Serbia, was 10097 tons collected from 5803 hectares. After picking and drying, tobacco leaves are used in cigarette and cigar production, while the residual tobacco stalks are considered a green agricultural waste. The heating value of tobacco stalks is satisfactory, and also, there is a very low and acceptable content of nicotine in tobacco stalks (0.5%). The aim of this paper is to determine the energy efficiency of tobacco stalks briquettes as the energy source. Emission of greenhouse gasses (CO, NO, O2, CO2 and THC) will be presented, and the economic and environmental benefits discussed.

Keywords: *Agricultural waste, Biobriquettes, Combustion emissions, Tobacco stalks.*

1. INTRODUCTION

Reduction of greenhouse gas emission has a strong environmental and economic influence in terms of energy use and consumption. Replacing the fossil fuels with renewable energy source becomes one of the main strategies in sustainable development. Biomass as a renewable energy source will be more exploited in near future in developing countries, mainly because of its prevalence and quantity. Biomass can be successfully used for generation of heat and electricity, which is one of the most effective and economical way of biomass use.

Therefore, use of biomass in form of briquettes and pellets can be reasonable in areas where there is a lack of other energy sources. [1] This particularly applies to countries that, on one hand, import conventional fuels, and on the other hand, do not use any available renewable energy source sufficiently.

It should be noted that agriculture is at the same time producer and consumer of great amount of energy. [2] In the countries, in which economies are mainly based on agricultural production, this fact is very important in many ways. In terms of energy consumption, potential use of any kind of agricultural waste should be priority. It is estimated that in the Republic of Serbia yearly production of agricultural waste is approximately 12.5 million t. Assuming that only 25% of this biomass can be used as energy source, this would be more than 3 million t, or 1.4 million t of fuel oil. According to the statistics, this biomass could completely cover all energy needs in agricultural sector. [3]

In the Republic of Serbia, one of the agricultural waste sources are tobacco stalks, the byproduct of tobacco industry. Tobacco production in Serbia in 2021, by the record of Statistical Office of the Republic of Serbia, was 10097 tons collected from 5803 hectares. After picking and drying, tobacco leaves are used in cigarette and cigar production, while the residual tobacco stalks are considered a green agricultural waste.

Literature data considering tobacco stalks as sustainable energy source are very scarce. The possible reason for this is presence of nicotine and heavy metals [4] in tobacco stalks, although nicotine content in tobacco leaves is approximately 2%, while in stalks it is less than 1%. According to the Waste Catalogue of Republic of Serbia, tobacco is rated as the non-toxic waste. [5] This means that in generally, all waste from tobacco processing could be used in some way as energy source. Also, the research performed in the North Macedonia suggested that briquettes and pellets from the oriental tobacco stalks contain less than 500 ppm of nicotine, which means that usage of tobacco stalks briquettes and pellets is ecologically acceptable. [6] In order to decrease nicotine content even more, tobacco stalks can be mixed with other similar biomass samples.

High heating value (HHV) is referred to the heat released from the fuel combustion with the original and generated water in condensed state. For biomass fuel this value can be determined experimentally in adiabatic bomb calorimeter, but this measured is complicated. Another way is predicting of high heating value based on proximate and elemental analysis and chemical composition, which is easier, more quickly and still reliable. HHV based on proximate analysis is calculated to the weight percentage of moisture, fixed carbon and ash, in elemental analysis to the carbon, hydrogen and oxygen mainly content. Unlike the fossil fuels, biomass is defined with low content of sulfur and nitrogen, which leads that in most formulas these elements are neglected. Also compared with fossil fuels, biomass includes cellulose, hemicellulose and lignin. High heating value of lignin is up to 25.58 MJ/kg, and it is shown that heating lignocellulose fuels is function of lignin content.

In literature, large number of papers related to the HHV calculation, for various kinds of biomasses, can be found. Relaying to the fact that content of particular element could vary in some small range, in this paper, various formulas have been used in order to determine high heating value. In Table 1, all formulas with references used in this study, are given.

Table 1. High heating value (HHV) correlation

Author/Reference	HHV correlation [MJ/kg]
	Based on elemental analysis
Tillman, 1978 (Ref. 10)	HHV1 = 0.4373C - 1.6701
Sheng and Azevedo, 2005 (Ref. 11)	HHV2 = 0.3259C + 3.4597
Annamalai, Sweeten, Ramalingam, 1987(Ref. 12)	HHV3 = 0.3516C + 1.16225H – 0.1109O + 0.0628N + 0.10465S
Channiwala and Parikh, 2002 (Ref. 13)	HHV4 = 0.349C + 1.1783H + 0.1005S – 0.1034O – 0.0151N – 0.0211 ash
	Based on chemical composition
	L - Lignin
Demirbas, 2001 (Ref. 14)	HHV5 = 0.0877L + 16.4951
Demirbas, 2001 (Ref. 15)	HHV6 = 0.0864L + 16.6922

2. BIOMASS ANALYSIS

Based on elemental analysis, various formulas are chosen for this study, starting with C content only, trough detailed chemical analysis. For high heating value calculated from chemical composition, in this study only lignin content was used, and two formulas are chosen in way Based on elemental analysis, various formulas are chosen for this study, starting with C content only, trough detailed chemical analysis. For high heating value calculated from chemical composition, in this study only lignin content was used, and two formulas are chosen in way of coverage all types of biomasses.

Preparation of the samples for the analysis of chemical composition was performed in the standard manner. After grinding, the stalks were milled and sieved to a series of vibrating sieves. The fractions of particle size of 0.5 - 1.0 mm were taken for the analysis of the chemical composition. In the context of the analysis of the chemical composition of tobacco stalks the following were done: determination of the moisture content of the samples, [7] lignin and extractive substances soluble in a mixture of organic solvents, [8] [9] and the determination of the ash content[19]. Based on the moisture content, the results of the analysis of the chemical composition of the samples of tobacco stalks are expressed relative to the dry weight of the samples. Within the elemental analysis, the determination of carbon, hydrogen and oxygen was carried out. Unlike fossil fuels, biomass is characterised by a low content of Sulphur and Nitrogen in trace amounts. Therefore, we considered that for the calculation of the HHV on the elemental composition basis is the most important to take into account the content of C, H and O. These elements are detected with elemental analysers. Approximately 200 mg of a sample is burned in an oxygen atmosphere at 9000ºC, and C is converted into CO_2, and H in H_2O. The components are quantitatively determined by using IR (infrared) detector. [11]

Table 2 presents result of elemental analysis and chemical composition of Virginia and Burley tobacco stalks and 6 other biomass samples. Analyses were performed in 5 replicates, but for clearly reasons in Table 2 are given only average values.

Table 2. Elemental analysis and lignin content for biomass samples[12]
(C – carbon, H – hydrogen, O – oxygen, N – nitrogen, S – sulfur)

Biomass	Element content					Ash	Lignin
	C	**H**	**O**	**N**	**S**		
	(%)						
Burley stalk	44.03	7.02	43.27	0.89	0.55	4.24	18.36
Virginia stalk	43.97	6.85	42.36	0.85	0.48	5.49	14.77
Corn cob	45.58	5.95	40.09	0.4	0.1	3.83	18.27
Corn stalk	44.75	5.80	41.76	1.28	0.05	6.49	12.75
Wheat straw	46.68	5.90	39.42	1.65	0.1	4.91	18.73
Sunflower stalk	46.50	5.52	39.62	2.00	0.12	4.06	16.43
Barley stalk	46.79	5.53	41.94	0.41	0.06	4.86	23.00
Oats stalk	46.32	4.90	38.66	0.69	0.11	7.82	15.40

Variation in content of particular element can be a result of various parameters which are related to the land composition, land cultivation, irrigation and fertilization. Characteristic of biomass could also vary depending on the origin or geographical region in which it is formed. These variations are also acceptable within the one plant culture in different years of cultivation. Although the nitrogen content in biomass samples is almost negligible, due to excessive fertilisation it can be increased. Content of three basic elements for all biomass samples is given in Fig. 1. From Fig. 1 it can be seen that carbon contents found in tobacco stalks are smaller than in other biomass samples, but very similar with that of corn stalks and cobs. This can be explained by the fact that tobacco stalks and corn stalks have very similar structure. Content of other elements is in range like in other biomass samples.

Regardless of the formula type, in the case of tobacco stalks, with almost all formulas HHV is in an acceptable range. For practical use, in briquette and pellet production, moisture content could not exceed 15%, and based on HHV calculation it can be concluded that lower heating value in the case of tobacco stalk would not go under the 15.5 MJ/kg.

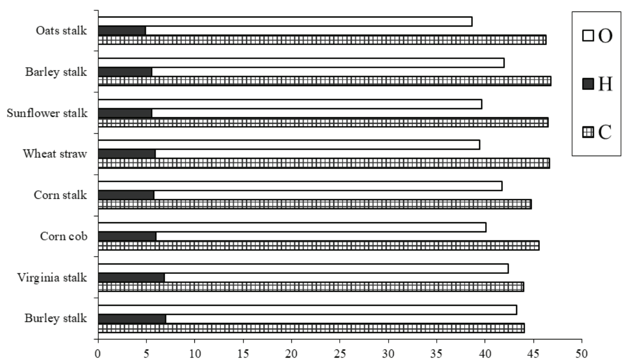


Figure. 1. Content of carbon, oxygen and hydrogen in biomass samples [12]

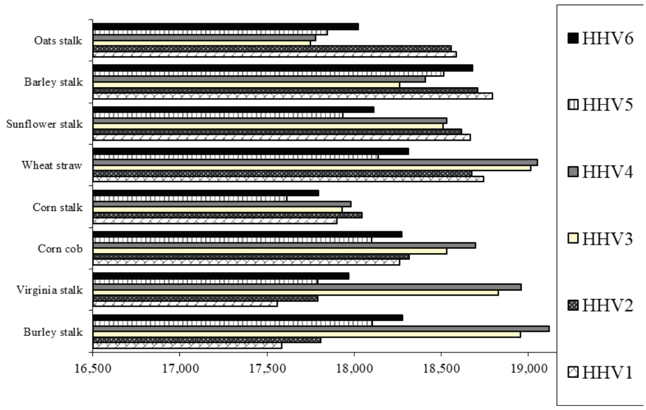


Figure. 2. HHV values for all biomass samples and formulas [12]

In Fig. 2, HHV values for all biomass samples and formulas are shown. It can be seen easily that variation in HHV is present for every sample due to used formula. For tobacco, sample with the lowest carbon content, formulas HHV1 and HHV2 resulted with lowest HHV value which was expected. Including the larger number of parameters like it was given in HHV3, and particularly in HHV3 formula, values are slightly increased for almost all cultures. Considering that sulfur and nitrogen content in biomass is very small, HHV can be calculated with satisfactory accuracy only based on C, H and O. HHV4 formula in the case of tobacco stalks resulted with the highest values.

In Fig. 3, the average values of HHV for all biomass samples based on selected formulas are shown. It is clearly evident that tobacco stalks, regardless to the type, showed good agreement with other biomass samples. Almost the same value of approximate 18.3 MJ/kg is calculated with Burley stalks, corn cob, and sunflower stalks.

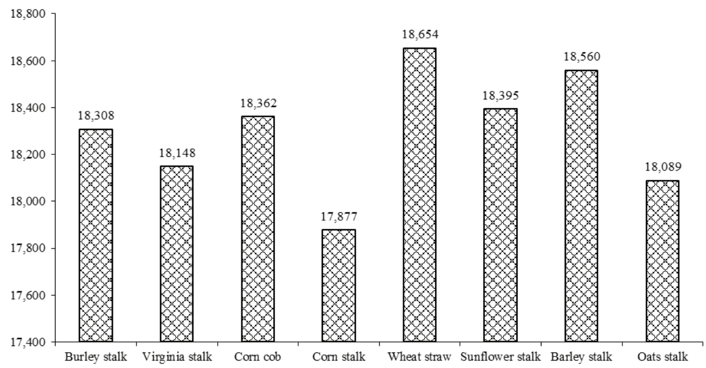


Figure. 3. Average HHV values for all biomass samples [12]

3. GREENHOUSE GAS EMISSIONS

Unlike the other common types of biomasses, tobacco stalk has greater amount of nitrogen and sulfur, which affect with increased SOx and NOx gasses in combustion. These increased values are result of fertilization from one side, and consequence of acid rains from the other side. Comparing with other biomass types, wheat straw also has greater amount of nitrogen, but corn cob has nitrogen level on minimum. These facts impose conclusion that mixing tobacco stalks with corn cob for example can lead to generate very effective renewable fuel which can have satisfactory heating level and in the same time low generation of toxic gasses.

Calculation of solid fuels combustion products volumes can be made based on knowledge of the ultimate analysis of the fuel, using the stochiometric combustion equation. Fuel composition can write in the form:

$$C + H + S + O + N + W + A^p = 100\% \quad (1)$$

Symbols C, S, O, N, W and A^p represents the percentage content of carbon (C), hydrogen (H), sulfur (S), oxygen (O), nitrogen (N), humidity (W) and mineral impurities (A^P) in the fuel.

For theoretical prediction of combustion gasses emission, detailed analysis is necessary. In this case, Virginia and Burley tobacco stalks and corn cob were selected for briquette samples. Corn cob is selected for mixing with tobacco stalk because of relatively low content of nitrogen and sulfur and close heating value with the same moisture content. Mixed briquettes are made from equal mass of tobacco stalks and corn cob in order to find average values of gasses emission between two biomass samples. Table 2 presents result of ultimate analysis and chemical composition of briquettes. Analyses were performed in five replicates, but for clearly reasons in Table 2 are given only average values.

Variation in content of particular element can be result of various parameters which are related to the land composition, land cultivation, irrigation and fertilization. Characteristic of biomass could also vary depending on the origin or geographical region in which it is formed. [13] These variations are also acceptable within the one plant culture in different years of cultivation. Although the nitrogen content in biomass samples is almost negligible, due to excessive fertilization it can be increased, which can be seen in Burley sample in Table 2. In the same manner, sulfur content in Virginia sample from Table 2 is a result of acid rains in the area where plants had been grown. All these variations would affect in amount of NOx and SOx gasses in combustion.

Based on ultimate analysis, for selected briquettes, volumes of combustion gasses are calculated. Emission of CO_2 for selected fuels is given on Figure 4. From Table 2, it can be seen that tobacco stalk have smaller amount of carbon, and result of this is decreased volume of CO_2 in combustion gasses for tobacco stalks compared with corn cob. Variation between samples is about 6%, and it can be concluded that all samples have similar volumes of CO_2 in combustion gasses. In briquettes which are made from mixing biomass emission of CO_2 was almost the same.

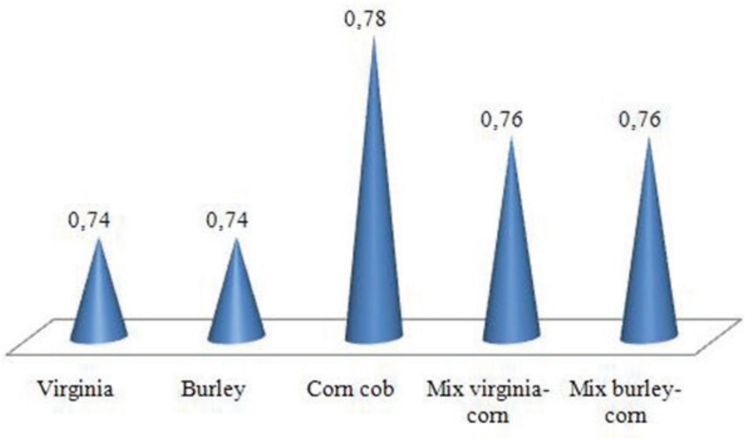


Figure 4. CO2 emission for selected biomass briquettes [13]

Volumes of SO_2 in combustion gasses for briquettes samples are given in Figure 5. As it was mentioned before, due to land contamination in area where selected Virgnia tobacco plants were grown, content of SO_2 is the higher. Comparing with corn cob, briquettes made from Virginia tobacco stalk have almost 90% greater SO_2 emission. In briquettes made from biomass mixture, this emission can be decreased up to 40% comparing with tobacco stalks briquettes.

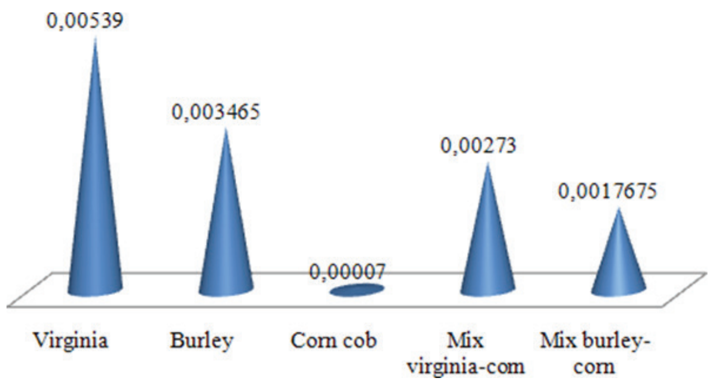


Figure 5. SO_2 emission for selected biomass briquettes [13]

Volume of NO_2 in combustion gasses is given on Figure 6. For clarity reasons, on Figure 6 is only shown content on nitrogen from biomass. Nitrogen content from air needed for combustion is neglected. As it was mentioned, in case of Burley tobacco, nitrogen from fertilizer binds to plant and this affect with increased amount of NO_2 in gasses. Comparing with corn cob, it is almost 50% greater NO_2 emission. In case of briquettes made from biomass mixture, this can be decreased from almost 30%.

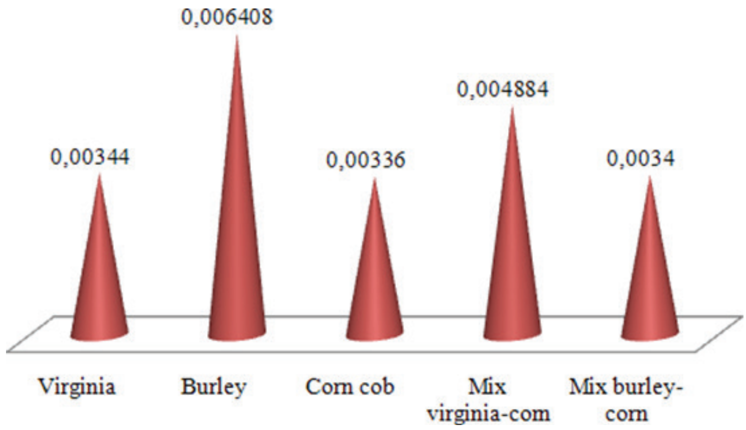


Figure 6. NO_2 emission for selected biomass briquettes [13]

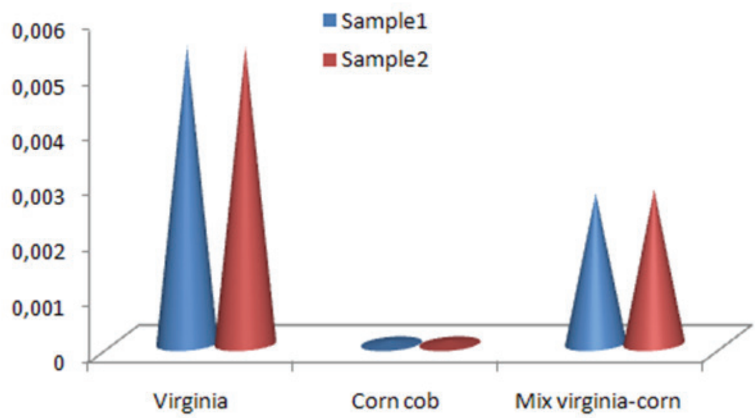


Figure 7. SO_2 emission for selected biomass briquettes for 1 kg fuel, and for the same heating value [13]

Comparison between Virginia tobacco stalks, corn cob and mixture briquettes in case of SO_2 emissions are given in Figure 7. Sample 1 is the emission produced by combustion of one kg of biomass, while Sample 2 denotes amount of biomass which is equal to heating value of Virginia tobacco stalks. Based on these calculations, the lower heating value of Virginia tobacco stalks briquettes were 14,97 MJ/kg, and for corn cob were 14,2 MJ/kg. Since content of sulfur in corn cob is almost negligible, it is obvious that volume of SO_2 in case of corn cob briquettes shall be on minimum, as mentioned before. In case of briquettes made from mixture, emission of SO_2 could be decreased up to 50% comparing with pure Virginia tobacco stalks briquettes.

NO_2 emissions for Virginia tobacco stalks, corn cob, and mixture briquettes are given on Figure 8. Although in case of corn cob briquettes NO_2 emission is smaller compared to Virginia tobacco stalks briquettes, in order to obtain the same energy value in combustion, it would be necessary to use greater amount of corn cob briquettes. This would increase NO_2 emission for almost 10%, and it can be concluded that tobacco stalks briquettes in order of same energy delivery would have better NO_2 emission. In case of mixture briquettes, emission would be almost equal.

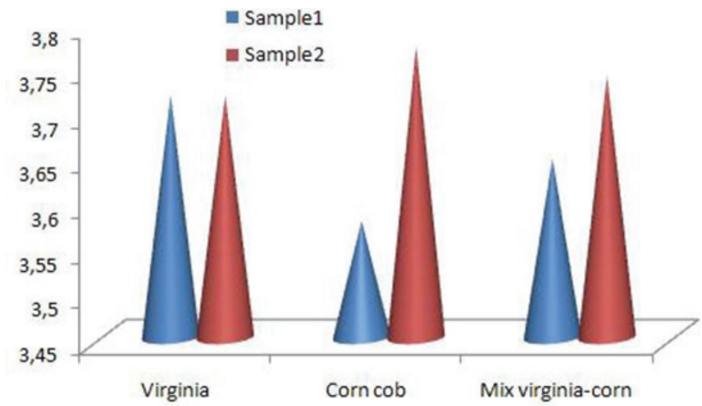


Figure 8. NO_2 emission for selected biomass briquettes for 1 kg fuel, and for the same heating value [13]

In case of Burley tobacco stalks, corn cob and mixture biomass briquettes, comparison in SO_2 emission are given on Figure 9. Considering the fact that sulfur content in corn cob is almost 90% smaller than Burley tobacco stalk, in case of biomass mixture briquettes this emission could be decreased up to 50% regardless if is compared per 1 kg of biomass or same energy delivered. Briquettes made from Burley tobacco stalks have 15,01 MJ/kg lower heating values which is more than any other biomass samples. From Figure 9 it can be seen that there is no significant difference for SO_2 emission in case of biomass mixture briquettes in case of 1kg fuels combustion and combustion for the same energy delivered.

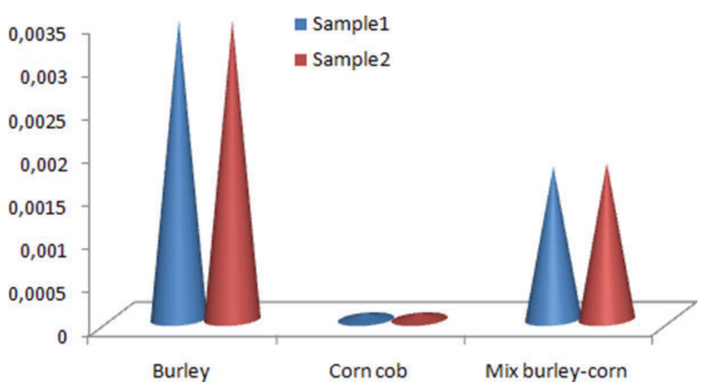


Figure 9. SO_2 emission for selected biomass briquettes for 1 kg fuel, and for the same heating value [13]

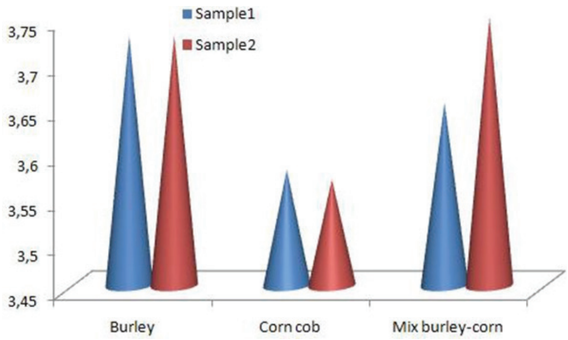


Figure 10. NO_2 emission for selected biomass briquettes for 1 kg fuel, and for the same heating value [13]

Unlike Virginia tobacco stalks briquettes, in Burley sample nitrogen level was higher, which was explained previously. Results of higher nitrogen value are decreased NO_2 emission in combustion gasses. According to these data, it can be concluded that mixing Burley tobacco stalks with other types of biomass samples could not significantly decrease level of NO_2 emission.

4. CONCLUSION

Of total available renewable energy in Republic of Serbia, biomass is accounted with almost 63%. This amount is more than sufficient to cover all energy needs in agriculture sector. However, this is not a situation at the moment, only a small proportion of biomass is used in agriculture. In this paper, tobacco stalks were taken as an example of a non-toxic biomass source, suitable for the energy production. The fact that tobacco stalks have no value in tobacco industry makes them more than suitable as a renewable energy source.

It was shown that tobacco stalks have smaller content of carbon and lower emission of CO2 than other types of biomasses. There is no significant difference in level of CO2 emission for pure substance briquettes and biomass mixture briquettes, which was shown in results. However, the level of sulfur in Virginia tobacco stalks was higher. This could be explained by variations of sulfur content due to land contamination by acid rains. As a consequence, the level of SO2 in combustion gasses was higher for Virginia tobacco stalks briquettes than in other samples. Mixing with other types of biomasses can significantly decrease level of SO2 in emission gasses. For Burley tobacco stalks briquettes lower level of SO_2 emission was detected, and it can be concluded that emission of SO_2 was significantly decreased.

The detailed analysis of nitrogen level has shown the highest emission rate by Burley tobacco stalks, which is result of using nitrogen fertilizers for plants growing. Also, the highest volumes of NO_2 in emission gasses were calculated for Burley tobacco stalks briquettes. In briquettes made from biomass mixture the level of NO_2 is decreased, but in case of same energy delivered by biomass (made from mixture) the level of NO_2 is almost the same. This can be explained by significantly lower heating value of Burley tobacco stalks compared to the corn cob. If Virginia tobacco stalks were used, briquettes made from biomass mixture would have a lower level of NO_2 emission.

The general conclusion, based on presented results, is that using of tobacco stalks as a renewable energy source is acceptable from the ecological point of view. Plants growing conditions can significantly affect the emission of certain elements from biomass samples. Emission of toxic gasses such are SOx and NOx gasses was found acceptable. Furthermore, briquettes made from biomass mixtures can decrease level of toxic gasses emission.

REFERENCES

[1] Lazaroiu, I., Oprea, E., Mihaescu, T., Prisecaru, I., Pisa, G., Negreanu, C., Mocanu R,: Biomass Briquettes from Pitcoal-Wood: Boiler Test Facility Combustion Case Study. Journal of Environmental Protection and Ecology, (Vol 13 Issue 2A, pp. 1070-1776) (2012).

[2] Gurel, A., Senel, Z.: Global Climate Change and Adaptations in Agriculture. J Environ Prot Ecol, **13** (1), 56 (2012).

[3] Jovanović, P., Parović M.: State and Development of Biomass in Serbia, Belgrade, 2009, (in Serbian), http://www.jeffersoninst.org/sites/default/files/Biomass.pdf.

[4] Angelova M., Ivanov, K., Ivanova, R.: Effect of Chemical Forms of Lead, Cadmium and Zinc in Polluted Soils on Their Uptake by Tobacco Journal of Environmental Protection and Ecology, (Vol 4 Issue 2, pp. 316-323) (2003).

[5] Waste Catalogue: Ministry of Environment and Spatial Planning and the Agency for Environmental Protection of the Republic of Serbia, 2010 (in Serbian).

[6] Peševski, M.,, B. Iliev, D. Zivkovic, V. Jakimovska-Popovska, M. Srbinoska, B. Filiposki: Possibilities for Utilization of Tobacco Stalks for Production of Energetic Briquettes. J Agr Sci, **55** (1), 45 (2010).

[7] NREL/TP-510-42621: Determination of Total Solids in Biomass and 251 Total Dissolved Solids in Liquid Process Samples. 2008.

[8] NREL/TP-510-42619: Determination of Extractives in Biomass. 2005.

[9] NREL/TP-510-42618: Determination of Structural Carbohydrates and Lignin in Biomass Laboratory Analytical Procedure. 2008.

[10] NREL/TP-510-42622: Determination of Ash in Biomass. 2005.

[11] Solar Energy Research Institute: Methods of Analysis Biomass for Fuels and Chemicals. Solar Energy Research Institute. Golden, Colorado, USA, 1991.

[12] Mijailović, I., Radoičić, V., Ećim-Djuric, O., Stefanovic, G., & Kulic, G. (2014). Energy potential of tobacco stalks in briquettes and pellets production Journal of environmental protection and ecology (Vol. 15, Issue 3, pp. 1034–1041).

[13] Gurel A., Senel Z.(2012) Global Climate Change and Adaptations in Agriculture. Journal of Environmental Protection and Ecology, (Vol.13, Issue 1, pp. 56-60).

[14] Ećim-Đurić, O., Radoičić, V., Mijailović, I., Kulić, G., Effects of tobacco stalks briquette combustion on air pollution, Proceedings of IV international conference “Ecology of urban areas” 2014 pp 55-62.

PROTOTYPE RESPIRATORY PROTECTION SYSTEM FOR WILDLAND FIREFIGHTERS

Uwe Reischl[1], Budimir Mijovic[2], Alex Honn[1]

[1] Boise State University, Idaho, USA
[2] University of Bihac, Bihac, Bosnia and Herzegovina

Abstract: The size and severity of wildfires around the world have been on the rise since the 1980s. In the USA alone, over 66,000 wildland fires occurred in 2022. Thousands of firefighters were employed to control these fires. The occupational health and safety risks associated with wildland firefighting are significant and numerous. The most common are physical injury, exposure to smoke and other particulates, and heat stress. This project was undertaken to develop a prototype technology that will be able to protect wildland firefighters from excessive exposure to smoke and particulates in the air while also reducing heat stress. A portable, lightweight air filtration system for use by wildland firefighters has been developed. The system consists of a battery-powered variable-speed air filter system that supplies air to a firefighter's helmet. Multiple air ducts channel filtered air into the firefighter's helmet. Two ducts provide air to the breathing zone while the other two direct filtered air inside the helmet in the space between the suspension system and the shell. This air flow promotes sweat evaporation from the head. The two air supply systems are operated independently of each other. The system provides a comfortable, unobtrusive, and simple solution for reducing occupational exposure to smoke and other particulates while also reducing firefighter heat stress.

Keywords: Wildland firefighter health, Respiratory protection, Heat stress reduction, Prototype technology.

1. INTRODUCTION

Climate change has increased the prevalence of droughts throughout the world. This has resulted in more wildland fires globally [1-3]. The size and severity of these fires have been on the rise since the 1980s. In the USA alone, over 66,000 forest and wildland fires occurred during 2022 [4,5]. Thousands of firefighters were required to protect the local communities. The occupational health and safety risks associated with wildland firefighting are significant. The most important are physical injury, exposure to smoke, and heat stress [6-8]. The goal of this project was to develop a prototype technology that will be able to protect wildland firefighters from excessive exposure to smoke while also reducing heat stress. This has resulted in a new system that will be able to achieve these health and safety objectives.

2. OCCUPATIONAL ENVIRONMENTS

Work environments associated with wildland firefighting differ from those associated with structural firefighting. Structural fires require arduous work, are generally shorter in duration, and expose firefighters to known hazardous materials for which specialized respiratory protective equipment is required [9]. The workloads required of wildland firefighters are intensive, usually longer in duration, and expose firefighters to smoke, dust, and diesel fuels without respiratory protection. To safeguard firefighters engaged in structural and other local point fires, “turnout gear” and self-contained breathing apparatus (SCBAs) are provided. However, wildland firefighters require much lighter clothing to perform their tasks efficiently, and no specialized respiratory protection is required or available. Wildland firefighters rely on standard hard hats and goggles for head and eye protection. Simple cloth facemasks are frequently used to reduce exposure to smoke and other particulates.

2.1. Structural Firefighting

Self-contained breathing apparatus (SCBA) are generally used by structural firefighters. This system provides an autonomous supply of air stored in a pressurized aluminum or steel tank carried on the back of a firefighter. The apparatus is independent of the ambient atmosphere and requires the use of a full-face mask. Depending on the breathing rate of the firefighter, the air supply lasts between 30 and 45 minutes [10]. While the system is primarily effective for use in structural firefighting, such a system is not suitable for wildland fire fighting.

2.2. Wildland Firefighting

The most frequently used respiratory protection employed by wildland firefighters are bandanas, surgical masks, and N95 masks. These have different filtration efficiencies where bandanas provide the least protection while the N95 masks provide substantially more protection [11]. Figure 1. illustrates examples of a self-contained breathing apparatus “A”, and a fabric facemask “B”.

A **B**

Figure 1. Illustration of a self-contained breathing apparatus, SCBA, worn by a structural firefighter (A) and a fabric mask worn by a wildland firefighter (B).

3. PROTOTYPE

To provide an alternative to the existing respiratory protection available to wildland firefighters, a new air filtration design was developed. The system includes a battery-powered variable-speed air filter that provides airflow directly to a firefighter's helmet. One set of air ducts provides airflow to the firefighter's breathing zone while the other provides airflow into the space between the helmet suspension straps and the outer shell of the helmet promoting sweat evaporation from the head. The two air supply options can be operated independently of each other. The overall system design is shown graphically in Figure 2. The details of the air supply and air filter unit are illustrated in Figure 3. Figure 4. shows the duct connections leading from the air filter to the helmet.

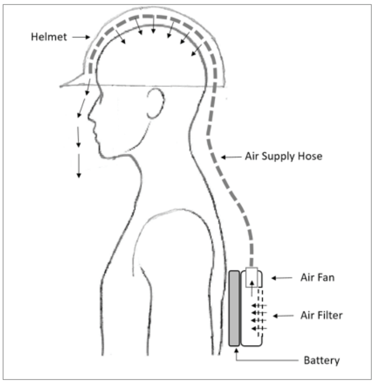


Figure 2: Graphic illustration of the overall prototype system.

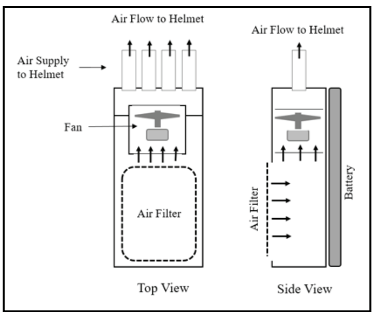
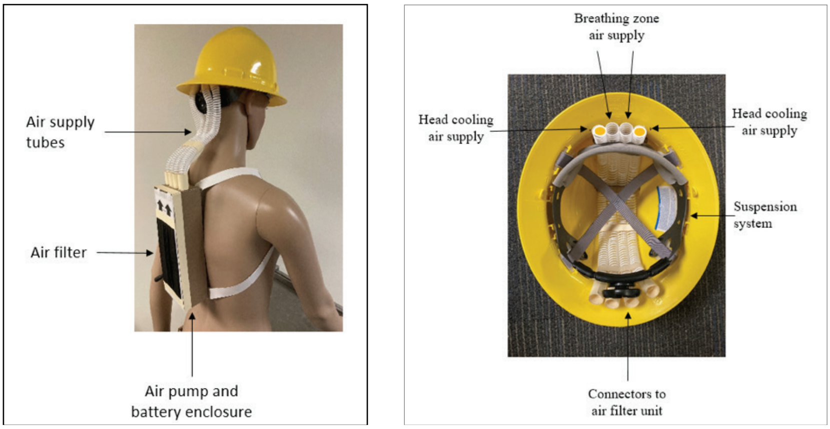


Figure 3: Design details of the air fan with filter.



A **B**

Figure 4: Air supply unit with the air filter (A) and air distribution tubing Placed inside the helmet (B).

4. SYSTEM PERFRMANCE

The air volumes directed to the firefighter's breathing zone and the air volumes directed to the inside of the helmet to promote sweat evaporation were measured at increasing airflow rates starting with 222 l/m and ending at 680 l/m. The tests included three configurations: Airflow to the breathing zone only, airflow to the head only, and simultaneous airflow to both the breathing zone and the head. All tests were conducted with a Covid fabric filter in place. Table 1. summarizes the results. Figure 5. illustrates the same results graphically.

Table 1: Summary of airflow rates for the breathing zone, for the inside of the helmet and the breathing zone and helmet airflow combined.

Filtered Air Supply (l/min)	Air flow to face only (l/m)	Air flow to head only (l/m)	Air Flow to Face + Head (l/m)
222	135	94	174
385	240	215	305
475	300	283	384
555	363	326	420
608	393	372	489

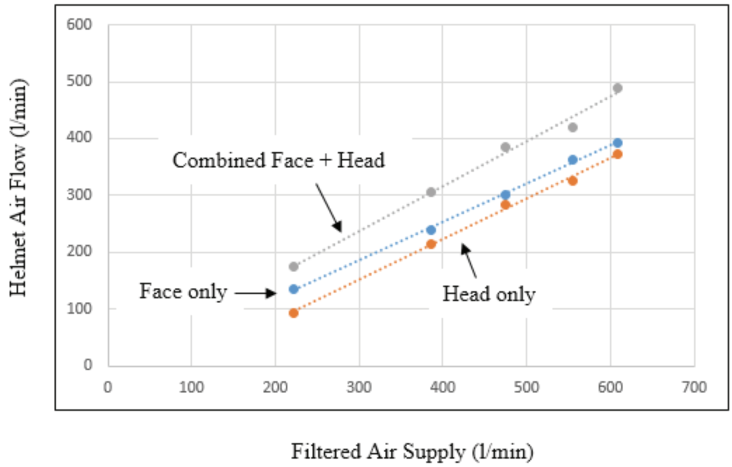


Figure 5: Summary of airflow rates observed for the inside of the helmet only, the breathing zone only and the combined breathing zone and the helmet.

4. DISCUSSION

The filtered air delivered by the prototype system to the firefighter's breathing zone exceeded the maximum anticipated respiratory volume of 200 l/min for heavy workloads (6). With an airflow of 400 l/min of filtered air directed into the firefighter's breathing zone, a "surplus" of filtered air will displace smoke and other air pollutants in the firefighter's breathing zone. In addition, the airflow introduced into the helmet promoting sweat evaporation from the head provides an additional benefit to a firefighter. Such an option is not offered by any commercially available product currently on the market.

5. CONCLUSIONS

The development and testing of the prototype firefighter respiratory protection system demonstrated the potential for improving the health and safety of wildland firefighters. Although the tests were conducted inside a laboratory, the fundamental principle of providing filtered air to a firefighters breathing zone displacing environmental smoke and particulate matter, while also providing heat stress reduction, appears feasible. It is anticipated that commercial development of this technology may lead to further performance improvements at a later time.

REFERENCES

+
[1] Li, T., Cui, L., Liu, L. et al. Advances in the study of global forest wildfires. J Soils Sediments, 2023, Vol. 23, pp. 2654–2668.
[2] Abatzoglou JT, Williams AP. Impact of anthropogenic climate change on wildfire across western US forests. Proc Natl Acad Sci USA, 2016, 113, 11770–11775.
[3] Aldersey, S., Murray, J., Corneel, S.E., Global and regional analysis of climate and human drivers of wildfire, Science of The Total Environment, 2011, 409, 18: 3472-3481.
[4] National Aeronautics and Space Administration (NASA): 2024, Website: https://www.earthdata.nasa.gov/topics/hazards/wildfires,
[5] Burke M., Driscoll, A., Heft-Neal, S., Xue, J., Burney J., Wara, M. The hanging risk and burden of wildfire in the United States, Proc.Natl. Acad. Sci. 2021, 118, 2.
[6] Budd, G.M., Brotherhood, J.R., Hendrie, A.L., Jeffery, S.E.,Beasley, F.A.,Costin B.P., Zhien, W., Baker, M.M., Cheney, N.P., Dawson M.P. Project Aquarius 5. Activity distribution, energy expenditure, and productivity of men suppressing free-running wildland fires with hand tools. International Journal of Wildland Fire, 1997, 7, 2, 105-118.
[7] Budd, G.M., Brotherhood, J.R.Hendrie, A.L., Jeffery, S.E., Beasley, F.A., Costin B.P., Zhien, W., Baker, M.M.,Cheney, N.P., Dawson M.P., Project Aquarius 6. Heat load from exertion, weather, and fire in men suppressing wildland fires. International Journal of Wildland Fire, 1997, 7. 119-131
[8] Budd, G.M., Brotherhood, J.R., Hendrie, A.L., Jeffery, S.E., Beasley, F.A., Costin B.P., Zhien, W., Baker, M.M.,Cheney, N.P., Dawson M.P. Project Aquarius 7. Activity distribution, energy expenditure, and productivity of men suppressing free-running wildland fires with hand tools International Journal of Wildland Fire, 1997, 7, 2, 113-144.
[9] Aisbett, B., Wolkow, A., Sprajcer, M., Ferguson, S.A., "Awake, smoky, and hot": Providing an evidence-base for managing the risks associated with occupational stressors encountered by wildland firefighters. Applied Ergonomics 2012, 43, 5, 916-925.
[10] Kodros, JK, O'Dell, K, J, Samet, JM, L'Orange,C., Pierce,J.R., Volckens, J. Quantifying the Health Benefits of Face Masks and Respirators to Mitigate Exposure to Severe Air Pollution. GeoHealth,, 2021; 5,9.
[11] De Vos, A.J., Cook, A., Devine, B., Thompson, P.J., Weinstein, P.J. Effect of protective filters on fire fighter respiratory health: field validation during prescribed burns, 2009, 52, 1:76–87.

2

OCCUPATIONAL SAFETY

WORK SAFETY AND PROTECTION IN POSTAL SYSTEM

Marijan Binički[1], Pero Škorput[2], Tomislav Kljak[2]

[1]Croatian Post, Poštanska ulica 9, 10410 Velika Gorica, CROATIA, marijan.binicki@posta.hr

[2]University of Zagreb, Faculty of Transport and Traffic Sciences, Vukelićeva 4, 10000 Zagreb, CROATIA, pero.skorput@fpz.unizg.hr, tomislav.kljak@fpz.unizg.hr

Abstract: *The aim of this article is to provide a thorough analysis of safety and protective measures in postal system, emphasizing the importance of a systematic approach to risk assessment and effective management to ensure a safe working environment for employees. Several types of injuries commonly present in postal system have been analysed, such as back injuries from lifting heavy loads; hand injuries from handling parcels and injuries caused by slipping or falling on the floor. Emphasis has been placed on the importance of preventive measures and employee training to reduce the frequency of such injuries. Measures have been selected for implementation to reduce the risk in postal system. These measures include the implementation of ergonomic solutions to reduce the risk of injuries, ensuring regular maintenance of facilities to prevent accidents, training employees on proper procedures in case of danger and conducting systematic inspection and audits to ensure compliance with regulations.*

Key words: *Postal system, safety, protection, risk.*

1. INTRODUCTION

Security and protection in the postal sector are crucial aspects of management and organization, necessary for maintaining the health and well-being of employees, as well as protecting shipments from loss, theft, or damage. This paper thoroughly analyses the methods and practices applied in postal systems to optimize security procedures and reduce risks. Various aspects of postal operations, including transport, shipment handling, and the work environment, are exposed to numerous risks that require systematic management and continuous evaluation.

Security in the postal system can be viewed from two primary perspectives: the security of shipments and the security of employees. Special attention is given to the analysis and monitoring of incidents such as robbery, disappearance of shipments, and damage to the contents of shipments. These indicators directly affect the perception of the quality of services provided by the postal system and therefore require rigorous protection measures and preventive actions.

Protection in the postal system encompasses a wide range of activities, from prevention to protection against unauthorized access, attacks, or accidents. These measures include the implementation of scientific methods, technological solutions, and organizational practices that ensure the protection of facilities, people, vehicles, and shipments. The purpose of these measures is to achieve a high level of security through access control, video surveillance, security checks, and similar methods.

2. ANALYSIS

The human factor is highly present in the postal system, both in service technological processes and on the customer side. For this reason, it is particularly important to pay great attention to the protection and safety of people from various threats to their mental or physical health. Table 1 provides a detailed overview of the collected data on workplace injuries in Croatian Post over a five-year period.

The number of workers decreased from 10,017 in 2019 to 9,380 in 2023, reflecting a streamlined workforce over the five-year period. There was an overall increase in the total number of injuries from 2019 to 2023, suggesting areas for improvement in workplace safety measures. The number of injured men remained relatively stable, indicating consistent safety practices. The number of injured women showed more variation, with an opportunity to focus on tailored safety measures for female employees. Positively, there was only one fatal injury reported over the five years, showing a generally safe working environment.

Table 1. Data on Workplace Injuries and Assessment of Collected Data in the Work Process at Croatian Post from 2019 to 2023

Type of data	**2019**	***2020***	***2021***	***2022***	***2023***
Number of workers during the period	*10017*	*9636*	*9677*	*9444*	*9380*
Total number of injuries	*249*	*197*	*233*	*266*	*278*
Number of injured men	*171*	*143*	*143*	*164*	*172*
Number of injured women	*78*	*54*	*88*	*102*	*106*
Number of fatal injuries	*0*	*1*	*0*	*0*	*0*
Number of group injuries	*0*	*1*	*0*	*0*	*0*
Number of severe injuries	*36*	*0*	*37*	*26*	*31,16*
Number of injuries per 1000 workers in the company	*24,86*	*31*	*24,08*	*28,17*	*0*
Number of injuries per 1000 workers in the transport and storage sector	*13,27*	*8,12*	*9,27*	*11,51*	*0*

Ratio between the number of injuries per 1000 workers in the company and the sector	*1,87*	*2,52*	*2,6*	*2,45*	*0*

[1], [4]

Group injuries were rare, with only one incident in 2020, highlighting effective safety protocols in preventing mass incidents. The number of severe injuries fluctuated, with significant decreases in some years, indicating periods of successful safety interventions.

The rate of injuries per 1000 workers varied, with a notable peak in 2020. The overall trend presents an opportunity to focus on continuous safety improvements. The transport and storage sector's injury rates per 1000 workers also fluctuated, peaking in 2019. This offers a benchmark for the postal system to compare and improve it.

The ratio of injuries in the company to the sector consistently showed higher rates for the company, emphasizing the need for ongoing safety enhancements. The reduction in workforce numbers allows for more focused safety training and resources for remaining employees. The stable injury rates among men and the variable rates among women highlight the opportunity for gender-specific safety programs, ensuring that all employees are adequately protected. The minimal number of fatal and group injuries over the five years is a positive indicator of the effectiveness of existing safety measures. The fluctuating injury rates suggest areas where safety measures can be further enhanced, providing a roadmap for continuous improvement. By comparing injury rates with the transport and storage sector, the postal system can adopt best practices and aim to meet or exceed industry safety standards. Implementing and regularly updating safety protocols can ensure a safer working environment, reducing the likelihood of injuries.

Risk assessment is a critical step in managing workplace safety and protection. This process includes evaluating potential hazards that could negatively impact workers and is based on legal regulations that require regular review and adjustment of working conditions in response to changes in the work environment. Methods and approaches defined by the Regulation on Risk Assessment are used to create risk assessments, including identifying threats, vulnerabilities, control analysis, and the likelihood of adverse events.

Risk in the postal system is defined as a function of the likelihood of a harmful event occurring and its consequences. This analysis includes identifying potential hazards, assessing the likelihood of their occurrence, and the possible damages that could result. Key elements include the perception of threats, system vulnerability assessment, and the value of exposed assets. Mathematically, risk can be expressed by the formula Risk = Threat × Vulnerability × Asset Value, which allows for a better understanding of the interdependencies of these elements. [4]

Understanding general methodological procedures for risk assessment, such as those according to NIST and ISO standards from the ISO 27000X series, is key to adapting these approaches to the specificities of the postal system. The goal of such an adapted risk assessment is to enable more effective decision-making regarding the protection of the postal system and its environment. Special emphasis is placed on the “concept of risk-tolerant intensity,” which allows for a more realistic assessment of risk tolerance and thereby contributes to better understanding and management of security challenges. [5]

Risk assessment for specific elements of postal system is important considering their strategic importance and exposure to various hazards. The assessment process begins with analysing the vulnerability of the particular postal system's element using risk matrices, which enable the identification and quantification of potential risks. The result of this process allows for the formulation of a protection model tailored to the specific conditions of each element, including appropriate technical protections. In table 2 is given main distribution of time interval between anticipated harmful event and probability assessment of the frequency of a harmful event.

Table 2. Probability assessment of the frequency of harmful events for postal elements

Probability assessment of the frequency of a harmful event	**Anticipation of a harmful event**
1	Every 10 000 days
2	Every 1000 days
3	Every 100 days
4	Every 10 days
5	Everyday

[4]

The application of the risk matrix allows for detailed consideration and categorization of all possible harmful events, as well as their probabilities and potential damages (table 3). This is instrumental in the process of defining specific security measures and provides a robust methodology for maintaining the security of postal elements at an acceptable level of risk.

Table 3. Possible consequences of harmful events for postal system's elements

Assessment of Harmful Events	**Harmful Consequences**
1	Negligible harmful consequences that do not have lasting effects on the postal element
2	Minor damages, consequences that require changes in protection measures for the postal element
3	Significant harmful consequences that require changes in protection objectives defined by the vulnerability assessment of the postal element

4	Major harmful consequences that require changes in protection measures and procedures, protection objectives, and interaction with other systems
5	Maximum harmful consequences that question the very existence of the postal element and require a complete change in the protection strategy for the postal element

[4]

The goal of risk mitigation measures is to minimize the exposure of postal workers and other elements of postal system (shipments, facilities, vehicles, etc.) to all forms of hazards. [2] Realistic and economical risk mitigation measures must be based on a thorough understanding of the nature and sources of potential hazards (table 4). In this context, it is important to consider different scenarios and available options for risk reduction, from technical improvements to organizational changes. [1]

Table 4. Risk value

Possible risk values	*Risk assessment*	*Level of risk*
4*5 / 5*4 / 5*5	5	Maximum
2*5 / 5*2 / 3*4 / 4*3 / 3*5 / 5*3 / 4*4	4	Big
1*5 / 5* 1 / 2*3 / 3*2 / 2*4 / 4*2 / 3*3	3	Medium
1*2 / 2*1 / 1*3 / 3*1 / 1*4 / 4*1 / 2*2	2	Small
1*1	1	Negligible

[4]

The calculation is based on quantitative analysis of data on workplace injuries in the postal system. The primary source of data is the Analysis of Workplace Injuries (AWI) by industry from the Croatian Institute of Public Health – Occupational Health Service.Using the formula

$$O_{1000} = \frac{1000}{Z} * OZ \qquad (1)$$

where is:

O_{1000} – number of injuries per 1000 workers

Z – number of employees

OZ –number of workplace injuries in the company

The number of workplace injuries (OZ) was calculated as the number of injuries per 1000 workers in the postal system and compared with the industry average in the transport and storage sector. [4]

The analysis showed that although the total number of workplace injuries in Croatian Post has increased but the state of security in the postal sector is not significantly alarming compared to the entire industry. This can be partially explained by the size and operational complexity of Croatian Post Inc., which represents a specific context within the industry.The analysis indicates that an integrated approach to risk management is crucial for maintaining workplace safety and protection. Risk assessment calculations can and should be done for all elements of postal system. Primarily human elements (employees and customers). [2]

The findings imply the need for constant monitoring, adaptation, and training to ensure that all workers are adequately informed about potential hazards and protective measures. It is particularly important to emphasize the need for training workers and employers, as well as regular testing and maintenance of equipment and the work environment.Successful implementation of risk mitigation measures requires a detailed plan that includes all aspects from technical solutions to employee training. It is important that all measures are practical, implemented in accordance with best practices, and aligned with rules and regulations.[6]

3. CONCLUSION

To ensure the safety and security of postal operations, several critical measures must be implemented. It is imperative to provide comprehensive protection for employees who are exposed to potential risks during their daily tasks. This includes equipping them with appropriate safety gear, providing regular safety training, and establishing protocols for handling hazardous situations.

Measures must be in place to protect customers in postal offices from risks associated with technological processes, such as handling letters and packages. This involves clear guidelines for safe handling, secure waiting areas, and prompt assistance for any issues that arise. Ensuring the safety and comfort of workers is essential for maintaining high levels of productivity and morale. This can be achieved by maintaining ergonomic workspaces, implementing health and safety standards, and providing access to wellness programs. All safety and security measures must comply with current legal regulations. Regular audits and updates to policies are necessary to ensure ongoing compliance and to address any new legal requirements promptly.

Robust measures should be put in place to minimize the loss of shipments. This includes improving tracking systems, enhancing security during transportation, and ensuring accountability at every stage of the delivery process.By implementing these measures, the postal system can significantly reduce risks, enhance safety and security for both employees and customers, and ensure compliance with legal and environmental standards.

REFERENCES

[1] National Institue of Standards and Technology: *Risk Management Guide of Information Technology Systems*.http://csrc.nist.gov/publications/nistpubs/800-30/sp800-30.pdf

[2] Kemp, A. W.: *Security through cooperation*. Routledge, London, (2021) https://doi.org/10.4324/9781003214267

[3] Fereirra,J.:Cooperative, *Connected and Automated Mobility (CCAM): Technologies and Applications*.MDPI,(2019).https://doi.org/10.3390/electronics8121549

[4] Croatian Post (2024). Data on Workplace Injuries 2019 – 2023.

[5] Xueyan, Y., Changxi, M., Changfeng, Z., Bo, Q., Fuquan, P., Chengming, Z. Design of hazardous materials transportation safety management system under the vehicle- infrastructure connected environment. *Journal of Intelligent and Connected Vehicles*, Vol. 2, issue 1, (2019)

[6] Kowalik, K.: *The role of safety in service quality in the opinion of traditional and digital customers of postal service*. Production Engineering Archives, Vol. 26, issue 1, p. 1-4, (2020) https://sciendo.com/it/article/10.30657/pea.2020.26.01

IRLEN SYNDROME AND ACCESSIBILITY OF DIGITAL MEDIA FROM THE PERSPECTIVE OF PROTECTION AT WORK

Neno Čabraja[1], Diana Kralj[2], Damir Kralj[3]

[1] Student of Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, Croatia-47000 Karlovac, neno.cabraja@student.vuka.hr

[2] SOOM Diana Kralj, dr. med., M. Krleže 19, HR-47000 Karlovac, dianakralj55@gmail.com

[3] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, Croatia-47000 Karlovac, damir.kralj@vuka.hr

Abstract: *Irlen syndrome is a perceptual processing disorder. It affects 14% of the general population in the world and is included in the so-called neurodiversity. It is not an optical problem but a problem with the brain's ability to process visual information. Signs of Irlen syndrome are the most common: light sensitivity, reading problems, headaches and migraines, attention and concentration problems, strain and fatigue, problems with depth perception and print, or environmental distortions. Science-based medicine does not recognize this disorder as an official diagnosis. Still, as a manifestation of several neurological disorders that fall under the so-called neurodiversity, they consider the diagnosis and treatment of syndromes pseudoscience. But regardless of the approach, this problem appears in practice. The stimulus for the manifestation of symptoms can come from the relationship between the color and intensity of the background and the content of the media, as well as from the influence of glare and the intensity and color of the lighting in the environment. Today, our sources of information are digital media based on graphical user interfaces and two-way communication. This means that when designing the living and working environment, we must consider both the parameters of the working environment and the accessibility elements of digital media. From the perspective of occupational safety experts, these risks must be carefully included in the risk assessment of modern workplaces.*

Keywords: *Irlen syndrome, computer applications, digital media, accessibility, inclusive and universally designed workplaces*

1. INTRODUCTION

Irlen syndrome, or Scotopic Sensitivity Syndrome, is a visual or perceptual processing disorder. It refers to the impossibility of the brain's perceptive ability to correctly process information that a person receives through vision. In the case of Irlen syndrome, obtaining this information is difficult because some colors from the spectrum are delayed during information processing. Due to the influence of stressors, the brain creates a distorted image of reality. [1] This visual perceptual disorder is primarily hereditary. However, the disorder can manifest later in life in addition to being a hereditary trait. It can also occur as a result of traumatic and severe head injuries (concussion), diseases (sclerosis), accidents (crashes, mistakes during surgery), and the like. [2] The main symptoms of Irlen syndrome are reading problems, sensitivity to light, headaches, nausea, irritability, lack of attention, fatigue, problems with depth perception, lower academic/business performance, etc. [3]

Official medicine is primarily divided when it comes to Irlen syndrome. No standardized educational, psychological, optometric, or medical test considers it an existing and recognized disorder, but it is seen as an overlap or confluence with other neurological conditions. The official position is that it is a pseudoscientific approach, with medically unproven symptoms that have not been sufficiently confirmed. Scientists who support it claim that Irlen syndrome is a valid diagnosis because of specific groups of symptoms that occur due to certain types of stressors. [4]

Regardless of the point of view and approach, this disorder appears and is present around us. It is present in areas from the educational system to the working environment. Therefore, this paper aims to determine how and with which techniques to adapt and make the workplace as accessible as possible to workers who suffer from this neurological disorder. Through digitization techniques and prevention methods, several ways to make the working environment as inclusive as possible will be presented.

The research method used for this paper is the analysis of written and online sources. Therefore, to design this work, a review of the content, an analysis of scientific papers, existing theories (which oppose and agree), and a study of different approaches to the problem were carried out. The final goal and contribution of this paper is to form a set of recommendations to enable accessible working conditions and inclusion for people with Irlen syndrome by applying the guidelines of accessibility of digital media from the perspective of occupational safety. [5]

2. RESEARCH AND DIAGNOSTIC OVERLAPS

Research and knowledge about Irlen syndrome began in the 1980s. It all started as a research project after Helen Irlen and Olive Meares found that some students had reading problems. These problems and difficulties could not be defined by the standard methods of vision assessment at the time, and based on further research, they established the theory of Irlen syndrome. Initially, they independently concluded that students experience visual symptoms such as reading oscillations, blurring of text, and color hallucinations when reading writing on white paper (Figure 1). The main conclusion was that certain types of light and contrast cause such symptoms. The disorder is also sometimes called Meares-Irlen syndrome. [5]

Helen Irlen later founded "THE IRLEN® INSTITUTE" to further research and assist people suffering from Irlen syndrome. There are currently more than 170 affiliated Irlen clinics in as many as 47 countries (also in Croatia), and more than 10,000 trained psychologists are trained to help people suffering from Irlen syndrome. [6]

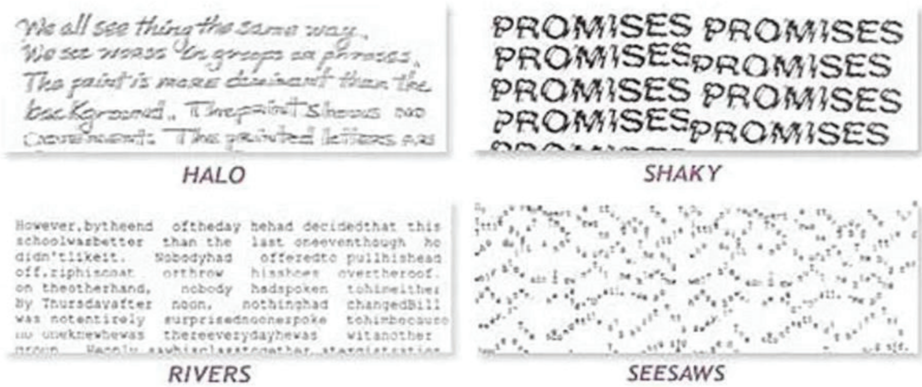


Figure 1: Some examples of text distortion [6]

Due to the division as mentioned above of opinion in the medical world, Irlen syndrome is often compared to other diagnoses such as dyslexia, dyscalculia, dyspraxia, dysgraphia, ADD/ADHD, autism, Asperger's syndrome, migraine, and sensory integration syndrome due to its overlapping symptoms. The reasons for the overlap lie in symptoms such as difficulties in reading, writing, understanding text, problems with concentration and focus, headaches, sensitivity to certain types of light, anxiety, complex adaptation, emotional issues, difficulties in processing sensory information, etc. [6] A systematic review of previous research carried out within the last five years [7] indicates that the results are heterogeneous and that there is a lack of solid evidence on the existence of the syndrome, as well as on the effectiveness of treatment.

3. DIAGNOSTIC METHODS

The testing procedure is the primary and official method of diagnosing and detecting Irlen syndrome. This is done using the Irlen method, which Helen Irlen devised. Trained professionals or "Irlen screeners" use questionnaires and reading strategies to determine whether someone suffers from Irlen syndrome or another diagnosis. Before the official testing, a self-testing procedure is carried out. This includes a short test of several questions, indicating whether a person has symptoms related to Irlen syndrome. If more than three answers in the self-test process are affirmative, a further procedure is started, which is a formal expert assessment. The official test consists of six parts designed to solve a specific problem. These are extended tests, reading tests, headache tests, autism tests (two tests), and activity on the so-called color light test. When the screener determines whether a person suffers from Irlen syndrome, the "treatment" process begins. There is no natural medicine in the form of drugs, so the Irlen method is used. Here, color filters and templates filter out light wavelengths that distort the brain's ability to respond to visual information. Irlen spectral filters (spectacles and lenses with colored glasses) are also used. [8]

As the medical world is divided on the existence of Irlen syndrome, the treatment techniques are not entirely acceptable. Many scientists claim that Irlen syndrome, together with the Irlen method, is a set of unproven diagnoses that have not been confirmed or lack more evidence to be accepted as an official diagnosis. According to research, Irlen glasses and lenses with colored filters do not help alleviate symptoms. In fact, they only serve as a placebo effect and thus raise the patient's self-confidence. In addition, some papers indicate that colored filters only add to the difficulty in reading. However, along with refutations, over the years, research has appeared that confirms treatment techniques and symptom relief. Harvard Medical School and the Canadian Medical Association endorse and support using Irlen lenses with a spectral filter, indicating that they have their own and potential benefits. [9]

4. METHODS OF PREVENTION

In addition to the mentioned glasses and lenses, some methods can provide more accessible working conditions to avoid all potential stressors. This is done using digitization techniques. We are exposed to technology in today's modern and technologically developed world. The use of technology can have its advantages and disadvantages. With the proper methods, technology can help people make their workplace as accessible as possible. [10]

Some of the techniques that we can use to technologically adapt computer work while using MS Windows 11 are:

• customized screen settings (adjustment of screen brightness through brightness settings to reduce glare and discomfort);

• the possibility of adjusting the text (there is the possibility of adjusting the size and the font in which the text is written);

• theme customization (there is a possibility of dark mode and different types of background colors);

• the ability to select icons on the desktop or in applications (Windows 11 thus enables greater concentration, reduced distractions, and increased focus and navigation during work);

• development of applications such as "Read&Write," "NaturalReader," and "Speechify" (applications adapted to the needs of users with Irlen syndrome). [10]

Using the mentioned techniques helps people with Irlen syndrome at work in terms of organization and productivity, alleviating symptoms. Numerous websites are increasingly being designed to be accessible to different groups of users, with or without neurological symptoms. Web accessibility or digital accessibility refers to the appearance of web pages and applications. Such a concept enables people with visual, hearing, motor, cognitive, and neurological difficulties to encounter obstacles more simply in the physical and digital worlds. This type of concept should be strived for in occupational safety so that the workplace in the digital world is adapted to people with different needs. [11]

WCAG (Web Content Accessibility Guidelines) are groups of guidelines that aim to make the Internet as easy and accessible as possible for everyone, regardless of whether people suffer from neurological or other disabilities. WCAG was established through W3C (The World Wide Web Consortium) 1994. The development initiative was to develop an accessibility standard that would be accessible to everyone, and since then, several versions of the WCAG guidelines have been created. The latest edition of

WCAG 3.0 is currently the most developed edition of the guidelines. The possibilities of web accessibility are vast, and users can adjust their settings according to their preferences. Some of them are the ability to narrate (play audio and read text), change colors, modify text and images, page refresh option, and navigation. [11] Figure 2 shows some means and methods of increasing accessibility for paper (a), combined (b), and digital media (c).

a) b) c)

Figure 2: Means and methods of increasing accessibility [6, 10, 11]

Table 1 shows four WCAG Accessibility Principles. The acronym POUR is used a lot when describing accessibility, as these four, high-level guiding principles are considered the ultimate goal in web accessibility. [11]

Table 1: WCAG Accessibility Principles [11]

Principle	Description of principle
1. Perceivable	Users should be able to perceive digital information without any challenges. In online spaces, the two main senses are sight and hearing, but touch is also applicable where haptic tools are used. Examples include alt texts for images, color contrast, audio captions, etc.
2. Operable	A website should be easy to operate and interact with, and navigation must be simple.
3. Understandable	Websites should be built around clear language and built around predictable navigation and operations. For example, making websites operate in intuitive ways helps users avoid mistakes.
4. Robust	Content must be reliable across multiple technologies or digital platforms and adaptable to various accessibility tools. Examples include using proper markup language formatting, unique ID attributes, etc.

Table 2 shows conformance levels of WCAG standards. Each successive level consists of a higher adherence to the preceding level, making digital assets more robust and comprehensive. Although making your web content WCAG AAA compliant will help the most people and should be what everyone strives for, it's important to note it isn't always possible for every website. Even the W3C, the creator of the WCAG guidelines, admits this level of accessibility should not be required in general policies because it's not possible for all content to satisfy the requirements. That's why the W3C says it is common for websites to aim for WCAG level 2.0 level AA conformity. This middle-ground level of conformance provides more than just the bare minimum but is still achievable for websites and other digital content to conform to. [11]

Table 2: WCAG conformance levels [11]

Level	Description of conformance level
A	The most basic level, easy to achieve with minimal impact on a website's structure or design. If your website doesn't meet this standard, it's likely that it has accessibility barriers that need to be addressed.
AA	This is the level of accessibility that's considered most desirable as it offers higher conformity than level A. It is most commonly referred to in court legal proceedings and is a good standard for online accessibility. Making a website legally accessible typically means achieving these WCAG AA standards. The WCAG 2.0 AA is recognized by countries like Canada, Japan, Germany, the United Kingdom, Australia, and India as a legal standard.
AAA	Includes a higher, more strict set of benchmarks. WCAG AAA is the most comprehensive standard for digital accessibility and the ultimate goal to strive toward. However, this shouldn't be the required level because some content cannot satisfy the AAA requirements.

In principle, today, one of the main tasks of an occupational safety engineer should be to introduce measures in the risk assessment (as a basic safety and protection document of every company) that will not exclude people suffering from Irlen syndrome from their daily work.

After defining all potential problems, it is necessary to carry out the risk assessment itself. This is how the probability of the occurrence of possible dangers, as well as the consequences, is determined. For this reason, work processes, equipment, machines, and devices are reviewed. Based on the risk assessment, a plan is created with prescribed security measures. With this plan, they try to reduce and eliminate risks. The plan includes necessary changes in workplaces, new and adapted work equipment/technology / protective equipment and means, proposals for adapting work processes, education techniques, and personnel training. After the adopted measures, it is necessary to start and implement them to have a successful effect. With implementation comes the obligation to conduct frequent measurements and audits to ensure that the measures have produced results.

Along with all the techniques of implementing and ensuring the best possible working environment, it is also essential to mention the human factor. People with various neurological symptoms (neuro-diversity) have immense qualities, but they are often neglected because of the symptoms that make their work difficult. That is why the best way is to approach people individually and find out through conversation what can be done to make their workplace accessible, acceptable, and inclusive. [12]

4. CONCLUSION

Through the research conducted, this paper highlights the importance of understanding and properly approaching Irlen syndrome in the work environment. The low percentage of diagnoses - at the same time incorrectly established - and the misunderstanding of the symptoms of this disorder indicate the need for better education and support.

Integrating prevention methods, such as Irlen spectral filters and applying digital accessibility guidelines (via WCAG guidelines), are crucial to alleviating symptoms and creating accessible working conditions.

Through inclusive approaches, the work environment can become safer and more productive for all employees. This paper highlights the challenges faced by people with Irlen syndrome and the importance of creating an inclusive work environment to support employee diversity. Occupational safety experts should define this as one of their tasks. So, from the perspective of occupational safety experts, these risks must be carefully included in the risk assessment of modern workplaces.

REFERENCES

[1] Irlen.hr: Irlen sindrom, *Available from* https://www.irlen.hr/irlen-sindrom/ *Accessed:* 2024-04-24

[2] Exceptional Individuals: Irlen Syndrome, 2023, *Available from* https://exceptionalindividuals.com/neurodiversity/what-is-irlen-syndrome/ *Accessed:* 2024-05-02

[3] Watson, S.: EFerrit: Simptomi i opis Irlenovog sindroma, *Available from* https://hr.eferrit.com/simptomi-i-opis-irlenovog-sindroma/ *Accessed:* 2024-05-02

[4] Stevens, R.: NEWS: Irlen syndrome, the condition medical experts say doesn't exist, promoted to school teachers, 2019, *Available from* https://www.abc.net.au/news/2019-06-26/irlen-syndrome-medical-eye-condition-controversy/11218184 *Accessed:* 2024-05-10

[5] Dyslexia Awareness: Meares–Irlen, *Available from* http://www.dyslexia-aware.com/dawn/meares-irlen *Accessed:* 2024-05-10

[6] Irlen: What everyone needs to know, 2017, *Available from* https://irlen.com/ *Accessed:* 2024-05-10

[7] Miyasaka, Jordan Da Silva et al. "Irlen syndrome: systematic review and level of evidence analysis." Arquivos de neuro-psiquiatria vol. 77,3 (2019): 194-207. doi:10.1590/0004-282X20190014

[8] Irlen: Irlen Syndrome Self Tests, *Available from* https://irlen.com/get-tested/# *Accessed:* 2024-05-10

[9] Ritchie, S.J.; Della Sala, S.; McIntosh, R.D.: Irlen colored overlays do not alleviate reading difficulties, *Pediatrics,* **Vol. 128** (2011) No. 4, pp. 932-8, doi: 10.1542/peds.2011-0314. Epub 2011 Sep 19. PMID: 21930551 *Available from* https://pubmed.ncbi.nlm.nih.gov/21930551/ *Accessed:* 2024-04-29

[10] Microsoft: Accessibility tools for neurodiversity *Available from* https://support.microsoft.com/en-gb/topic/accessibility-tools-for-neurodiversity-6dbd8065-b543-4cf8-bdfb-7c84d9e8f74a *Accessed:* 2024-05-10

[11] User Way: WCAG Compliance Levels A, AA & AAA: Navigating Web Accessibility Standards, *Available from* https://userway.org/blog/what-are-wcag-2-0-a-aa-and-aaa/ *Accessed:* 2024-05-10

[12] Health Assured: HA_Neurodiversity in the Workplace_V2, *Available from* https://www.healthassured.org/blog/neurodiversity-in-the-workplace/ *Accessed:* 2024-05-10

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

REMOTE WORK CHALLENGES IN OCCUPATIONAL HEALTH AND SAFETY IN REPUBLIC OF CROATIA

Alojzije Grzelja Iveta[1]

[1] HŽ Infrastruktura d.o.o., Mihanovićeva 12, Zagreb, CROATIA,
alojzije.grzeljaiveta@hzinfra.hr

Abstract: *In the contemporary business world, the practice of working from home is becoming increasingly common. Although this flexibility offers many advantages to both employers and employees, the aspect of occupational health and safety is often overlooked. Workers who perform tasks from the comfort of their own homes may be exposed to various risks and unfavorable conditions that could affect their health. Unfortunately, a legal framework to regulate this type of work is still lacking. The aim of this work is to explore the shortcomings and uncertainties in the field of occupational health and safety concerning remote work. This paper will analyze the current situation, emphasize the importance of assessing the workspace and the conditions under which the worker performs their duties in a remote location, and highlight the potential negative health consequences for workers resulting from the lack of adequate regulation.*

Keywords: *Remote work, Safety, Regulation, OSHA*

1. INTRODUCTION

The expansion of working from home and remote work in the Republic of Croatia emerged with the onset of the coronavirus, specifically with the declaration of the coronavirus epidemic in the Republic of Croatia on March 11, 2020. Workers who could perform their jobs from home or remotely led to the expansion of such a work model with the aim of preventing the spread of the virus.

The work-from-home and remote work model only began to be regulated in laws and regulations at that time, which resulted in the legal framework not being sufficiently well-regulated in terms of occupational safety and ensuring a safe and healthy workplace for workers who would participate in working from home and remote work.

Although working from home does not fall under high-risk jobs for workers' health and safety, it is necessary to regulate it to meet at least the requirements related to computer work and to implement the same measures as for work in the employer's premises.

Remote work, or work using information and communication technology (ICT), leaves the location of the work itself much more flexible. The Labor Law states that the worker determines where such work will be performed and that it depends solely on the worker's will, and that the provisions on work at the workplace and on work at a separate workplace in terms of occupational safety regulations cannot be applied to such work. [1]

2. REMOTE WORK USING ICT

Remote work using information and communication technologies (ICT) has become a common practice in the modern business environment. The development of the internet and digital tools has enabled employees to perform their work tasks outside traditional office spaces, providing them with greater flexibility and autonomy. This method of work gained particular significance during the coronavirus pandemic, when many companies were forced to adapt to new circumstances to continue their operations.

Previous studies in this area have identified various levels at which this field needs to be regulated. Other European countries already have established foundations that can be followed to prescribe measures for protecting workers performing tasks via ICT or working from home. One of the studies recognized the levels that must collaborate to ensure a safe working environment. In our country, working from home has been incorporated into the Occupational Health and Safety Act as work at a separate location, while ICT-based work has not been recognized due to the difficulty in establishing protective measures. Currently, the only obligation of the employer is to instruct workers on the basic occupational safety measures regarding computer work.[2]

2.1. Advantages of Remote Work Using ICT

Remote work using ICT has many advantages for both employees and employers in terms of the financial and logistical complexities of this type of work relationship. Some of the benefits for employers who hire remote workers include:

- Lower costs for renting office space, utility services, office supplies, travel expenses, accommodation costs, and employee meal allowances
- The ability to hire experts from various geographical locations without the need for relocation
- Better organization and task tracking, which can lead to greater efficiency

Employees who work remotely using ICT primarily perform tasks such as software development, IT support and administration, data analysis and management, digital marketing, e-commerce, and similar jobs. From the perspective of how these jobs are performed, it is clear that they are computer-based and can be categorized as office jobs in terms of occupational safety. The advantages of remote work using ICT for employees include:

- Better alignment of work obligations with personal life

- Working in the comfort of their own home, which eliminates daily commuting, thus saving time and reducing transportation costs
- Working in an environment that suits them best

In addition to benefits for employers and employees, ICT-based remote work also has advantages related to environmental sustainability due to the reduction in commuting, leading to decreased emissions of carbon dioxide and other harmful gases.

2.2. Disadvantages of Remote Work Using ICT

Despite numerous advantages, remote work using ICT also has its drawbacks that can affect productivity, health, and overall employee satisfaction. Recognizing and managing these challenges is crucial for the successful implementation of remote work.

A major drawback in terms of occupational safety is the inability to implement all measures for the health and safety of workers. This issue arises because many countries, including the Republic of Croatia, do not have adequate legal and regulatory frameworks addressing the specific issues related to remote work. This is one of the key problems that can arise between employers and employees, related to working conditions, working hours, and workers' rights.

One significant disadvantage is the impact on workers' mental health, as they must balance work and private life, which can be challenging. Without a good balance, workers can easily experience stress, anxiety, and burnout.

A clear drawback is the lack of distinct boundaries between work and personal time, making it difficult for employees to relax and rest. For employers, there are also technical issues related to the security and confidentiality of data, which pose a significant risk in terms of cyber attacks and unauthorized access to sensitive information.

One of the main disadvantages of remote work using ICT is inadequately equipped workspaces. Many workers do not have access to ergonomically designed furniture, which is standard in offices, leading to serious health issues. Instead of ergonomic desks and chairs, many workers use regular tables in home environments, cafes, or other informal settings. Such spaces are often not suitable for prolonged sitting and working.

Using regular chairs that do not meet office work standards can result in discomfort and health problems such as back, neck, and shoulder pain. Prolonged sitting on non-ergonomic chairs can cause poor posture, increasing the risk of developing musculoskeletal disorders. In addition to physical problems, working in inadequately equipped spaces can reduce workers' productivity and concentration, negatively impacting overall work efficiency.

Inadequate lighting is another significant issue in these informal work environments. Many workers operate in spaces where natural light is insufficient or where artificial lighting is not suitable for working conditions. Poor lighting can cause eye strain, headaches, and fatigue, further reducing work efficiency. Working in overly dark or overly bright environments can disrupt concentration and increase the risk of errors.

2.3. The Issue of Workplace Injuries in Remote Work Using ICT

One significant challenge of remote work is the reporting of injuries that occur while performing work tasks. Traditionally, workplace injuries are reported and documented within the employer's premises, where clear procedures and responsible personnel manage record-keeping and provide first aid. However, remote work introduces a series of complications to this process.

Remote workers may have difficulty identifying an injury as a work-related injury, especially if it occurs in a home environment or another space where the line between work and private life is blurred. Additionally, determining the exact moment and circumstances of the injury can be challenging, further complicating the reporting process.

Injuries that occur in office work are most often caused by slips or trips. Such injuries are difficult to manage because the cause of the injury cannot be controlled if the worker is performing tasks from home. This problem stems from the Constitution of the Republic of Croatia, which states in Article 34, "The home is inviolable" [3], meaning that there is no ability to regulate or align the space in which the worker performs their job according to the requirements arising from regulations governing workplace safety.

3. LEGAL FRAMEWORK FOR REMOTE WORK USING ICT

The Labor Law (NN 64/23) is the fundamental law regulating employment relationships and serves as the basis for defining work areas to be regulated by other laws. The Labor Law has left too much room regarding the regulation of remote work safety by not applying the provisions on work at a separate workplace in terms of occupational safety regulations. According to Article 17.b, paragraph 6, the Labor Law states that workers performing such tasks must only be given written instructions related to health and safety at work [1].

It is challenging to define a model for implementing health and safety protection for remote workers under the Occupational Safety Act due to poorly defined concepts of such work. The Labor Law does not classify this type of work as work at a separate location, giving workers absolute freedom regarding their place of work.

The workplace of a worker who performs their job from home or remotely must be considered and treated like any other workplace. A risk assessment must be conducted, and minimal technical conditions must be defined to ensure a safe and healthy working environment. [4]

3.1. Minimum Health and Safety Requirements for Workplaces

The minimum health and safety requirements for workplaces are prescribed by the Regulation on Occupational Safety for Workplaces (NN 105/2020). This regulation applies to work in the employer's premises and work from home, as indicated in Articles 3 and 4, which set the minimum requirements for work in the employer's premises and work from home. However, it does not address the requirements for remote work or the minimum standards for using such spaces to perform tasks for the employer. [5]

Remote work is partially regulated by the Labor Law (NN 64/23), where the core issue of such workplaces lies in ensuring occupational safety, whose primary goal is to provide a safe and healthy workplace for remote workers.

Article 17, paragraph 2 of the Labor Law states: “Remote work is work that is always performed using information and communication technology, where the employer and the worker agree on the worker's right to independently determine where the work will be performed. This can be variable and depend on the worker's will, which is why such work is not considered work at a workplace or at a separate workplace in terms of occupational safety regulations.” [1]

The Occupational Safety Act defines what a separate workplace is, but it does not prescribe measures to be taken during remote work or how to ensure a safe and healthy workplace for a worker performing such work. [4]

Table 1: Equipment Used by Employees in different forms of work environments

	Type of work		
Equipment Type	*On-site Work*	*Work from Home*	*Remote Work (ICT)*
Computer	Yes	Yes	Yes
Monitor	Yes	Yes	Yes
Office Desk & Chair	Yes	Yes	Yes

From Table 1, it is evident that regardless of the space in which office tasks are performed, workers use the same equipment, but the legal conditions are not defined in the same manner.

When such tasks are performed in the employer's premises, they are regulated by regulations that prescribe minimal conditions, including minimum lighting, computer positioning, periodic workplace inspections, and similar requirements.

When a worker performs such tasks from home, there are two types defined by law: regular and occasional, which actually leave a fairly flexible situation for the employer. If the worker performs tasks occasionally, and considering they are low-risk jobs, the employer is not obligated to inspect or register that place in the risk assessment.

For remote work, there are no legally prescribed conditions for ensuring a safe and healthy workplace, as the root of the problem lies in the absolute freedom of choice of the work location by the worker. Consequently, the employer is unable to implement or assess protective measures for the worker's workspace. Therefore, it is legally necessary to define minimum conditions for remote work, similar to those defined for work in the employer's premises and for work from home, as without this, it is impossible to ensure a safe and healthy working environment for workers who work remotely.

The Government of the Republic of Croatia issued a Regulation in 2023 regarding the possibility of civil servants working at a remote workplace, working remotely, and working part-time, referring to the Occupational Health and Safety Act and other laws regulating remote work. However, there is no specific legislation in Croatia that clearly defines remote work. [6]

.

4. RECOMMENDATIONS FOR REGULATING REMOTE WORK

The legislative body in the Republic of Croatia plays a crucial role in the development and adaptation of regulations governing remote work. This process should involve experts from relevant fields to introduce clear guidelines aimed at ensuring a safe and healthy remote work environment. Only a clear legal framework that allows for flexibility in remote work alongside minimal technical workspace requirements can lead to the protection of workers' lives and health.

In addition to safety concerns regarding the equipment used by workers, significant attention must be given to workers' mental health. This includes providing support for stress management, promoting a balance between work and personal life, and offering resources for mental well-being.

The legal framework must ensure the possibility of monitoring work equipment and protective measures. Legislators should consider subsidizing costs for adapting home workspaces and encourage employers to provide adequate equipment and support.

3. CONCLUSION

The workplace of a worker who performs their job from home or remotely must be considered and treated like any other workplace, and minimal technical requirements must be defined for it. These requirements aim to ensure a safe and healthy working environment for the worker.

The only way to improve and ensure a safe and healthy remote work environment is through the amendment of laws and regulations.

REFERENCES

[1] Zakon o radu (Narodne Novine 64/23)
[2] Robelski, S.; Sommer, S. ICT-Enabled Mobile Work: Challenges and Opportunities for Occupational Health and Safety Systems. Int. J. Environ. Res. Public Health 2020, 17, 7498.
[3] Ustav Republike Hrvatske (Narodne Novine 5/14)
[4] Zakon o zaštiti na radu (Narodne Novine 96/18)
[5] Pravilnik o zaštiti na radu za mjesta rada (Narodne Novine 105/2020)
[6] Uredba o mogućnosti rada državnog službenika na izdvojenom mjestu rada, rada na daljinu i rada u nepunom radnom vremenu (Narodne Novine 141/2023)

ENHANCING WORKPLACE SAFETY: STRATEGIES AND PRACTICAL STEPS DERIVED FROM INA GROUP'S EXPERIENCE

Jelena Ivančan[1], Dragica Ličko[1],
[1]INA Plc., Avenija Većeslava Holjevca 10, Zagreb, Croatia, Jelena.Ivancan@ina.hr

Abstract: *Injuries in the workplace pose a significant challenge for organizations worldwide, not only due to their immediate impact on employee health and safety but also because of their repercussions on productivity, financial costs, and employers' social responsibility. Incident investigation management and the implementation of appropriate protective measures are vital for workplace safety. This study paper examines workplace injuries in the INA Group, comparing findings with industry reports to identify best practices. The aim is to explore injury frequency, types, and trends to develop effective prevention strategies. Through analysing safety protocols and employee training, practical steps for enhancing workplace safety programs will be provided. The research aims to contribute valuable insights to improve safety within INA Group and the industry at large. Emphasis will be placed on the effective utilization of personal protective equipment as a crucial aspect of injury prevention.*

Keywords: *HSE, TRIR, PPE, personal injury, workplace*

1. INTRODUCTION

The two documents, "European downstream oil industry safety performance Statistical summary of reported incidents from Concawe and Safety performance indicators from the International Association of Oil & Gas Producers (IOGP), provide comprehensive analyses of safety performance within sectors of the oil industry.

The document "European downstream oil industry safety performance Statistical summary of reported incidents" provides a detailed analysis of safety performance within the European downstream oil industry. In 2022 comparing the data presented in the repor [1], the industry reported eleven fatalities, a significant increase from the previous year. The fatalities included two manufacturing staff and nine contractors. The total number of Lost Workday Injuries (LWI) recorded was 568, marking an 11% increase from 2021. The most common causes of these injuries were slips and trips at the same height, cuts, punctures, and being caught in or between objects. The document "IOGP Safety Performance Indicators " provides a comprehensive analysis of safety performance within the oil and gas exploration and production industry, covering global safety performance in 92 countries and involving data from 51 companies. In report [2] for 2022, there were 33 fatalities from 29 separate incidents, marking an increase from

20 fatalities in 2021. The Fatal Accident Rate (FAR) significantly rose by 71% to 1.28 per 100 million work hours. A total of 682 Lost Work Day Cases (LWDC) were reported, with the leading causes being slips and trips at the same height, cut, puncture, scrape caught in or between objects, and struck by objects not dropped (see Figure 1).

Although the Concawe and IOGP reports focus on different segments of the oil industry and cover different geographical scopes, they share a common goal of enhancing safety through data-driven insights and standardized safety performance indicators. Both reports advocate for rigorous adherence to safety protocols, continuous learning from past incidents, and the implementation of life-saving rules to significantly reduce workplace injuries and fatalities in the industry.

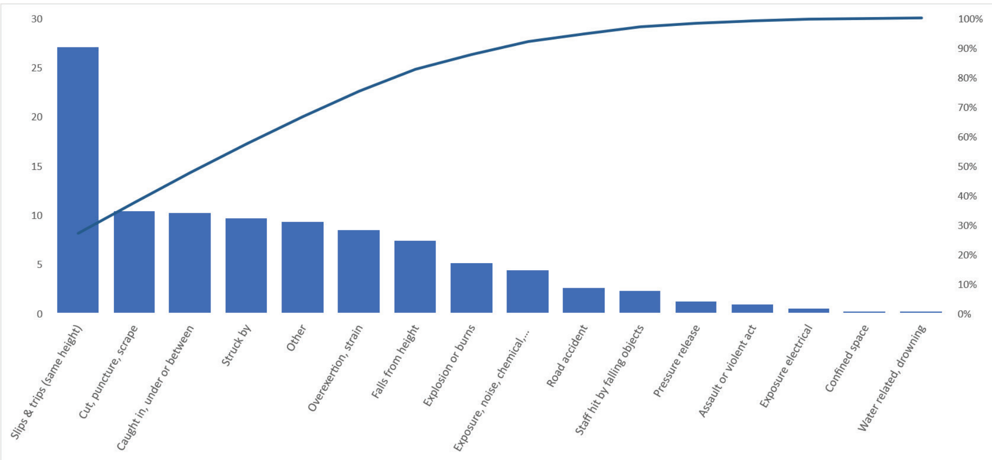


Figure 1. Pareto- percentage of LTI root causes out of total nomber of incident

The proposed programs for specific categories of incidents are derived from the best global practices and INA Groupe industry experience. For each of the specified categories of workplace incidents, incorporating Health, Safety, and Environment (HSE) aspects into preventive actions (PA), recommendations, and protective equipment (PPE) can significantly mitigate the risks associated with these incidents. Here are detailed approaches for each category tailored for an HSE engineer in the oil and gas industry:

1. Road Accident

PA: Implement regular and rigorous driver training programs focusing on defensive driving and hazard recognition. Monitor vehicle conditions through a systematic maintenance schedule and utilize GPS tracking and behaviour monitoring systems to ensure compliance with safety protocols and route adherence. **Barriers:** Deploy Advanced Driver Assistance Systems (ADAS) such as automatic braking and lane-keeping assist to reduce human error. Implement strict speed limits within operational zones and ensure all transport routes within facilities are clearly marked and illuminated. **Equipment:** Equip all vehicles with safety belts, airbags, and comprehensive emergency kits, including first aid supplies and fire extinguishers.

2. Falls from Height

PA: Establish a mandatory fall protection program including personal fall arrest systems, guardrails, and safety nets. Conduct regular safety audits and equipment inspections to ensure compliance and integrity of fall protection systems. Provide intensive training for all workers on proper usage of fall protection gear and safe work practices at heights. **Barriers:** Install permanent safety barriers such as guardrails and toe boards at all elevated workspaces. Use aerial work platforms equipped with enhanced safety features for high elevation tasks. **PPE:** This is one of the most dangerous types of work and choosing the right PPE is essential to prevent falls and keep workers safe in the workplace. Require the use of Safety Harness, Lanyards and Connecting Devices, Anchor Points and Access Equipment, Work Restraint, Height Safety Helmet.

3. Staff Hit by Falling Objects

PA: Enforce strict policies requiring the securing of all tools and materials at height to prevent them from falling. Implement exclusion zones under elevated work areas and use tool lanyards to prevent tools from dropping. **Barriers:** Install debris nets and overhead protective structures in areas where works are conducted above ground level. These systems should be designed to catch or deflect falling objects effectively. **PPE:** hard hats, safety goggles, and footwear with cap in areas where there is a risk of falling objects. Hard hat headbands and chin and nape straps should be adjusted to keep the hat comfortably on the head.

4. Slips & Trips (Same Height)

PA: Implement a comprehensive housekeeping protocol to ensure all work areas are free from slip and trip hazards. Regularly inspect and maintain flooring and walking surfaces to ensure they are in good condition and free of hazards. Apply anti-slip floor coatings in areas prone to wet or oily conditions. **Barriers:** Educate employees on the importance of maintaining clean and organized work areas. Mark transitional areas with different floor textures and lighting to alert workers of potential hazards. **PPE:** Require the use of footwear with anti-slip sole designed specifically for the operational environment.

5. Exposure Electrical

PA: Conduct regular electrical safety training that includes the proper handling and maintenance of electrical equipment, emergency response, and the use of lockout/tagout procedures. Ensure all electrical installations comply with the latest safety standards and regulations. **Barriers**: Implement and strictly enforce lockout/tagout systems to control all forms of hazardous energy. Regularly inspect electrical systems to identify and rectify potential hazards before they lead to an incident. **PPE:** Depending on the job task to be performed, PPE for the electric power industry generally includes safety glasses, face shields, hard hats, safety shoes, insulating (rubber) gloves with leather protectors, insulating sleeves, and flame-resistant (FR) clothing.

6. Explosion or Burns

PA: Adhere to stringent chemical handling protocols, including proper labelling, storage, and transfer procedures. Conduct regular risk assessments and safety audits to identify potential hazards associated with explosive materials. **Barriers:** Enhance the training on emergency response and fire safety, including the use of fire extinguishers and suppression systems. Upgrade to automated fire detection and suppression systems that can detect and react to fires without human intervention.

PPE: Suitable personal protective equipment for flammable solids includes fire-resistant clothing, thermal gloves, eye protection, safety helmets, safety footwear and respirators.

7. Confined Space

PA: Require entry permits for all confined space operations that detail the nature of the work, the personnel involved, and emergency contact information. Continuously monitor the atmosphere within confined spaces for hazardous gases or oxygen deficiency. **Barriers:** Conduct regular training exercises focused on confined space safety that includes rescue drills and scenario-based learning. Improve ventilation systems within confined spaces to ensure adequate air quality and circulation. **PPE:** The requirements will vary according to each confined space, but the basic PPE needs will consist of the following: fire-resistant clothing, head protection, hand and foot protection, respiratory protection, fall protection, rescue equipment.

8. Assault or Violent Act

PA: Implement comprehensive security measures including surveillance cameras, controlled access to sensitive areas, and background checks for all new hires. Develop and regularly update an emergency response plan that addresses potential security threats. **Barriers:** Increase the presence of security personnel, especially in high-risk areas. Hold regular training sessions on conflict resolution and maintain a strict zero-tolerance policy towards workplace violence. **Equipment:** Distribute personal alarm systems and consider the use of body cameras for security personnel to deter assaults and accurately record incidents

9. Water Related, Drowning

PA: Ensure that all work near or on water includes life jackets and other personal flotation devices as mandatory. Implement rigorous safety barriers around large bodies of water to prevent accidental falls. **Barriers:** Conduct regular drills that practice emergency response to water-related accidents, including man-overboard drills and the proper use of life-saving equipment. **PPE:** Provide water-resistant and buoyant life jackets that are inspected regularly for integrity and buoyancy.

10. Cut, Puncture, Scrape & Struck by

PA: Standardize the use of protective guards on all machinery with moving parts to prevent accidental contact. Store sharp objects safely and ensure that tools are maintained in good condition. **Barriers:** Implement a tool management system that tracks and maintains all tools used on-site to ensure they are stored safely and are in good working condition. Provide training on the proper handling and storage of sharp objects. **PPE:** Require the use of cut-resistant gloves, safety goggles, and protective clothing that can prevent injuries from flying or falling objects.

11. Exposure, Noise, Chemical, Biological, Vibration

PA: Implement comprehensive hazardous material management systems that include proper storage, handling, and disposal procedures. Use engineering controls to reduce exposure to harmful substances and vibrations. **Barriers:** Regularly conduct health screenings and monitoring to detect early signs of exposure-related illnesses. Use administrative controls to limit the duration and intensity of exposures. **PPE:** Provide specialized PPE such as respirators, earmuffs and earplugs, gloves and chemical-resistant clothing tailored to the specific hazard workers are exposed to.

12. Caught in, Under or Between

PA: Install physical guards on all machines with moving parts to prevent accidental entrapment. Utilize lockout/tagout procedures to ensure machinery is de-energized during maintenance. **Barriers:** Commit to following all Safety Protocols and provide training on the risks associated with working around heavy equipment and the importance of using protective guards. Conduct regular safety audits and maintenance checks to ensure all machinery guards are in place and effective **PPE:** Equip workers with sturdy work clothes and gloves that provide a high level of protection against crush and shear points.

13. Overexertion, Strain

PA: Design workstations to promote good ergonomics and reduce the physical demands on workers. Implement job rotation policies to prevent repetitive strain injuries. **Barriers:** Foster a workplace culture that encourages regular breaks and physical exercises to relieve tension and stress. Train workers on how to recognize the early signs of overexertion injuries and to report them promptly. Make sure workers take suitable work breaks. **Equipment:** Provide back supports and ergonomic tools that help maintain good posture and reduce strain.

14. Pressure Release

PA: Regularly inspect pressure systems and relief devices to ensure they are functioning properly and are not susceptible to unexpected pressure releases. **Barriers:** Implement stringent inspection and maintenance schedules for all pressure vessels and associated piping. Train workers on the dangers associated with pressure systems and the importance of adhering to operational protocols. **PPE:** Use protective shields and barriers to contain potential explosions or releases from pressurized systems. Generally, appropriate PPE for high pressure applications includes at a minimum chemical-resistant gloves, protective clothing, eye and face protection, and respiratory protection.

15. Other Causes

PA: Develop a flexible and responsive safety management system capable of adapting to unique or unexpected challenges. Investigate all incidents thoroughly to tailor specific safety measures. **Barriers:** Maintain a dynamic process of continuous improvement in safety measures, incorporating lessons learned from past incidents and near misses into future safety planning. **PPE:** Provide specialized protective equipment based on the specific risks identified during the incident analysis.

These expanded descriptions provide a detailed blueprint for HSE engineers to implement robust safety protocols in the oil and gas industry, ensuring compliance with international standards and promoting a culture of safety.

2. INA GROUPE PERFORMANCE DATA

During 2023, there was one work-related fatality of contractor worker in INA Group. The fatality incident occurred during works at height. A detailed investigation carried out where the root causes were analysed, corrective and preventive measures were determined for elimination of deficiencies and solving systematic errors. The activities that we carry out after the investigation are related to the contractor safety management, improvement of the classification and checking of safety critical activities, contractor's trainings for working at height by authorized institutions, pre-screening and pre-qualification. Then the improvement of the work permit issuing system, the process modification and the quality of the work permit, research of possible solutions and best practices. Activities dedicated to improving the quality of HSE inspections, document them and analyse, improve contractor on-site HSE training, Walk-to-Talks, etc. Renewal of education of life safety rules, monitoring of violations of life safety rules is being performed and all workers are involved.

INA Group experienced an increase of Total Recordable Injuries (TRI) among own employees and contractors, reaching a combined 37 in 2023, compared to 32 in 2022. Out of Total Recordable Injuries (37), one was fatality, 28 were lost-time injuries, 8 were medical treatment cases. Comparative data of the INA Group [3] and benchmarking are shown in Figure 2. with an indication that for Y2023 official data for Europe have not yet been published.

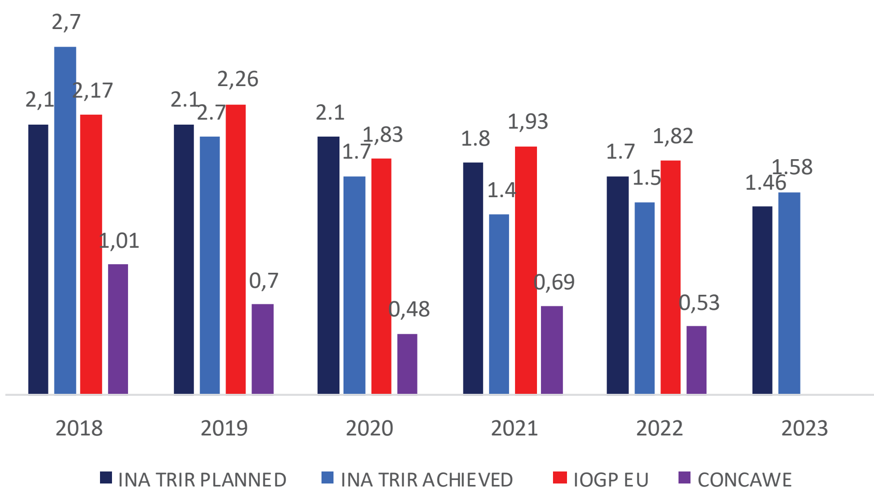


Figure 2. TRIR rate 2019-2023

Five main causes of injuries occurred in 2023 in INA Group are presented in the pie chart below, seen Figure 3.

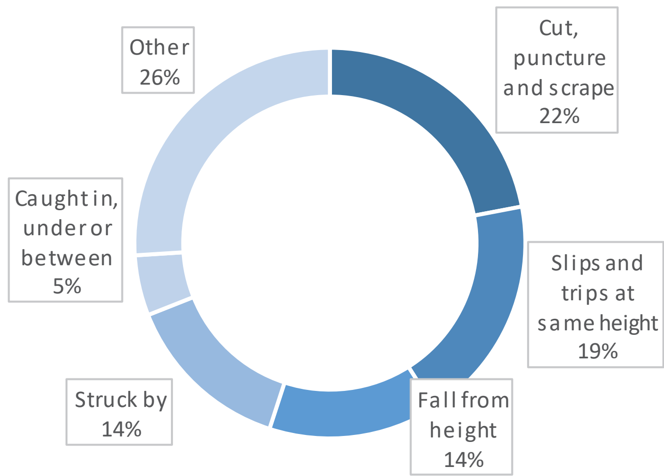


Figure 3. Main causes of injuries INA Group

3. LIFE SAVING RULES

Life Saving Rules are established to improve safety performance and to ensure employees a license to say 'NO' based on the most important aspects of safe working in industrial environment. They are simple, sharp and do what they say – save lives, that is why it is so important and expected to always obey by them. This goal can only be achieved if every single person remembers the importance of safety, accepts his/her personal responsibility, and knows what to do. It is important that the Life Saving Rules are understood by all individuals, their supervisors, and their leaders, while following the Rules is not only mandatory for everyone, but it is ensured that we are all enabled to do so. All INA Group employees and contractors should adhere to the safety rules (see Figure 4.), intervene, and stop work if there is a doubt about safety, so everybody can return home safely after working day!

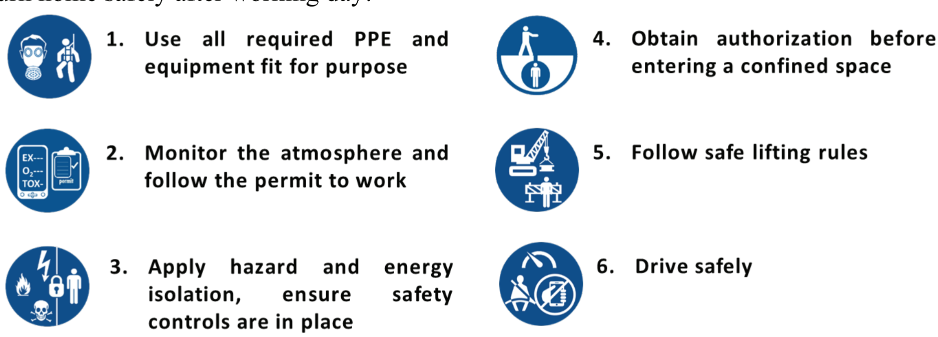


Figure 4. Life saving rules[4]

4. PROCES SAFETY FUNDAMENTALS

Process safety fundamentals PSF are a set of basic principles intended to support frontline workers, supervisors, and operational management. They draw attention to situations that could lead to a release of a hazardous chemical with potential for severe consequences and emphasize existing good practices to prevent such events. The Process Safety Fundamentals mention typical critical aspects that are not easy to do well and that have result multiple serious incidents and potentially serious consequences of process safety events (lost of primary containment). Not all chemical safety hazards are addressed. They can be used very well at industrial sites dealing with hazardous chemicals, in addition to the existing process safety management systems. Therefore, the PSFs do not replace existing safety management systems (including policies, safe systems for work, safety training programs, change management, critical task analysis & procedures etc.) but provide a tool to increase understanding on the items that often go wrong. Process Safety Fundamental in INA Group are shown on Figure 5.

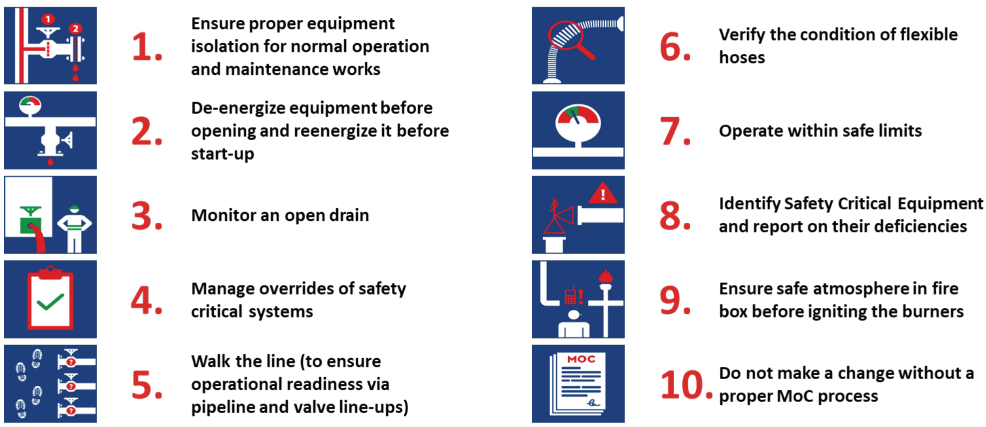


Figure 5. Process Safety Fundamental in INA Group [4]

4. CONCLUSION

Every employee should be aware of the dangers in the workplace and has the right to use “Stop Work Authority” whenever real or potentially unsafe condition or unsafe actions are identified. All control measures must be taken including personal protective equipment, which means that it must be implemented along with all other control measures.

REFERENCES

[1] Concawe, European downstream oil industry safety performance: Statistic summary of reported incidents-2022, *Available from https://www.concawe.eu/publication/european-downstream-oil-industry-safety-performance-4/*

[2] IOGP Safety performance indicators - 2022 data, *Available from: https://www.iogp.org/bookstore/product/safety-performance-indicators-2022-data/*

[3] INA Annual Report 2023, *Available from https://www.ina.hr/app/uploads/2024/05/Annual-report-2023.pdf*

[4] INA Internal Standard operative procedures

Live working - Accidents in electrical transformation stations

Isidoro, Rui[1], Serra, Luís[2]

[1] Polytechnic University of Beja, Life Quality Research Center (LQRC), Portugal, rui.isidoro@ipbeja.pt

[2] Polytechnic Institute of Beja, Portugal, luisviegas.serra@hotmail.com

Abstract: Ensuring the continuity of the electricity supply service is, nowadays, one of the most principal factors for its distributors and consumers, which is why efforts are increasingly being sought to promote, apply, and develop techniques and materials to optimize live line work, to minimize the impact of interventions in the electrical, transport and distribution grid networks.

However, nothing should override the safety of workers, as work plays a central role in the lives of these operators, and regardless of the importance of any organization's objectives, they have a legal and moral obligation to provide safe and healthy working environments to achieve its objectives.

The present study case is fundamentally based on an empirical analysis of a reflective nature, regarding a set of data collected in a company in the electricity sector, referring to a period of 10 years, in order to understand the impact that certain measures adopted by the organization had on the influence of accident rates.

This analysis will provide to understand the impact that all the investment channeled by the organization in safety management for 10 years had on accident rates, namely in those that occurred at electrical transformation stations.

Keywords: *Life quality, Electrical Grid, Live Line Work, Occupational safety, Accident index*

1. INTRODUCTION

This study is part of a real problem experienced by organizations in order to understand, within the scope of occupational safety management, what is the balance between the needs and objectives of the business, because it is absolutely necessary for companies to have a clear vision of whether their investment translates into an effective return. This is even more evident when organizations, the majority of work is carried out in facilities that, due to their characteristics are a source of danger, we are obviously talking about electrical installations, namely installations, particularly transformer substations, which have historically had the highest weight in accident rates.

Clark [1] suggests the need to clarify that the risks of operational work are not univocally linked to the individual actions of employees, but are necessarily related to and interdependent on the directives issued by the chain of command, and with the modus operandi in terms of the administration and management of the service's operational organization.

The administrative and managerial decisions made upstream of the site of operations act significantly as determinants in the production of risks.

The administrative conception of work, prevalent among managers, entrepreneurs and consultants specializing in organization, assumes that standardization will mostly solve the problems identified and the difficulties of work. However, this is not the case in reality.

Experience has shown that it is very difficult, when drawing up an operating procedure, to take into account the many complex combinations of eventualities, events and likely scenarios [2].

Batista [3] analyzed the activity of a company in the printing industry, which employs 700 people, and the associated occupational accidents, in order to identify the most relevant direct and indirect causes of accidents at work in this sector of activity. To this end, a current and detailed analysis of the company's accidents was carried out, using both a management report and a history compiled in Excel files, applying the Retirement Income Advice Assessment Tool (RIAAT) methodology to the treatment of 29 non-fatal accidents.

After analyzing the data and the company's knowledge, the added value of applying an accident analysis methodology such as RIAAT became clear. Although the number of accidents analyzed was not very large and there were no serious consequences for the injured party, the results of the analysis provided an informed idea of the main safety problems in the sector.

The action plan was to implement a number of measures, such as training courses more focused on practical cases, greater responsibility on the part of both operators and, above all, foremen, and updating machinery whose functions can be carried out by newer machines.

The aim of Graça's [4] dissertation was to analyze the evolution of serious and fatal occupational accidents in the extractive industry, a sector where the incidence rate of accidents is very high compared to other sectors of activity in the years (2001 to 2012).

Based on surveys of accidents at work carried out by the Portuguese Authority for Working Conditions (ACT). The methodological process aimed to find out about the causes and evolution of occupational accidents, their circumstances and related occupational injuries/consequences by comparing the results obtained with statistics published by official sources and similar academic works. The RIAAT methodology was applied to the data obtained, with the necessary adaptations, in order to analyze the causality of accidents at work. The study has once again revealed how extremely important top-level training is in companies, aimed at improving the qualifications of the workers involved in the processes, with a view to changing behaviors and attitudes.

In his PhD thesis, Montemor [5] addressed the problem of accidents in the agriculture, livestock and forestry sector, where there is a significant volume of accidents, both at work and on the road. In this way, Montemor hoped to help solve the problem of underreporting and, consequently, contribute to the prevention and reduction of accidents by creating a single platform for registration.

By characterizing the environments in which accidents occur, namely the policy guidelines and regulations on occupational health and safety, the structure of the organizations, the traits, social relations and the workforce used, as well as the risk factors. The characterization of accidents was based on statistical data from different Portuguese authorities in order to cover all types of accident (at work, on the road and those occurring while carrying out tasks associated with hobbies, leisure time or to supplement income).

One of the conclusions drawn from the study by the author was that there is a trend towards the ageing of rural producers, where there is little information and training on occupational risks and the massive use of tractors, mostly old ones, leading to a notable volume of accidents in the sector.

More recently, Neto, et al. [6] addressed accidents in the road freight transport sector, where reducing accidents is one of the major challenges for companies in the sector today. The methodology focused on the application of questionnaires to around 30 organizations considered to be benchmarks in the sector.

It was then concluded that the issue of accidents in the road transport companies that were the subject of the study did not have the necessary management involvement, nor did they have initiatives in communication and training for their employees. To remedy this shortcoming, the authors proposed the creation of a conceptual model that would be easy for people to understand. This conceptual model proposes that companies draw up their policies and plans, including objectives and process design, focused on reducing accidents, and put into practice their communication, training and awareness-raising activities.

The various references presented above in various sectors of activity show that there is a commitment to information/training as a means of preventing and minimizing accidents. Various research approaches have been applied, such as the application of accident investigation methodologies and the application of questionnaires to certain population samples in quantitative approaches.

2. METHODOLOGY

2.1. The concept of indicators

Searching for information on indicators returns countless results, and from the most diverse categories: economic, social, financial, environmental, health, political, etc. However, all these indicators have one thing in common. This is that they refer to precise and constant information that allows top management to make organizational decisions. The importance of indicators is clear and their role has become fundamental in decision-making, whether in small companies or multinationals.

In a report on environmental indicators, the Organization for Economic Cooperation and Development (OECD) defines indicators as follows: "(...) a parameter, or a value calculated from parameters, providing indications about or describing the state of a phenomenon, the environment or a geographical area, of a wider range than the information directly linked to the value of a parameter." [7].

There are various definitions by various authors, but Hartmut Bossel defines indicators as something we live with every day. "Indicators are our connection to the world. They condense its enormous complexity into a manageable amount of meaningful information, into a subset of observations that inform our decisions and direct our actions. (...) Indicators represent valuable information. (...) Indicators are an expression of values" [8].

In summary, although different authors use different terms to define the concept of indicator (referring to it as a parameter, measure or value), they agree that indicators are a way of simplifying and summarizing phenomena by quantifying them.

2.2. Organizational indicators

According to APCER [9], there are various indicators that we can use in order to measure and monitor performance (table 1).

Proactive

- Supported by the management program;
- Based on operational criteria;
- Consistent with legal and regulatory requirements.

Reactive

- Based on accidents, illnesses and other historical evidence of poor performance (such as statistical analyses of claims).

Indicators can be monitored qualitatively or quantitatively and, whenever possible, performance measures should be quantified so that comparisons can be made efficiently. Quantitative measures can be described in quantitative terms and recorded on a scale.

Qualitative measures, which are, for example, descriptions of conditions or situations that cannot be quantified, can be evaluated and recorded, for example, with a comment on the deliberations of an OSH committee [9].

Table 1: Safety indicators

Pro-Active Indicators	a) Number of people trained in OSH; b) Effectiveness of OSH training; c) Number of suggestions from workers for OSH improvements; d) Frequency of OSH audits; e) Time taken to implement OSH audit recommendations; f) Frequency and effectiveness of OSH committee meetings; g) Frequency and effectiveness of OSH meetings with employees; h) Reports from OSH specialists; i) Time taken to implement actions on complaints or suggestions; j) Number of health surveillance reports; k) Sample reports on personal exposure; l) Workplace exposure levels (e.g. noise, dust, gases, etc.); m) Use of personal protective equipment.
Reactive Indicators	a) Number of unsafe acts; b) Dangerous conditions; c) Number of "near misses"; d) Accidents that only cause material damage; e) Dangerous occurrences reported; f) Accidents involving absence from work for more than three days; g) Absences due to illness - employee absences due to illness (occupation-related) (occupation-related); h) Complaints made, for example, by members of society.

Indicators that allow for active surveillance are indicators that allow for the monitoring of objectives and, above all, those that confirm the implementation of risk control measures. This continuous monitoring allows us to predict potentially unwanted events and preventive measures to be implemented and maintained before any occur.

2.3. Occupational safety and health indicators

Table 2 summarizes the accident index.

Table 2: Accident Index

Accident Index	
Frequency Index (IF)	Number of occupational accidents by one million hours worked
Severity Index (IS)	Number of lost days by one million hours worked
Incidence Index (II)	Number of occupational accidents for 1 000 employees

2.4. Workers

The success of a company in more competitive markets depends not only on the quality of its products and services and other factors, but largely directly on all employees.

In this way, it is important that management can count on teams that are organized and aligned with the management's objectives, but also that it promotes and guarantees the satisfaction and motivation of employees, ensuring that their dedication is increasingly better, increasing their productivity.

2.5. Professional training

Employers and their representatives are obliged to promote qualifying training, with the aim of promoting the creation of skills that allow preventive management to be integrated into the company's overall management. The training of workers and their representatives must also be training, whose primary objective is the creation of skills and the internalization of appropriate preventive behaviors.

2.6. Preventive Safety Observations

Preventive techniques, aimed at identifying and controlling unsafe acts/conditions, through the observation of workers during the development of their work, when compared with the values collected from work accidents, reveal to us that in years of greater focus on prevention and In anticipation of the most common risk situations and the discovery of new dangers, accident rates tend to decrease. The used was Audits, Inspections, Visits and Observations (AIVO).

2.7. Weather

The climate is constantly changing, and industrialization is increasingly polluting. The industry, in partnership with large energy utilities and some large equipment manufacturers, has tried to respond to these challenges by developing processes to improve the manufacturing of new technologies.

Electrical power distribution lines are frequently subject to overvoltages and atmospheric discharges that contribute to interruptions in the supply of electrical energy, caused by atmospheric conditions, namely salt fog.

3. RESULTS

3.1. Accident Index

Table 3: Accidents evolution

Accidents evolution	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Work accidents (Electrical sector)	52	43	45	48	52	43	39	28	27	36	21
Deadly Accidents	4	3	4	2	3	1	3	0	3	1	1

Table 4: Accident Index Results

Accident Index	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Frequency Index (IF)	4.4	3.4	3.9	4.0	4.5	4.8	3.5	2,4	2.5	2.9	2.4
Severity Index (IS)	7.9	6.3	6.9	7.2	8.2	6.8	6.3	4.3	4.4	5.3	3.2
Incidence Index (II)	354	353	326	359	411	277	294	248	180	203	306

Analyzing the evolution of accidents over the years under study, showed in table 3, 434 accidents were recorded in service, of which 25 were fatal accidents. Non-fatal work accidents generated 40,162 lost days. The trend of both fatal accidents and others was decreasing, with the lowest value being recorded in 2017 both in number (0) and in incidence rate (4.3). In 2020, compared to 2010, 3 fewer workers died. In 2020, the incidence rate of work accidents was 3.21. This is the year in which the lowest incidence rate has been recorded since 2010. This year, the highest accident rates were recorded (52).

The accident index results are summarized in table 4:

Regarding the FI, the lowest value (2.35) was recorded in 2020 and the highest (4.5) in 2014.

The II had its lowest value (3.21) in 2020 and its highest (8.2) in 2014.

The IS reached the lowest value (180), it was reached in 2018 and the highest (411) in 2014, where, in the same way, IS severity in the organization is also included in the parameter “Very Good”.

3.2. Professional training

After analyzing the values collected, included in the interval (2010-2020), there is a focus on 256,738.00 hours of training in OSH, with a universe of 142,539.00 participants internal and external to the company. Having its maximum peak in 2014 with 44,157.00 training hours (table 5)

Table 5: Professional training

Professional training	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Trainees	8452	9326	10499	9534	13325	12921	20856	11659	11011	10407	24549
Training hours	15184	23362	23557	22790	44157	21831	27539	19680	26150	20866	11622

3.3. Audits, inspections, visits and observations

Being one of the bets of the company under study, and this being reflected in the annual results referring to each employee, there is an increase in the actions carried out since 2010, meaning that from that first year under study, the values no longer returned to their initial values, reaching their maximum value in 2020, as shown in table 6.

Table 6: Audits, inspections, visits and observations

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
AIVO	1084	1499	3211	4647	5726	3850	6891	3145	3751	6016	6950

3.4. Weather

Analyzing the graph above, there is a decreasing trend in precipitation throughout the period under study (2010-2020), being the year with the highest average precipitation recorded in the various meteorological stations in mainland Portugal, the year 2010 with 1155.0 (mm), and with less precipitation, the year 2017, presenting a value of 554.4 (mm).

Due to the constant increase in distribution networks, and the impact of climate change on their behavior, the possibility of service interruption becomes increasingly realistic, which causes companies in the electricity sector to adopt measures to reduce these inconveniences (table 7).

Table 7: Mean rainfall

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Mean rainfall	1155,0	831,4	618,3	742,1	1015,6	632,3	797,4	554,4	856,0	685,8	728,5

3.5. Workers

Throughout the period studied, the company continually changed its workforce (table 8). There is a decreasing trend in the number of employees throughout the period under study (2010-2020), with the year with the highest recorded number of employees being 2012 with 16,900 employees, always with decreasing trend, in 2020 the number of employees was reduced to 13,439. The reduction in staff over the 10 years of the study was 3,461 employees.

Table 8: Workers

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Workers	16678	16687	16900	16761	16745	14571	16613	14665	14312	14321	13439

3.6. Technology

The new technology presents a significant improvement against direct contacts; connection point for generator; smaller weight and dimensions.

It involves a cost of around €1k per intervention, depending on whether or not sections of medium voltage cables need to be replaced.

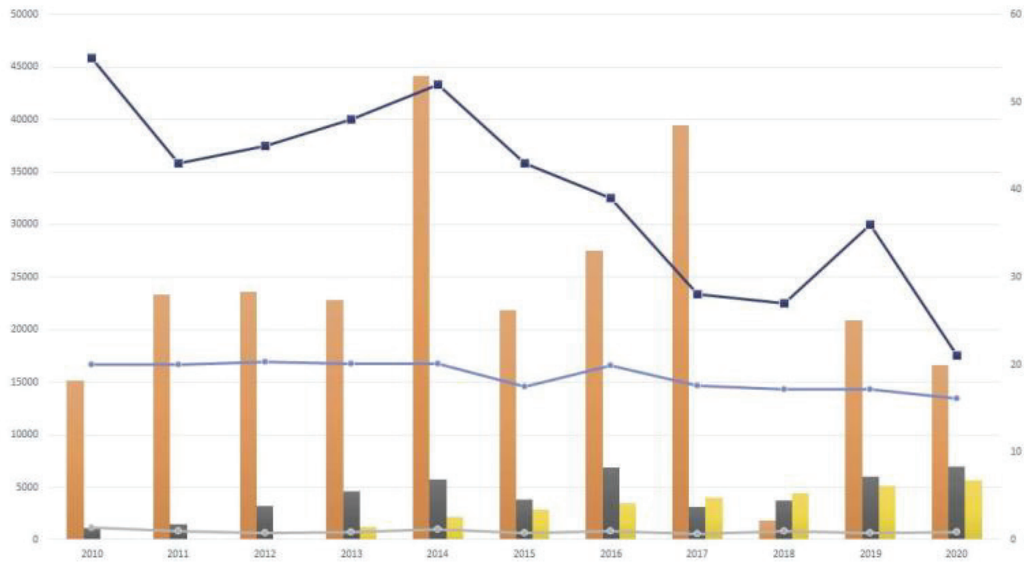
Starting its installation in 2013, total standardization across the entire territory is expected, with devices currently installed from the previous generation being upgraded due to their failure or investment plan proposals. Those data can be consulted in table 9.

Table 9: Old and new technology

Equipment	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Old technology	62259	63302	64471	64470	64466	64459	64457	64449	64449	64441	64440
New technology	-	-	-	1203	2133	2895	3499	4013	4452	5108	5620

4. CONCLUSIONS

From the results obtained, there are certain direct and exclusive relationships between the variables studied and the occurrence of accidents. The representation in the form of bars alludes to all the investment in (training, AIVO and investment in new technologies) by the company.



	Training hours
	AIVO
	New technology equipment
	Workers
	Rainfall
	Accidents

Figure 1: Combination of Indicators

The graph in figure 1 summarizes all the results mentioned above.

In general, these indicators convey the importance of investment in safety, in the sense of the value of prevention in the lives of workers, in improving environmental conditions, in reducing risks in work processes, in qualification and in the adoption of control measures preventive. We can infer that there is a direct correlation between the investment effort made by organizations and the results obtained by the accident rate indicators, as it was perfectly clear that during the period under analysis the trend line never exceeded the data from the starting year. Furthermore, and in a more incisive way, it was found that investing in the qualification of professionals was a viable option, as through the involvement of these employees, it is possible to multiply and promote prevention measures, with the vision of those who carry out the activities, improving the development processes and operational methods promoting a safe and effective culture of action.

REFERENCES

[1] Clark, J. L. (1793). The Management Oversight and Risk Tree (MORT) - A New System Safety Program. https://www.osti.gov/servlets/purl/4175026/
[2] Llory, M. (2013). A Investigação de Acidentes Industriais: uma entrevista com Michel Llory, pp. 262-269
[3] Batista, G. A. (2013). Estudo Aprofundado da Sinistralidade numa Empresa da Indústria Gráfica em Portugal. https://run.unl.pt/bitstream/10362/10906/1/Batista_2013.pdf
[4] Graça, M. J. (2014). Sinistralidade laboral no setor da indústria extrativa no triângulo do mármore. https://repositorio.ipl.pt/bitstream/10400.21/4225/1/Sinistralidade%20laboral%20no%20setor%20da%20ind%C3%BAstria%20extrativa%20no%20tri%C3%A2ngulo%20do%20m%C3%A1rmore.pdf
[5] Montemor, C. M. (2017). Sinistralidade laboral nos setores de atividade agrícola, pecuária e florestal. doi:978-989-8905-53-6
[6] Neto, A. G., Silva, J. C., Reis, M. B., Ribeiro, M. F., Costa, M. F., & Brito, P. C. (2020). Redução da sinistralidade no transporte rodoviário de carga. https://repositorio.itl.org.br/jspui/bitstream/123456789/497/1/Redu%C3%A7%C3%A3o%20da%20sinistralidade%20no%20transporte%20rodovi%C3%A1rio%20de%20carga.pdf
[7] OCDE. (2002). Rumo a um Desenvolvimento Sustentável – Indicadores Ambientais, 9, p. 191; 204. https://www.oecd.org/env/indicators-modelling-outlooks/2345364.pdf
[8] Bossel, H. (1999). (I. I. Development, Ed.) Indicators for Sustainable Development: Theory, Method, Applications. DOI: ISBN 1-895536-13-8
[9] APCER. (2003). Linhas de orientação para a interpretação da norma OHSAS 18001/NP 4397. Obtido em 26 de março de 2022

OCCUPATIONAL HEALTH AND SAFETY RISKS MANAGEMENT - FUNDAMENTAL PHILOSOPHY

Marijana Leontić[1], Darko Palačić[2]

[1] University of Applied Sciences in Security and Safety, Veslačka 2a, Zagreb, CROATIA, marijana@vss.hr

[2] University of Applied Sciences in Security and Safety, Veslačka 2a, Zagreb, CROATIA, darko@vss.hr

Abstract: *Occupational health and safety management is becoming more and more important every day. This is especially important in the global market where many companies want to be competitive. The requirements of the global market are increasingly significant and strict in this area. Occupational health and safety are generally defined as the science of predicting, identifying, assessing, and controlling the risks of certain hazards that arise in the workplace, and which can damage the health of workers and other persons at work. Therefore, the occupational health and safety risk management is of particular importance. The philosophy of risk management in this area has certain specificities compared to some other areas. The paper provides an overview of the theoretical assumptions of occupational health and safety and describes the fundamental philosophy of occupational health and safety risk management. The discussion and conclusion provide recommendations and guidelines for further reflection on the philosophy of occupational health and safety risk management and possible research.*

Keywords: *fundamentally, philosophy of risk management, occupational health and safety, risk management.*

1. INTRODUCTION

Occupational health and safety (OHS) are generally defined as the science of predicting, identifying, assessing, and controlling the risks of certain hazards that arise in the workplace, and which can damage the health of workers and other persons at work. Therefore, OHS risk management is of particular importance.

Risk is a very complex concept, and it occurs in all areas of life, in private and business activities. Risk exists in every job; it relates to the future and future events. OHS risk management is based on principles, framework, and process. In general, the purpose of risk management is to create and protect value. The greatest value is human life and health, and therefore OHS risk management has a special significance. Risk cannot be eliminated because it always exists. Therefore, organizations must manage all the factors that increase and decrease these risks to achieve improved safety and reduced costs [1]. Establishing a process that ensures hazard identification with a strong OHS management program is the primary goal of a modern and progressive organization. OHS risks, in their various forms and interrelationships, can be the subject of observation and management based on different perspectives. Although the concept of treating occupational health risks has changed over time, it is clearly recognized in the scientific literature.

The philosophy of OHS risk management is very complex, but its fundamental features are clearly discernible. It consists of several philosophical perspectives and aspects. Probably in no other field of management is the ethical and moral approach as important as in the management of OHS risks. In addition to the above, risk has its objective and subjective aspects. This is particularly significant in OHS risks. Objective aspects imply a fact-based risk assessment. Subjective concepts form a set of values adopted by a person who assesses risk, depending on the knowledge of risks and dangers that the assessor knows, and depending on the exposure of the assessor to the risk [2].

2. RESEARCH METHODOLOGY

The problem that has been recognized is the lack of knowledge and understanding of the fundamental philosophy of OHS risk management. The problem is manifested in the lack of published current research in this area. Regarding the recognized problem, the goal of the research is to identify the fundamental philosophy of OHS risk management.

According to the set goal, the research tasks are:

- analyze and present the concept of OHS risk management
- analyze and present the fundamental philosophy of OHS risk management
- encourage further empirical research into the philosophy of OHS risk management.

In the analysis, several scientific methods are applied, which in combination form the research methodology. Concepts and philosophy of OHS risk management were analyzed using the method of studying the content of scientific and professional literature. A combination of deductive and inductive analysis is used to classify and summarize the theoretical foundations of the research subject. The description method is applied to describe the field of OHS, risk management and the fundamental philosophy of OHS risk management. After the analysis and comparison, essential properties are synthesized, and conclusions are drawn.

3. OCCUPATIONAL HEALTH AND SAFETY RISK MANAGEMENT

2.4. Occupational health and safety

One of the 20 principles of the European Pillar of Social Rights is a healthy, safe, and well-adjusted working environment and data protection. In the Action Plan for the Implementation of the European Pillar of Social Rights from 2021, it was pointed out that, among other things, special attention should be paid to improving aspects of OHS. The same is particularly important not only for the health of the workers and their safety at the workplace, but also for the productivity of work, employment, and the overall development of the economy. In the past decade, European policy and the implementation of rules and guidelines for health and safety at work have led to a significant improvement in working conditions (the number of workplace deaths has decreased by 30%). They consider working conditions in the European Union (EU) to be among the best in the world. For the further implementation of the European pillar of social rights, including a healthy and safe workplace, the Action Plan determines the measures that need to be taken. It is expected that the Commission will review this Action Plan in 2025. This will create the foundations for taking further measures at the level of the EU, to achieve the goals by 2030. [3].

An important segment of sustainable development, as well as the competitiveness of the economy of the EU, is the prevention of accidents, accidents and occupational diseases related to work. Statistics show that the number of fatal accidents at work in the period from 1994 to 2018 decreased by about 70% [4]. From 2018 to date, there have been more than 3.300 fatal accidents and 3.1 million non-fatal accidents. Every year more than
200.000 workers die from work-related diseases. Such data highlight that, although there is significant progress in reducing the number of accidents at work, there are still serious challenges in ensuring the safety and protection of workers in the workplace. The fact that every year more than 200.000 workers die from work-related diseases shows that it is necessary to continue investing in prevention and protection measures. According to data from 2019, the costs to the economy due to work-related accidents and diseases amounted to around EUR 460 billion (more than 3.3% of GDP per year). The consequences arising from the above figures indicate that good practice in the field of OHS contributes to companies becoming more productive, sustainable, and therefore more competitive. The return on investment in OHS can be double as investment in prevention reduces the costs associated with occupational accidents, sick days, medical costs, and lost productivity.

EU strategic framework for health and safety at work for the period 2021-2027. he set three key goals:

- predicting and managing changes in the new world,
- a higher level of prevention of accidents and illnesses at the workplace,
- increasing preparedness for all challenges regarding the future health crisis.

To achieve the stated goals, it is necessary to undertake a series of measures in synergy at the EU, national, sectoral and company level. Anticipating and managing changes in the new world is motivated by the fact that many patterns and ways of working are changing, because of the green and digital transition. This is how jobs were created that didn't even exist before and about whose risks it is necessary to pay special attention. Also, recent times have shown that there has been a change in the demographic picture in the EU, regarding an increasingly aging workforce, which presents new challenges and considerations, and the search for answers. Therefore, the Commission states in the strategic framework that to achieve the stated goal, it is necessary that the rules adopted by the European Union on health and safety at work, and in the context of the green and digital transition, be improved and simplified. A greater emphasis on psychosocial and ergonomic risk is also needed. Achieving better prevention of work-related diseases and accidents is possible only by increasing the awareness of each individual and the culture of prevention. The health of workers is the foundation of a strong and resilient economy as well as society. By encouraging a healthy lifestyle in the workplace, the number of absences from work due to the most common diseases such as cancer, circulatory system, musculoskeletal disorders, heart disease and diabetes is significantly reduced. The European plan to fight cancer will take measures to ensure that workers have more information about cancer risks and other determinants of health, all with the aim of reducing risks. The pandemic of the disease COVID-19 has largely shown that it is necessary to have quick responses and reactions to threats, and it is necessary to increase preparedness for all future health crises. Measures to increase hygiene, non-pharmaceutical interventions, support for mental health, as well as synergy between employers and health institutions are just some of the ways to reduce the risk of future health crises. The basis for achieving these goals is social dialogue, a stronger evidence base, stronger implementation, information, and financial support [5].

In accordance with the principles of sustainable development, the global market is focused on sustainability, social responsibility, and the well-being of workers. The established OHS management system increases the safety and satisfaction of workers and reduces costs due to accidents and injuries at work. Lower injury rates usually indicate positive trends in staff morale and productivity. Companies can implement different strategies to improve the health and safety of their employees. The evaluation of the effectiveness of good practices is usually carried out by comparing them with the average in the industry to which the company belongs to determine how successful the companies are in reducing injuries at work and improving the health and safety of their employees [6].

Changes in technological processes and the work environment require constant adaptation and innovation to ensure that workers are safe and have a healthy work environment. In today's context, advanced tools such as artificial intelligence and robotics can increase productivity and efficiency, but also new challenges in terms of hazards for workers. It is therefore important to carry out a risk assessment and ensure that measures are applied to reduce the possibility of accidents and injuries. With all the changes that are happening, it is necessary to keep up, identify new risks and implement appropriate measures to ensure that the safety and health of workers is a priority. Adaptation to change can only be achieved through close cooperation between employers, workers, trade unions, government, and other relevant stakeholders to ensure that all aspects of OHS are addressed appropriately.

4. RISK MANAGEMENT

Risk management and risk conversations are all around us. The life of an organization based on risk is increasingly discussed and emphasized. Not only private sector companies, but also public organizations, including the highest levels of public government, are all challenged to varying degrees by ideas about risk and its management [7]. Enterprise risk management is an area where the discipline of risk management has recently evolved into an approach called enterprise or enterprise-level risk management (ERM). ERM differs from traditional risk management by taking a more integrated or holistic approach. In many ways, it can be considered a unifying philosophy that unifies the management of all types of risks, including OHS risks. ERM is an overall philosophy that consolidates the management of individual risks into a single and consistent approach to risk across the enterprise [8].

Establishing a process that ensures hazard recognition is the primary goal of a progressive organization with a strong safety management program. The organization removes or reduces the risks associated with these hazards to the lowest possible and reasonable level. The state of OHS, or in other words, the efficiency and effectiveness of the prevention of injuries at work and occupational diseases, depends on the success of the implementation of occupational safety in relation to the existing risks at work. Therefore, the key precondition for the planning and implementation of occupational safety is the assessment of occupational risks, and further and continual management of occupational risks. Risk management is a preventive process by which risks at work are identified and further procedures are carried out to avoid and/or reduce them [9]. Depending on their forms and interrelationships, risks can be the subject of observation and management based on different perspectives. The main perspectives of risk observation derive from studies in the economic-corporate and production fields, and can be summarized as a strategic perspective, a corporate management perspective, a financial perspective, and an operational perspective. To discover the aspects and forms in which risks appear, risks should be viewed simultaneously from several different perspectives [10].

5. FUNDAMENTAL PHILOSOPHY OF OHS RISKS MANAGEMENT

Risk management is based on the principles, framework, and process. The purpose of risk management is the creation and protection of value. It improves performance, encourages innovation, and supports the achievement of objectives. Risk management generally has its own philosophy. Given that OHS risk management can be considered a subtype of general risk management, it has its own philosophy. Risk management philosophy is an integral element of risk management strategy. The role of philosophy in the development of risk science was rather limited [1]. Hansson provided an overview of philosophical issues in risk research, including the definition of risk, the relationship between risk and uncertainty, the effects of cognitive limitations on the limits of rationality, the implications of unknown possibilities, and the difficulties current decision theory and moral theory face when applied to problems of risk. It has been concluded that some of the models and assumptions commonly used in risk studies are highly problematic [11]. Numerous problems were identified in the analysis and management of OHS risk, the solution of which could contribute to the understanding of the fundamental philosophy of risk. OHS risk management directly affects the indicators of OHS implementation.

Risk has its objective and subjective aspects. Objective aspects imply a fact-based risk assessment. Subjective aspects imply a set of values adopted by the person who assesses the risk, depending on the knowledge of the risks and dangers that the assessor knows, and depending on the exposure of the assessor to the risk [12]. The philosophy of OHS risk management encompasses the underlying principles, beliefs, and approaches that guide how organizations and individuals handle risks. OHS risk management philosophy varies between organizations and individuals, and is influenced by factors such as industry, culture, knowledge, experience, and personal values. It is a dynamic field that continues to evolve in response to changing risk landscapes, new technologies, and new insights into risk assessment and mitigation.

6. CONCLUSION

From all the above, it can be concluded that the philosophy of OHS risk management is very complex. It consists of several philosophical perspectives and aspects. Perhaps in no other area of management is the ethical and moral approach as important as in OHS risk management. The basic premise of the fundamental philosophy of OHS risk management states that risk management is primarily carried out to protect human life and health. Fundamental philosophy directs us to understand its objective and subjective aspects. It can be said that the goals and objectives of this research have been achieved. The analysis was carried out and the fundamental philosophy of OHS risk management was presented. Further empirical research into the philosophy of OHS risk management is certainly needed, which can further contribute to the development of prevention of unwanted events at work.

REFERENCES

[1] Palačić, D.: Concepts and Philosophy of OHS Risk Management. *The 20th International Conference "Man and Working Environment" SAFETY ENGINEERING & MANAGEMENT – SCIENCE, INDUSTRY, EDUCATION (SEM-SIE 2023)*, pp. 31-36, Niš, Serbia, University of Niš, Faculcy od Occupational Safety, Niš, 2023.

[2] Peschard, I., Benétreau-Dupin, Y., Wessels, C.: *Philosophy and Science of Risk: An Introduction*. Routledge. ISBN 9780429023521, London, 2022.

[3] European Commission: The European Pillar of Social Rights Action Plan, Luxembourg, Publications Office of theEuropean Union, 2021 https://op.europa.eu/webpub/empl/european-pillar-of-social-rights/en/index.html *Accessed:* 2024-05-12.

[4] Eurostat, Database, data for common economic sectors in the EU-15 (1994-2009) and for all economic sectors in the EU-27 (2010-2018), https://ec.europa.eu/eurostat/data/database *Accessed:* 2024-05-12.

[5] European Commission: EU Strategic Framework on Health and Safety at Work 2021- 2027. Occupational safety and health in a changing world of work, https://eur- lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021 DC0323 *Accessed:* 2024-05-12.

[6] Matešić M., Pavlović, D., Bartoluci D.: *Društveno odgovorno poslovanje*, VPŠ Libertas, Zagreb, 2015.

[7] Power, M.: *The Risk Management of Everything - Rethinking the politics of uncertainty*. Demos. London, 2004.

[8] Hopkin, P.: *Fundamentals of Risk Management – Understanding, evaluating and implementing effective risk management*. 4th edition. Kogan Page. IRM, 2017.

[9] Palačić, D.: Chemical Health and Safety Risk Management Model. *18th International Conference Management and Safety 2023*. pp. 26-36, Maribor and online, ESSE, 2023.

[10] Borghesi, A., Gaudenzi, B.: *Risk Management - How to Assess, Transfer and Communicate Critical Risks*. Springer-Verlag Italia. Verona, 2013.

[11] Hansson, S.O.: A Philosophical Perspective on Risk, *AMBIO*. 28, 1999, 6, pp. 539-542.
[12] Peschard, I., Benétreau-Dupin, Y., Wessels, C.: *Philosophy and Science of Risk: An Introduction*. Routledge, 2023.

TRAINING AND DEVELOPMENT OF VOLUNTEER FIREFIGHTERS

Antonio Metić[1]

[1] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9,47000 Karlovac, Croatia

Abstract:

The scientific paper deals with the method of organization and implementation of the training and development of volunteer firefighters in the Republic of Croatia. Training and further education are an indispensable part of a firefighter's career, because through continuous education, a firefighter is faced with new methods of action in firefighting interventions and learns to use firefighting equipment in a proper and safe manner. In order for teaching to be of high quality, it is necessary to pay attention to the parameters that affect it. The learning abilities of firefighters determine the dynamics of teaching and the division of teaching groups. the lecturer's task is to assess the ability of the participants and to choose the teaching method that will suit the participants best. student motivation is a factor that has a significant impact on the student's activity in class. Despite the lower motivation of the participants, the lecturer can motivate the participants to participate in the class and further work by providing a quality lesson.

Keywords: *education, firefighting, teaching, motivation, participants.*

1. INTRODUCTION

In order for a firefighter to be ready to carry out firefighting activities and respond to firefighting interventions, they need to be educated to acquire the competencies necessary for quality work. Through a training program, knowledge and skills for performing less complex tasks are acquired, with an emphasis on practically mastering and adopting less complex skills. As the participants' knowledge is enhanced through experience, they approach the training with life experience, which depends on their age, employment, educational background, previous education, and interest in undergoing the training itself.

2. LEARNING ABILITIES OF FIREFIGHTERS

The reputation of the firefighting profession also depends on high-quality curricula and effective teaching. Experience shows that there are excellent scientists and experts from various fields who do not know how to clearly convey their knowledge to the trainees.

The basic prerequisite for quality teaching is the instructor's ability to successfully transfer knowledge. The foundation of an effective firefighting service is systematic and consistent training and practice for both volunteer and professional firefighters. To ensure that instructors (firefighting trainers) are as successful as possible in imparting specific knowledge and skills (in both theoretical and practical teaching), they must be professionally and methodically trained.[1]

Motivation is the psychological process of satisfying an individual's needs or motives. This process is manifested in behavior directed towards achieving goals that serve to satisfy the individual's needs and motivation. Motives are the characteristics of a person that drive them to activity, direct the activity towards specific goals, and determine its intensity and duration. Motives can be divided into innate and learned. There are other classifications as well, but from the perspective of educational theory, the most suitable classification is the one mentioned, as the focus of education is on learned motives.[2]

2.1. Assessment of the teaching group

Before the start of the course, it is necessary to analyze the group that is beginning the training. Trainees attend training and professional development for various reasons, such as the desire to acquire new knowledge and skills and the desire to be competitive among colleagues. Additionally, the teaching program should be explained to give them an overview of what they will learn during the course. It is the instructor's task to motivate and prepare the trainees during the course using indirect methods. In the first lesson, it is desirable for the instructor to get to know the trainees. Once the instructor is familiar with the trainees, they can encourage them to participate in discussions based on their experience and acquired competencies.

2.2. Life Experience of Trainees

The activity of trainees in class, as well as their learning ability, is influenced by subjective and objective factors. These factors may include the trainees' health status, desire for advancement in their work or firefighting profession, customs and traditions, teaching aids, and similar aspects.

In subjective factors, the trainee is at the center. If the trainee is motivated, has a satisfactory level of mental or intellectual ability, and is physically capable of performing firefighting tasks, it is very likely that there will be no difficulties in their progress and they will easily acquire the course content. Objective factors depend on the environment in which the trainee is situated. These objective factors are important to the trainee and can significantly impact their learning experience. In today's world, where the cost of living is extremely high compared to incomes, firefighters often struggle to find time for training and professional development. They frequently work overtime or hold multiple jobs to secure a livelihood and a decent life for themselves and their families. In this context, the selection of training and development schedules is a crucial factor.

2.3. Selection of Trainees for Training and Development

Trainees are operational firefighters who must have a medical check-up every two years. It is desirable for the commander to be an initiator and motivator for the firefighters; however, if the primary motivation is present within the trainees, it is expected that they will approach the training with interest. Even if a trainee begins the educational process under the pressure of the commander, with a quality and encouraging instructor, they may recognize the value and usefulness of what they are learning and change their initial attitude.

2.4. Comparison of Trainees

It is crucial not to confuse the concept of intelligence with that of knowledge, as these two concepts are not the same. When working with trainees who learn more slowly, the instructor must be patient and repeat the material multiple times if it is unclear to the trainee. A lack of intelligence can be compensated for by diligence. Memory is not equally developed in all individuals. It is a general ability to retain previously experienced content, which is reflected in their reproduction and recognition.[3]

Knowledge is the ability to apply content or skills. It is a result of learning, and experience shows that we initially acquire material much faster, while later we gain a smaller amount of knowledge, a phenomenon referred to in the profession as "plateau learning." Plateau learning has a negative effect on motivation, so it is the instructor's role to keep trainees motivated even after the plateau occurs. Concentration on specific content, exercises, or tasks is also called attention. Over time, attention can become a habit. To enhance concentration, motivation is a crucial factor, as it is easier to focus on engaging content. Experience and prior knowledge are key factors that can lead to successful communication and dialogue in the classroom.

3. ORGANIZATION OF TEACHING

Firefighting education consists of multiple factors. Organizing quality teaching is demanding and requires the satisfaction of various conditions. What is specific in firefighting is that nearly every part of the curriculum holds equal importance; if terms become mixed up, a trainee may endanger themselves or others during a firefighting intervention, jeopardize property, or become disoriented. The tasks of teaching are to educate, train, and develop the trainees. When discussing the learning of new information, it pertains to the educational task. The trainee acquires new knowledge and skills and learns to solve problems. Trainees engage in training to gain knowledge about firefighting.[1]

The educational task directs trainees towards unity and teamwork. In a team, firefighters must care for one another, be diligent, complete their tasks promptly, and adhere to the ethical code of firefighting while executing their duties. The ethical code applies to the entire firefighting community in the Republic of Croatia, encompassing principles that govern relationships among professional and volunteer firefighters, as well as with other entities encountered while performing firefighting duties as a public service.[4]

3.1. Factors of Teaching

The primary factors that make up teaching are: Trainee, Instructor, Educational Content, Objective Conditions.[1]

As noted by Popović et al. in the Handbook for Training Firefighters and Officers (2006), a quality instructor must possess competencies related to their profession, society, and pedagogy (andragogy). Professional competence is linked to knowledge of firefighting, as well as the necessary professional knowledge and experience in the field. Quality instructors support their lectures with practical examples, such as those described in this chapter, and draw conclusions based on their own experiences. As a result, trainees respect their teaching methods. To work as an instructor, a firefighter must possess experience, theoretical and practical knowledge, and the ability to transfer skills to trainees.

The trainees' opinions about the instructor are formed based on first impressions during their initial meeting. It is beneficial for the instructor to conduct an introductory conversation to familiarize themselves with the trainees, as well as to introduce the content that will be covered and the expected learning outcomes. Factors such as resolving crisis situations, monitoring and evaluating trainees, providing guidance on whom to contact during training, and advising and motivating trainees are essential for gaining a positive opinion of the instructor.

3.2. Implementation of Teaching

To define the educational content, we use the curriculum and teaching program. Based on these documents, lessons are prepared and conducted, ensuring alignment with the advancements in technology, science, and practice.

According to Popović et al. in the "Handbook for Training Firefighter Non-Commissioned Officers and Officers" (2006), the choice of teaching media depends on the objectives of the lessons, the experience and psychophysical characteristics of the trainees, the availability of specific media, computer equipment, and the qualifications of the instructors. Teaching aids must be aligned with the development of trends, technologies, and methods. The choice of teaching aids is the responsibility of the instructor, and it is advisable to vary these aids during lessons to avoid monotony. This approach can lead to increased concentration, greater motivation among trainees, and ultimately better knowledge retention.

By employing a combination of these methods, the instructor can enhance engagement and facilitate better learning outcomes. In Edgar Dale's learning pyramid, a classification of learning experiences is visualized, ranging from direct experiences (at the bottom) to abstract experiences (at the top). Dale emphasizes that these are not concrete and unchanging categories, and he does not use numerical data.

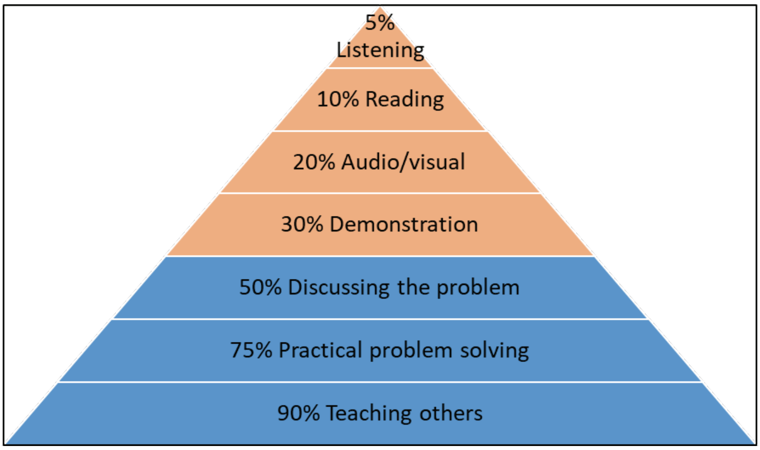


Figure 1. Pyramid of learning

As shown in the learning pyramid, students acquire the least knowledge when listening to lectures and the most when teaching others. Using the verbal method, or storytelling, the instructor describes the teaching material to the students. This is certainly the oldest and cheapest method as it does not require teaching aids. The instructor can describe, teach, and explain. Participants learn through practice after theoretical lessons by performing exercises. These are practical methods. By applying practical methods, participants become actively involved in the work; they participate in discussions, carry out tasks, and apply the knowledge they have learned in theory. The instructor demonstrates the exercise, and then the participants perform it independently. When a mistake occurs, the instructor points it out, repeats the exercise, and then the participant repeats it on their own.

Figure 2. Practical work of training participants

3.3. Recognizing the Purpose of Learning and Motivating Participants

After the preparation of the instructors, organization of the classes, familiarization with the participants, assessment of the group of participants, and other factors, education, or learning, begins. It is certain that there will be firefighters in the educational group who have had a longer break in their education. For such participants, it is important that the classes are more interesting and conducted using multiple teaching methods and aids. The instructor's task is to motivate the participant after assessing which teaching method suits which profile of participants. The instructor can approach the participant in various ways, such as involving them in classroom discussions, asking for their opinion on the teaching topic or concept, initiating a discussion, using role-playing methods, seeking their cooperation in task execution, or even engaging in informal conversations during class breaks.

3.4. Evaluation of Participants' Knowledge and Collection of Feedback

Classroom work needs to be evaluated. By assessing the participants' knowledge, class organizers and instructors receive feedback on the participants' achievements. The assessment can be oral, written, or practical, and at the end of the assessment, participants need to be graded.

In oral examinations, it is important to consider the way questions are asked. Questions should not be ambiguous but clear and straightforward. Instructors must not use questions with unfamiliar terminology or content that was not covered in the lessons the participant attended. Oral examinations are an integral part of almost every class, while oral grading should be conducted at the end of the training or advanced training. By evaluating knowledge through oral examinations, participants also reinforce their knowledge.

In a student's response during an examination, not only knowledge is reflected but also their ability to skillfully manipulate verbal symbols, eloquence, and understanding of language expressions. Since these abilities are not the same as knowledge and are not equally developed in all students, more eloquent students who easily reproduce and linguistically shape learned content tend to receive better grades, while those who generally struggle to express themselves and have difficulties in reproducing knowledge may stutter or falter, receiving lower grades. A resourceful student observes and tracks all such feedback that the teacher provides, whether intentionally or unintentionally, in response to their answers. As soon as they notice even the slightest sign of disapproval in these reactions, they immediately correct themselves and try to adjust their responses to align with what the teacher expects.[5]

4. CONCLUSION

Firefighters learn throughout their careers through training and advanced courses, as well as classes and exercises. Participants are significantly influenced by their life circumstances, social skills, and the environment they are in. Some firefighters, despite having excellent opportunities for advancement and education, may not participate in training or further education due to personal beliefs or a lack of time. Training programs prepare participants for specific tasks. Instead, they will minimize the danger or eliminate it entirely.

The effort put into organizing classes is an essential factor that influences participants and their satisfaction. Participants' opinions about the instructor are formed based on first impressions during initial encounters. The instructor's task is to strive to reach every participant and assess which teaching method would suit which profile of participant.

The historical development of andragogy has led to significant advancements in the teaching of firefighters, as it has modernized in all aspects. Despite this, we must continue to focus on the education of instructors and teachers so that they can transfer their knowledge effectively and efficiently to firefighters, who will ultimately apply that knowledge in the field.

REFERENCES

[1] Popović, Ž.; Purgar, S.; Knežević, D. i dr.: *Priručnik za osposobljavanje vatrogasnih dočasnika i časnika*, Hrvatska vatrogasna zajednica, ISBN 953-6385-16-13, Zagreb, (2006)

[2] Pastulović, N.; Žiljak, T.; Strugar, V. i dr.: *Obrazovanje odraslih: teorijske osnove i praksa*, Učiteljski fakultet Sveučilišta u Zagrebu, ISBN 978-953-8115-47-9, Zagreb, (2018)

[3] Turković, I.: *Planiranje i programiranje obrazovanja odraslih*, Informator, ISBN 953-170-057-5, Zagreb, (2019)

[4] Hrvatska vatrogasna zajednica, *Available from* https://hvz.gov.hr/UserDocsImages/dokumenti/Propisi/PravilaVatrogasneSluzbe2011.pdf *Accessed* 2024-05-17.

[5] Grgin, T.: *Školska dokimologija*, Naklada Slap, ISBN 953-191-001-4, Jastrebarsko, (1994).

IMPROVING THE QUALITY OF EDUCATION OF OCCUPATIONAL SAFETY ENGINEERS BY INTRODUCING A COMPULSORY COURSE IN ANDRAGOGY AT THE SPECIALIST STUDY OF SAFETY AND SECURITY

Lada Purgar [1]; Maja Šikić (student) [2]
[1]Karlovac University of Applied Sciences, J. J. Strossmayera 9, 47000 Karlovac, Croatia, ladapurgar@gmail.com
[2]Karlovac University of Applied Sciences, J. J. Strossmayera 9, 47000 Karlovac, Croatia,

Abstract: *The most effective method of improving the work of occupational safety engineers is quality and organised education and training of them. Training for safe work is a carefully planned pedagogical and andragogical activity. Pedagogical criteria are met, training content is determined, educational documentation and personnel are determined, educational groups are formed, and criteria and criteria for determining success are defined.*

An insufficiently professional approach to training for safe work puts people and the environment in direct danger, so a requirement is placed on experts who train workers to work in a safe way and be trained for this activity. They are in the role of a teacher who teaches, i.e. creates the necessary conditions for successful learning of trainees.

Keywords: *occupational safety, training for safe work, andragogy, lifelong learning*

1. INTRODUCTION

The purpose of adult education is to improve the quality of life that is prolonged, and which ensures social and economic development. The development of individual societies is based on the development of technologies, science, scientific research, technological progress of society and others. Education enables community members to raise their quality of life. Social development enables the development of the individual through the application of education that develops personality traits. Economic development is based on the productivity of society's labour; production of the necessary workforce for contributions to society. Economic goals ensure the profitability, productivity and economic development of the country, as well as increased employment opportunities for the population. In order to achieve economic goals, investments are made in adult education, which results in the realisation of large projects by which the state becomes competitive in the labour market and achieves profitability. Although countries invest in adult education, the problem is created by the attitudes of society.

A change in traditional attitudes can result in the development of a qualified social structure. The economic development of countries is achieved by improving programs, through which adults are educated by adjusting the criteria in the labour market. The goal is to educate adults to increase the quality and expertise in work, using innovative education programs. So, the basic goals of adult education are:

- involving citizens in the education process
- ensure funding for lifelong learning
- ensure the inclusion of citizens in formal and non-formal forms of education
- to ensure the development of knowledge and skills of andragogical workers
- encourage citizens to continuous education
- include the participation of people with disabilities, lower economic status and others in lifelong learning processes
- to ensure lifelong learning of workers by conducting various trainings and advanced training in the workplace
- develop a system for raising the quality of education
- to ensure the quality organisation of adult education
- ensuring equality of citizens in education
- the use of modern technologies in adult education
- providing a system for monitoring adult learning
- encouraging workers to be educated
- ensure that school institutions are encouraged to implement adult education
- to implement the inclusion of senior citizens in education processes (ASOO, 2007)

2. SAFETY AND SECURITY

Safety and security is an interdisciplinary science whose application ensures health protection and safe working conditions.
The main goal of occupational safety is to ensure working conditions that prevent accidents at work as well as occupational diseases. Safety at work is achieved by: employers activities, organisation of workplaces and workers activities, job classification, structuring of production systems. In order to ensure the quality implementation of occupational safety, it is necessary to comply with laws and regulations. The Occupational safety and health act regulates the conditions that establish safe workplaces for workers. This law ensures the prevention of injuries and accidents at work and occupational diseases. Every employer must train workers to work in a safe way according to the law. Training can be carried out by occupational safety experts. In order for occupational safety experts to be able to conduct quality training of their workers, they must have andragogical knowledge. Andragogical knowledge implies the knowledge necessary for quality education of workers. Quality training of workers for training for safe work means teaching workers about: work processes, instructions at workplaces, procedures at the workplace, how to apply personal protective equipment, and the like. harmfulness and effort in the workplace"
Training of workers is carried out in order to eliminate dangers, harmfulness and effort at the workplaces of workers. Training prepares the worker to notice dangers, harmfulness and effort at workplaces and the manner and methods of their removal for safe work. After training, the worker receives an assessment of practical competence given by an occupational safety expert.

Since the safety of workers comes first, studies focused on the health and safety of workers are being introduced in the Republic of Croatia. In this way, future generations of students are raised to acquire the knowledge and skills necessary for the labor market upon completion of their studies. Accordingly, three Safety and Security Studies in the Republic of Croatia were established. In order to ensure lifelong learning in the field of these studies, the course of Andragogy is introduced. The aim of the course is for security professionals to acquire the knowledge and skills they need to conduct training and upskilling of workers.

3. OCCUPATIONAL SAFETY STUDIES IN CROATIA

There are three institutions in the Republic of Croatia that carry out safety and security studies:

1. Karlovac University of Applied Sciences
2. Polytechnic of Rijeka
3. College of Security in Zagreb

All institutions conduct undergraduate and graduate professional studies in Security and Protection. "In the period from 1997 to 2014, more than 5500 people completed education in the field of occupational safety and health in the Republic of Croatia in appropriate educational institutions. According to the records of the Croatian employment service, in 2015., a total of more than 300 people were employed who acquired appropriate education by completing the undergraduate professional study of security and the specialist graduate professional study of security." (Deriš, Rešetar, 2016). These data indicate the importance of training and lifelong learning for protection professionals. After completing their studies, security specialists take a professional exam to work in a state institution.

In the sixties, the Higher technical school of mechanical engineering was founded in Karlovac, which operated in the building of the then school metal center. Departments for experiments have been introduced, which have a program similar to the school of metal orientation. In the 1980s, schools had to decide whether to merge with colleges or abolish them. Thus, many schools have teamed up with individual faculties, such as the School of Mechanical Engineering, which joined the study of mechanical engineering at the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb. "After that, on April 16, 1997, the Karlovac University of Applied Sciences was founded at Ivana Meštrovića 10, where only the mechanical engineering department and library are located, while all other services, dean's office and all departments are located at Trg Josipa Juraja Strossmayera 9." (Karlovac University of Applied Sciences). After the establishment of the Karlovac University of Applied Sciences in 2000., the study of Safety and Protection was introduced, and after that, in school year 2019/2020, the course of Andragogy for occupational safety experts was introduced. The course of andragogy at the Karlovac University of Applied Sciences is a compulsory course, while at the University of Applied Sciences of Rijeka and the College of Safety, it is not compulsory, but an elective course. Each faculty has its own curricula for conducting andragogy courses, but it is important that they are implemented because they contribute to the training of protection experts in further work.

These academic programmes in Croatia aim to achieve the safety of workers in the workplace, reduce the number of injuries and accidents at work and occupational diseases. To this end, security experts are educated to transfer their knowledge to employees, thus ensuring a safe and healthy workplace for workers and at the same time conducting lifelong learning. This course creates the competencies of professionals that are needed for easier and faster implementation of adult education. The purpose of introducing the Andragogy course is the acquisition of knowledge and skills that are necessary for the proper organisation of teaching content, motivating students for education, the correct choice of methods and techniques for adult education, the ability to properly communicate with students, and the like. With the help of andragogical knowledge, protection experts can conduct lectures for the training of workers. This allows workers to facilitate the training process, so that they can perform their jobs and develop the skills and knowledge they need for the labor market. Introduction of the andragogy course in safety and protection studies in the Republic of Croatia achieves the competencies of safety experts that are important for the overall progress and improvement of the occupational safety system, as well as the development of andragogical practice. In order to achieve a safe and high-quality occupational safety system with the application of regulations and laws, it is also important to continuously train safety experts and implement a lifelong learning policy. The training of experts ensures the ability to independently conduct training for workers.

3.2. TRAINING OF OCCUPATIONAL SAFETY EXPERTS

With the development of new technologies, it is necessary to continuously develop knowledge and skills to achieve lifelong learning. An occupational safety expert has the right to train in order to be able to develop a career, help employers by taking responsibility for jobs, help workers by protecting their lives, conduct supervision, educate workers, cooperate with other organisations. "According to the provisions of art. 22., st. 2 of the Occupational safety and health act, the employer is obliged to provide the occupational safety expert with professional training in occupational safety and to bear the costs of such training" (Occupational Safety and Health Act, OG 96/18)

Lifelong safety and security education can be improved by:

- defining all the necessary elements that achieve an effective lifelong learning system
- ensuring the implementation of lifelong learning for protection professionals
- enabling development of lifelong learning by introducing protection in primary and secondary education subjects
- improving the quality of formal and non-formal education
- recognition of new risks in workplaces and the application of procedures to reduce and eliminate them
- cooperation between organisations implementing protection in the workplace and organisations implementing lifelong learning
- highlighting the importance of investment in the field of safe and security
- conducting statistical data on the education of protection professionals

- cooperation with european bodies (e-consultations)

4. HOW DO ADULTS LEARN ?

Characteristics of adult learners to consider when adapting lessons:

- adult learners have previous personal and work experience
- the attention of adult learners needs to be attracted and maintained
- adult learners are task-oriented
- adult learners are intensely cautious, anxious and easily discouraged in new situations
- adult learners should be independent and autonomous
- adult learners expect a high level of educational experience

Modern societies are developing technologies and an increasing number of findings indicate the need for lifelong education and education of adult education workers and teachers. Each person is unique and has a specific way of learning, so the basic role of the teacher is to determine the competencies of the students through conversation and adapt to them. An adult education worker is one of the key factors in the process of adult education. Adults learn based on principles that lead to successful learning. The key principle of adult learning is motivation. Motivation is the process by which certain goals are achieved that affect our behaviour and encourage us to cognitive activities in order to acquire competencies. Adults can be motivated to learn, if their time invested in learning will result in solving problems. Motivational factors (forms, forms, types), related to learning and teaching, can be presented as:

Intrinsic (intrinsic) motivation - depends on natural, internal stimuli that emanate from the person himself. Learning is motivated by the desire for new knowledge, skills and insights, it is focused on the changes it brings and on the feeling of self-esteem and satisfaction.

Extrinsic (extrinsic) motivation - depends on external stimuli that determine the intensity and duration of a person's behaviour in order to achieve possible goals that satisfy economic and social motives. Learning is motivated by acquiring certain competencies in order to obtain a reward: good grades, money, promotion, recognition, highlighting, and the like.

4.1. METHODS OF TEACHING ADULTS

Some of the most common methods of teaching adults are:

- the conversation method: encourages student activity through conversation, which can be useful for revision, practice, and oral assessment.
- oral presentation method: teacher verbally conveys the information to the students.
- demonstration method: students can perceive what is presented in class, often with the use of material means and aids.
- method of practical work: students actively participate in practical tasks.
- method of reading and working on text: focuses on reading and analyzing text.
- drawing and writing method: encourages creativity and expression

- role-playing method: students put themselves in roles and simulate situations.

In adult education, it is necessary to apply certain concepts that help teachers and students in education, and they are included in the concept of educational technology. "The term educational technology is used in didactic literature today in the sense of applying technical terms and organisational procedures based on the results of science, primarily didactics, psychology and cybernetics, for the realisation of educational tasks. The purpose of such technology is to rationalise and optimise the teaching and learning process. Modern educational technology makes teaching and learning easier, faster, more rational, more economical, more productive and more objective." (Andrilović, et.al., 1985, p. 258). Scientific research ensures technological progress and the development of new discoveries, which creates a need for the application of advanced technology in adult education. The application of modern technologies in adult education creates the necessary competencies for the labour market. That is why it is necessary to ensure the application of technologies in adult education for teachers and students. The teacher can independently search for data, communicate with other experts, connect with organisations that provide adult education, and more. Students can independently search for data, collaborate with colleagues, facilitate and speed up the learning process, and more. In the field of technology for adult education, the media are also applied. The media relates to communication between students and teachers, which facilitates the educational process and is divided into visual, auditory and audiovisual.

Technology is a tool omnipresent in life, business, education and elsewhere, so it is necessary to continuously harmonize technology with education, which increases the quality of education. As part of adult education using technology, there are certain advantages and disadvantages of using technology.

"Advantages of using technology: attracting the attention of the participants, a higher level of interest, motivation and satisfaction of the participants, the possibility of easier clarification of difficult concepts and principles, a more complete understanding of the content and more effective acquisition of new concepts, better memorization of the content and the possibility of applying knowledge in new situations" (Dumić, Matasić, 2012, p.146).

Technology also has disadvantages such as: internet costs, endangering health, lack of concentration of participants, reduced perception, reduced ability to use language skills, incomprehensibility of the content to be interpreted.

4.2. DISTANCE LEARNING

Distance learning for adults does not require the physical presence of students and teachers. They are spatially and temporally distant, but this distance is overcome with the use of modern technology. This form of education is available at all levels – from primary, secondary and university to adult education.

The Adult education act (Official Gazette 144/21) states that the adult education program can be implemented through regular classes, consultative-instructive classes and correspondence-consultative and distance learning, which confirms that the adult education system has been the originator from the very beginning, and to this day, along with some faculties, the most recognizable user of distance learning.

The introduction of such methods enables flexibility and adaptation of adult education to their needs and life circumstances.

Under the influence of the global pandemic, distance learning, and especially online teaching, has attracted attention both in practice and in scientific and research terms. However, distance learning and learning have a long history, thanks to adult education. At the end of the 20th century, under the influence of the development of the Internet, the paradigm of distance learning began to change, when multimedia and the Internet provided completely new possibilities for this form of teaching. Online teaching has opened up completely new perspectives and has begun to change the understanding of the teaching process on the entire educational vertical, which was especially evident during the pandemic.

5. ANDRAGOGY / ADULT EDUCATION TEACHER

An andragogue is an expert who deals with planning, organizing and improving the work of institutions that implement adult education. An andragogue represents a person who is a guide for teachers, and directs them on how and in what way to educate adults. Andragog performs administrative tasks and ensures the development and training of teachers for better implementation of adult education. Adult education teachers have the competences necessary to develop and acquire the knowledge and skills of the adults they teach. The teacher is also responsible for planning and organizing classes for adults.

Andragog is increasingly engaged in continuous education and professional development of adults. His jobs are no longer exclusively focused on teaching adult learners. An andragogue is expected to possess a variety of competencies, including generic (universal) competencies applicable to all workplaces, as well as specific competencies inherent in andragogical work.

Andragogy is a science of education and upbringing of adults, and training for safe work is by its nature a pedagogical and andragogical activity. Occupational safety experts often educate and train workers for safe work, which requires an understanding of andragogical principles.

When training to work in a safe way, it is important to meet pedagogical criteria. This includes determining the content of training, educational documentation, personnel and the formation of educational groups. Occupational safety experts who provide training must have basic andragogical knowledge. This includes understanding how adults learn and how to create the conditions for successful learning for trainees. Occupational safety professionals need to be motivated to continuous learning in order to develop the necessary skills and competences.

6. CONCLUSION

6. CONCLUSION

Andragogist plays a key role in supporting adults in their education and development Adult learning plays a key role in society. Adults are educated to improve their skills and knowledge, which helps them in their careers. This may include the acquisition of new skills, reskilling or upskilling of existing competences. Adult education enables people to stay connected to society, developing their interests and competencies. Learning throughout life contributes to personal growth and self-confidence. Adults who are educated feel more fulfilled and satisfied. Educated adults contribute to society as a whole. Their knowledge and skills are used in various sectors, from the economy to culture. Adult education is not only about acquiring knowledge, but also about investing in a better future for the individual and society.

REFERENCES

[1] Maic, Ž.: Development of Andragogical Science: Historical Development of Adult Education. Life and School: Journal for the Theory and Practice of Education, LXIII (2), pp.169-180. (2017) available at: https://hrcak.srce.hr/195195

[2] Andrilović, V.; Matijević M.; Pastuović N.; Pongrac S.: Špan M.; *Andragogy,* Školska knjiga, Zagreb, WT145, (1985).

[3] Vican, D.: Educational Structure and Educational Needs of Citizens of the Republic of Croatia - Platform for Changes in Adult Education Practice: Introduction. Andragoški glasnik : Bulletin of the Croatian Andragogical Society, *17* (2. (31)), 0-0. Preuzeto s https://hrcak.srce.hr/116174 , (2013)

[4] Bognar, L.; Matijević M.; *Didactics,* Školska knjiga, ISBN: 953-030-2312, Zagreb, (2002).

[5] Čepić R.; *Pedagogy of Lifelong Learning*, Faculty of Teacher Education, University of Rijeka, Rijeka, (2017). Available at: https://www.ufri.uniri.hr/files/nastava/nastavni_materijali/141117_Renata_Cepic_Nastavni_materijal_PCO_LOCK.pdf.

[6] Agency for Vocational Education and Training and Adult Education, *How to teach adults successfully*, Agency for Vocational Education and Training and Adult Education.Zagreb, (2012), Available at: https://www.asoo.hr/UserDocsImages/projekti/

[7] Dumić, S., Matasić, I.: Multimedia Technologies in Education: The Positive Effects of Multimedia Are. Media Research : Scientific and Professional Journal for Journalism and Media, 18/2018 (1), pp.143-151., ISSN 1330-6928 (2012)

[8] Official Gazette. (2007), Adult Education Act. Zagreb: Narodne novine d.d. Available at: https://narodne-novine.nn.hr/clanci/sluzbeni/2007_02_17_668.html.

[9] Official Gazette, (2014, 2018), Occupational Safety and Health Act, Zagreb: Narodne novine d.d., Available at: https://narodne-novine.nn.hr/clanci

[10] Pastuović N.; Žiljak T.; Strugar V.; Petričević D.; Bejaković P.; Kušić S.; Vrcelj S.; Zovko A.; Rajić V.; Kranjc A.;, Matijević M.; *Adult Education: Theoretical Foundations and Practice,* Učiteljski fakultet Sveučilišta u Zagrebu, Pučko otvoreno učilište Zagreb, ISBN: 978-953-8115-47-9, Zagreb, (2018)

ANDRAGOGICAL SKILLS OF OCCUPATIONAL SAFETY EXPERTS

Lada Purgar [1]; Ana Marija Bonić (student) [2]
[1]Karlovac University of Applied Sciences, J. J. Strossmayera 9, 47000 Karlovac, Croatia, ladapurgar@gmail.com
[2]Karlovac University of Applied Sciences, J. J. Strossmayera 9, 47000 Karlovac, Croatia,

Abstract:

Andragogy is a scientific discipline that studies the theory and practice of learning and education of adults. Andragogy and occupational safety are interrelated, as the work of occupational safety professionals involves the education and motivation of others for healthy forms of work, the development of protection and, in addition, the personal implementation of lifelong learning.

Given that there is stil no university programs for andragogy in Croatia and there is no officially declared who is by profession an andragogist / adult education expert in Croatia, it is challenging to define the competencies of an occupational safety engineer whose role is to teach others how to work in a safe way, protect themselves, others and the environment.

Keywords:

andragogy, lifelong learning, skills, motivation, occupational safety, occupational safety experts

1. INTRODUCTION

Occupational safety as an interdisciplinary system is subject which lives thru changes. Such a system expects occupational safety experts to continuously develop knowledge and skills of a wide range and adapt to changes that occur in the professional field, with the aim of improving the quality of work and living conditions of themselves and those with whom they cooperate.

Interdisciplinarity is required to perform professional tasks in the field of occupational safety. In order to achieve this, in addition to general formal education, non-formal and informal forms of education are important. The interest and motivation of occupational safety experts therefore play very important roles in the development of the necessary skills and competencies.

Andragogy is a scientific discipline that occupational safety professionals encounter in their professional work. The work of an expert implies educating and motivating others for healthy forms of work, developing a culture of protection and personal implementation of lifelong learning. Andragogy has a special importance in the field of occupational safety, which is confirmed by the Occupational safety and health act, the obligation of basic andragogical knowledge for occupational safety experts prescribed by the Occupational safety and health act. Knowledge and understanding of adult education is essential for quality work and development of professionals in the professional field.

2. ADULT EDUCATION

Adult education is realized through formal education as well as informal forms of training and further education. Non-formal training and upskilling takes place mainly alongside work, while adult education should be predominantly work-based. Formal education is linked with schools and training institutions; non-formal with community groups and other organizations; and informal covers what is left, e.g. interactions with friends, family and work colleagues**.** The concept of adult education therefore encompasses all important areas of human activity, and all paths of education – from institutionalized schooling to non-intentional self-education. (Ibid., p. 9.)

2.1. EDUCATION OF OCCUPATIONAL SAFETY EXPERTS

The education of occupational safety experts in the Republic of Croatia is carried out in the form of undergraduate professional and graduate specialist studies in safety and protection, at three higher education institutions; Karlovac University of Applied Sciences, Rijeka University of Applied Sciences, Security College (Zagreb).

During education for occupational safety experts students acquire competencies important for the profession of occupational safety professionals, and these are:

Assessment of educational needs: ability to identify the educational needs of target groups and individuals

Planning and organization of education: the ability to choose educational programs in accordance with educational needs, as training refers to the needs for theoretical and/or practical training of workers,

Implementation and evaluation of education: ability to inform target groups about the educational program, selection of methods of performing the process, ability to successfully evaluate and conclude the educational process, the effect of education, a record of the qualification of workers to work in a safe manner.

Present problem is the mismatch of curricula or training programs in the field of andragogy, because some institutions issue certificates for two-day workshops lasting several hours, which are considered to be enough for an adult in the technical profession to understand the importance and applicability of andragogy in education. This issue is very present in the adult education system and it will be necessary to intervene in the law in order to present andragogy as a scientific discipline important to those who who work with adults. Andragogy should never be a multi-day workshop or course. This problem is so widespread in adult education in Croatia that it must be a separate topic for a new professional paper, research or e-counseling.

2.2. ANDRAGOGICAL SKILLS AND COMPETENCIES OF OCCUPATIONAL SAFETY PROFESSIONALS

A person's competences represent the ability to combine skills, knowledge and understanding, interpersonal and practical skills. It is the ability to use the acquired knowledge and skills in personal and professional development. People who work in adult education or participate in part of their education must constantly develop their competencies in order to be successful in their work.

In order for an occupational safety expert to successfully carry out education, training and motivation of workers for healthy forms of work, he must understand how adults learn. Based on such knowledge, it is much easier to determine the approach to the participants and bring a certain topic closer. Occupational safety experts have the role of experts, pedagogues and andragogists at the same time. Such competencies include the ability to work with others, the ability to work with and within society, and the ability to work with new knowledge, information and technology.

The author Čepić states that there are numerous studies showing that four areas of individual competence are mainly sought. Such necessary competencies of people in the 21st century are:

- the ability to learning, knowledge of self-study and management of one's education
- know how to communicate, listen and speak, read and write meaningfully
- know how to decide, quickly and correctly, choose the right option between several of them, take personal responsibility
- to master interpersonal relationships, to participate in a team, to lead and subordinate, to be able to dialogue" (R. Čepić, Pedagogy lifelong learning, P. 67.-68.)

3. SURVEY RESEARCH OF OCCUPATIONAL SAFETY EXPERTS

During the pandemic and distance learning (2021.) the survey "Survey for Occupational Safety Professionals" was conducted *online* thru google forms. The study involved 100 respondents who work as occupational safety professionals in Croatia. The purpose of the research is to collect data on formal, non-formal and informal education of occupational safety professionals, age and experience, contentment with education in the field of adult learning, institution that provides such training and with separate training in the field of basic andragogical knowledge and other non-formal forms of education in order to determine respondents' satisfaction with such trainings, outcomes and opinions on the importance of them for the needs of professional work.

3.1. RESULTS AND DISCUSSION

A larger number of male respondents (58%) were represented in the sample, then the female (42%), based on which it can be concluded that the work of occupational safety experts is more often performed by men.

More respondents belong to the age group between 30 and 39 years, (35%), and the least to the age group of 60 years and older (2%).

Almost half of the respondents (44%) have completed their undergraduate studies, and (56%) have completed their graduate studies. Almost all respondents are employed, (98%), and 2% participate are in auxiliary work on occupational safety through a student contract. Almost all respondents are employed in the profession.

The least work experience has (14%) to a maximum of 2.5 years, but most respondents, (40%) have 3-5 years of work experience. It is to conclusion that this is a relatively interesting professional field for young people in accordance with the age of the respondents.

Large number of experts, 72% have a certificate of competence in the field of basic andragogical knowledge, and (28%) do not. There is a great interest of respondents – occupational safety experts in andragogical knowledge with which they complement their professional work in such a way that they acquire the skills and competencies necessary to train workers to work in a safe way.

Training for andragogical skills and competencies is carried out in sixteen different authorised institutions, except in the case of 9 respondents who did not provide the exact name of the institution. The ZIRS College Zagreb, the Institution for Adult Education and the College of Security Zagreb stand out with results from the rest.

And it is evident that the most training of the examinees was carried out there. Largest number of respondents conducted training at the ZIRS College – Adult Education Institution (Zagreb), a total of 22.22%. The College of Security equals trained 19.44% of examinees and Euro Eduka 8.33%. Vimal, the CTZ Institution and the Križevci Instruction Center, trained the same number of examinees, (5,556%) with completed training. Other institutions are negligible.

As part of the Zagreb College of Safety, the respondents acquired andragogical knowledge within the curriculum – a separate course, while the ZIRS College – Adult Education Institution enables occupational safety experts to acquire andragogical knowledge at any time, which is a great advantage for adults that are already employed but need or motivated to learn more or get certificate, and therefore there is a greater interest and possibility of individuals for education in that institution.

Much of respondents who have a document or certificate of competence in the field of basic andragogical knowledge, (91.67%) are satisfied with the training and learning, while (8.33%) of the respondents are not satisfied with the training. It could be concluded that authorized institutions for conducting training in the field of basic andragogical knowledge mostly successfully conduct trainings, in which experts acquire the necessary knowledge and skills.

When training, (65%) had some benefit from training in the field of basic andragogical knowledge, 15 respondents (21%) believe that such training did not help them much in their work, while 10 respondents (14%) remained reticent.

In positive comments, respondents state that training in the field of basic andragogical knowledge has helped them in promotion, salary increase, they also believe that it is useful to have a document or certificate when employed, and as far as applicability in work is concerned, they point out that it helped them the most when working with people, for greater independence in work during the process of training workers and are generally of the opinion that it is necessary to constantly improve and train.

The results show that andragogy as a knowledge about adult learning is necessary, but (35%) who are not satisfied or have remained restrained, indicate the fact that it is necessary to work on the interests and requirements of the participants, in order to achieve greater applicability in the work.

Out of a total of 100 respondents, (3%) have not participated in non-formal forms of education in their work experience in occupational safety, 34 respondents (34%) have participated up to 5 times, (20%) have participated up to 10 times, (28%) have participated up to 20 times, while (15%) have participated in non-formal forms of education more than 20 times.

Number of respondents' participation in non-formal forms of education related to work experience – less work experience often means less participation in non-formal forms of education. Such results indicate that there is a need to invest more interest in such forms of education and to participate more often, regardless of work experience.

While (14%) are not satisfied with the implementation of non-formal education, (15%) believe that sometimes trainings and seminars are conducted well, and sometimes they are not, stating that it depends on the lecturer and the topic being covered, as well as the lack of required information, while (48%) are satisfied with the implementation of non-formal education. It is not enough just to maintain non-formal education or attend, but it is important to learn something new, clarify doubts or ambiguities that occupational safety professionals encounter in their professional work. Respondents independently decide on non-formal forms of education (24%), for the needs of the employer (17%), while in the largest number, (50%) participate in non-formal forms of education independently, and sometimes according to the instructions and needs of the employer.

Most of them (94%) believe that non-formal and informal forms of education are important for performing the tasks of occupational safety professionals, while (4%) do not consider them important, and (2%) did not express their opinion.

Respondents are very aware of the importance of non-formal and informal forms of education for performing the work of occupational safety professionals, forms of education should be invested in order to ensure that the outcomes and satisfaction with them are of the highest possible quality

4. CONCLUSION

Interdisciplinarity is required to perform professional tasks in the field of occupational safety. The necessary competencies are acquired through various forms of education, formal, non-formal and informal. In addition to education, work experience, motivation and the desire for continuous learning and improvement play a key role. Each individual is responsible for his or her own advancement. Skills that we acquire in different ways are a permanent source of competitiveness, if we constantly expand them.

Task of occupational safety experts is to teach others how to work in a safe way and what are the requirements for such a way of working, which ultimately results in the creation of a healthy working environment. In order to achieve this, cooperation, communication and understanding between occupational safety experts and their business associates are very important. In doing so, they can be helped the most by workers who, based on their daily work, can point out the advantages and disadvantages of jobs.

Based on the conducted research, we can conclude that training in the field of basic andragogical knowledge is important and for most respondents has brought very positive developments in professional work, such as promotion at work or salary increase, achieving better communication and better quality work with people. Respondents – occupational safety experts who often participate in non-formal forms of education believe that any education that is applicable in professional work is important and useful.

Although research results, due to methodological limitations (a small number of examinees, simple questionnaire), do not allow generalisations, it is possible to recognize directions and tendencies in relation to possessing (needed) andragogical competences. Research results reveal a need for a continuous research of the education of andragogues and their competences, especially andragogogues whose primarliy vocation is occupational safety expert . Paying attention to the needs of andragogues also imposes a need to examine educational needs of andragogues and to redesign existing programmes of further professional trainings for a more efficient acquiring of andragogical competences.

5. REFERENCES

[1] Andragogy, Croatian Encyclopedia, online edition. Miroslav Krleža Institute of Lexicography, Zagreb, (2021) Available at: https://www.enciklopedija.hr/natuknica.aspx?ID=2579.

[2] Andrilović, V.; Matijević M.; Pastuović N.; Pongrac S.;, Špan M.; *Andragogy,* Školska knjiga, Zagreb, WT145, (1985).

[3] Brlas, S.; *The Psychology of Communication,* Naklada Slap, ISBN: 978-953-191-394-2

Jastrebarsko, (2010).

[4] Bognar, L.; Matijević M.; *Didactics,* Školska knjiga, ISBN: 953-030-2312, Zagreb, (2002).

[5] Čepić R.; *Pedagogy of Lifelong Learning*, Faculty of Teacher Education, University of Rijeka, Rijeka, (2017). Available at: https://www.ufri.uniri.hr/files/nastava/nastavni_materijali/141117_Renata_Cepic_Nastavni_materijal_PCO_LOCK.pdf. (Accessed on 16.06.2021.)

[6] Agency for Vocational Education and Training and Adult Education, *How to teach adults successfully*, Agency for Vocational Education and Training and Adult Education.Zagreb, (2012), Available at: https://www.asoo.hr/UserDocsImages/projekti/

[7] Kušić S.; Vrcelj S.; Zovko A.; *Didactic Determinants of Andragogy Education – A Comparative Approach,* Faculty of Humanities and Social Sciences in Rijeka, ISBN 978-953-7975-36-4, Rijeka, (2016).

[8] Official Gazette. (2007), Adult Education Act. Zagreb: Narodne novine d.d. Available at: https://narodne-novine.nn.hr/clanci/sluzbeni/2007_02_17_668.html.

[9] Official Gazette, (2014, 2018), Occupational Safety and Health Act, Zagreb: Narodne novine d.d., Available at: https://narodne-novine.nn.hr/clanci
[10] Pastuović N.; Žiljak T.; Strugar V.; Petričević D.; Bejaković P.; Kušić S.; Vrcelj S.; Zovko A.; Rajić V.; Kranjc A.;, Matijević M.; *Adult Education: Theoretical Foundations and Practice,* Učiteljski fakultet Sveučilišta u Zagrebu, Pučko otvoreno učilište Zagreb, ISBN: 978-953-8115-47-9, Zagreb, (2018)

EXPERIENCE OF FOREIGN WORKERS – SAFETY ISSUES

Anita Stilin[1], Ljerka Tomljenović[2], Ana Blažević[3]

[1] University of Applied Sciences of Rijeka, Vukovarska 58, 51000 Rijeka, CROATIA, anita.stilin@veleri.hr

[2] University of Applied Sciences of Rijeka, Vukovarska 58, 51000 Rijeka, CROATIA, ljerka.tomljenovic@veleri.hr

[2] University of Applied Sciences of Rijeka, Vukovarska 58, 51000 Rijeka, CROATIA, ablazevic0406@gmail.com (student)

Abstract: *The construction industry in Croatia has encountered numerous challenges in recent years, with labor shortage ranking among the most significant. Consequently, many construction companies are turning to foreign workers to meet their operational needs effectively. However, the increasing employment of foreign workers has brought attention to safety concerns within the industry. This paper aims to identify safety-related issues faced by foreign workers. The research was conducted within a single construction company, surveying 34 foreign workers employed at one construction site. The findings indicate that, while foreign workers generally possess a positive attitude towards safety practices, procedures, and regulations, they encounter minor difficulties in task execution, particularly due to language barriers.*

Keywords: *safety, foreign workers, diversity management, construction*

1. INTRODUCTION

The construction industry in Croatia is facing a labor shortage, similar to many other countries worldwide (e.g. EU [3], Hong Kong [5], [7], USA [2], [8]). Furthermore, labor shortages are expected to increase in the future due to declining population and the ageing workforce [3], [4], [5]. In accordance with the Aliens Act (Croatia), in 2023, a total of 172,499 residence and work permits were issued, of which the largest number was in construction (68,912). The largest number of residence and work permits in 2023 were issued to citizens of the following countries: Bosnia and Herzegovina (38,236), Serbia (24,028), Nepal (23,493), India (15,627), North Macedonia (13,412), Philippines (10,999), Kosovo (9,922), Bangladesh (8,749), Turkey (5,067), Albania (4,244) [9].

The construction industry is considered one of the most unsafe industries [1], [10]. It is also perceived as difficult and dirty compared to many other industries, making it unattractive for employment [5]. Even though Croatian Institute of Public Health – Department of Occupational Health provides various analysis on work-related injuries, data on these injuries among the foreign workforce compared to the local workforce are not available. However, research from other countries shows that ethnic minority workers are more vulnerable to safety-related accidents and injuries than local workers, e.g. Germany [1], United Kingdom [6], USA [6], [11]. There is lack of research on the experiences of foreign workers regarding safety issues in Croatia.

The purpose of the research was to assess the attitudes of foreign workers towards workplace safety and to identify and address any obstacles or challenges they encounter in adhering to safety rules and procedures.

2. METHODOLOGY AND RESULTS

The research was conducted in a private construction company in Croatia. The headquarters are in Zagreb, but the company has many construction sites, including one at the Refinery in Rijeka where the research was administered. The company was engaged as a subcontractor for plant reconstruction. It lays the foundations for the installation of steel structures and new power plants and concretes columns and other slabs in preparation for the installation of steel structures.

The survey was conducted on May 25, 2023, among foreign workers employed at the Rijeka Refinery location. The company hires new foreign workers daily. At the time of the survey, 40 workers were employed at the Refinery. A smaller group of foreign workers did not participate due to annual vacations, days off, and urgent work tasks. The questionnaire was completed by 34 foreign workers, representing an 85% response rate. All respondents were male, reflecting the male composition of the organization's foreign workforce.

The questionnaire was first prepared in Croatian and then translated into English for foreign workers who do not understand Croatian. Furthermore, for those workers who do not comprehend either Croatian or English, their colleagues translated the questionnaire into their respective native languages. Each respondent received a paper questionnaire. The questionnaire is composed of two sections: general information about the respondents and statements referring to safety issues. A 5-point Likert scale was used to rate the items (1 = “strongly disagree” – 5 = “strongly agree”).

The characteristics of the respondents are shown in Table 1.

Table 1: Characteristics of the respondents

Variable	Categories	N=34	Percentage (%)
Country of origin	Albania	13	38.2
	Bangladesh	2	5.9
	Bosnia and Herzegovina	3	8.8
	Ghana	2	5.9
	India	3	8.8
	Kosovo	4	11.8
	Turkey	6	17.7
	Ukraine	1	2.9
Job title	Rebar workers	6	17.6

	Carpenters	26	76.5
	Masons	2	5.9
Years of experience in construction	< 1 year	4	11.8
	1 – 5 years	9	26.5
	6 – 10 years	7	20.6
	11 – 15 years	5	14.7
	16 – 20 years	3	8.8
	> 20 years	6	17.6
Work-related injuries	Never	30	88.2
	1 – 3 times	4	11.8
	4 – 6 times	0	0
	> 6 times	0	0

The 34 respondents originate from 8 different countries. Most of them come from Albania (13, or 38.2%). There is only 1 foreign worker from Ukraine. Most of the respondents (26, or 76.5%) are employed as carpenters. The smallest number of respondents (3, or 8.8%) have 16 to 20 years of experience working in construction. Most of the respondents have between 1 and 5 years of working experience, representing younger workers. Almost 60% of respondents have 10 or less experience in construction (20, or 58.8%). It is encouraging to note that 30 respondents (88.2%) reported no work-related injuries. However, 4 respondents (11.8%) stated they were injured 1 to 3 times. As they did not formally report these injuries, it is assumed they experienced minor injuries such as cuts, lacerations and punctures, bruises, and soreness, which they treated themselves.

Language barriers pose one of the most common obstacles to ensuring safe behavior [5][6]. A 5-point Likert scale was used to evaluate foreign workers' safe behavior and the language challenges they face in the working environment (Table 2). The Cronbach's alpha coefficient for the entire scale was 0.8 representing good reliability.

Table 2: Descriptive analysis: safe behavior and language barriers

Variable (statements)	M	SD	Mode	Skew	Kurtosis
I understand the instructions made by the occupational safety officer.	4.53	0.51	5	-0.12	-2.11
Coworkers who speak my native language help me understand and apply the occupational safety rules.	4.47	0.83	5	-2.48	8.62
I have adopted the rules of occupational safety by observing more experienced workers.	4.41	0.82	5	-2.32	8.08
I respect the rules of occupational safety.	4.47	0.62	5	-0.71	-0.38
I regularly use all personal protective equipment assigned to me.	4.32	0.81	5	-1.41	2.29
I have the necessary knowledge and skills to	4.41	0.56	4	-0.19	-0.92

perform work tasks successfully.					
I speak English well enough to perform work tasks successfully.	3.38	1.16	4	-0.32	-1.15
I speak Croatian well enough to perform work tasks successfully.	3.71	1.51	5	-0.59	-1.35
I would accept a free Croatian language course if it were offered to me.	3.74	1.38	5	-0.75	-0.52
The language barrier represents a major problem for me in complying with occupational safety rules.*	2.47	1.33	1	0.35	-0.96

Reverse coding

The company communicates with foreign workers in Croatian or English, depending on their proficiency in either language. Respondents gave the highest average rating to the statement regarding their understanding of instructions given by the occupational safety officer (M = 4.53, SD = 0.51). This is consistent with the low scores on the statement about language barriers being a problem in complying with occupational safety rules (M = 2.47, SD = 1.33). These high scores can also be attributed to the occupational safety officer's effort in carefully explaining instructions and ensuring that workers understand them correctly. In a comparison of language knowledge, respondents are more proficient in Croatian (M = 3.71, SD = 1.51) than in English (M = 3.38, SD = 1.16). This can be explained by the fact that some of the foreign workers come from countries where languages similar to Croatian, such as Bosnian and Serbian, are spoken. Additionally, some of the workers have already made significant efforts to learn Croatian. Adherence to safety practices and successful task performance are likely the result of working in groups with coworkers who speak the foreign worker’s native language as well as English or Croatian (M = 4.47, SD = 0.83) and observing more experienced workers (M = 4.41, SD = 0.82).

Even though approximately 47% of respondents do not consider a language barrier to be a problem (scoring 1 and 2), nearly 56% of respondents would enroll in a free Croatian language course (scoring 4 and 5). Knowledge of the local language facilitates the integration of foreign workers into society and the work environment. It also enables a better understanding of superiors' requests and tasks, as well as communication with colleagues who do not speak their language [8].

A diverse workforce requires adaptation in behavior not only by the management of the organization but also by the employees. A 5-point Likert scale was used in investigating diversity management (Table 3). The Cronbach's alpha coefficient for the entire scale was 0.7 representing acceptable reliability.

Table 3: Descriptive analysis: managing diversity

Variable (statements)	M	SD	Mode	Skew	Kurtosis
My superiors treat me the same as coworkers from other countries.	4.32	0.84	5	-1.34	1.62
My cultural and religious differences are accepted and respected.	4.44	0.56	4	-0.30	-0.90

I am subject to racial and/or ethnic discrimination at work.*	2.47	1.83	1	0.63	-1.56

**Reverse coding*

Fair and equal treatment of all foreign workers by superiors can be observed in the company studied (M = 4.32, SD = 0.84). Furthermore, it can be noticed that workers with different cultural and religious backgrounds have their differences accepted and respected (M = 4.44, SD = 0.56). Despite respondents rating racial and/or ethnic discrimination with an average score of 2.47 (SD = 1.83), the results are surprising given the high scores for previous statements. Specifically, 11 respondents (32.35%) consider themselves subject to racial and/or ethnic discrimination (scoring 5). One possible explanation could be that the statement was unclear to some respondents because the questionnaire was not in their native language. Another explanation is that they have missed the reverse scoring (expressing disagreement with the statement), especially since it was the last statement following others that had been rated differently (expressing agreement with the statement).

By managing diversity, the organization actively promotes and encourages respect for all employees, recognizing their unique identities and contributions. An occupational safety officers, as part of an organizational team, can provide expertise and recommendations to ensure that the various aspects of workplace safety are addressed to all employees in a fair and inclusive manner.

3. CONCLUSION

This study examined the safety issues encountered by foreign workers in Croatia. The findings indicate that respondents recognize the importance of safety measures, even though they are not accustomed to them. They have support from safety officers and their colleagues in understanding and applying safety rules and procedures. Their cultural and religious differences are mostly accepted. The language barrier represents the most challenging issue, which is consistent with previous research. The findings suggest that safety management should offer language instructions to ensure better compliance with safety measures and should make additional efforts in managing diversity. Both concepts of safety culture and diversity management are mutually supportive. A safety culture can improve the sense of safety among employees of different identities, while diversity management can contribute to better awareness of safety risks and promote cooperation and trust among employees.

There are some limitations to this study. The sample of the study represents only one organization and includes a small number of respondents, which limits the generalization of the findings. Nonetheless, it can serve as a basis for future research, offering a glimpse into the safety management challenges of having a diverse workforce. More detailed research defining different ethnic minorities would offer a clearer understanding of the specific problems they encounter. Also, the study did not include the viewpoints of supervisors and/or occupational safety officers, which might differ from those of foreign workers. This can represent another avenue for future research.

With the increased employment of foreign workers, safety problems related to foreign (migrant) workers require more attention and investigation. A better understanding of the safety and health problems of foreign workers is necessary to create effective safety measures and ensure their inclusion in the working environment.

REFERENCES

[1] Arndt, V.; Rothenbacher, D.; Daniel, U.; Zschenderlein, B.; Schuberth, S. & Brenner, H.: All-cause and cause specific mortality in a cohort of 20000 construction workers; results from a 10 year follow up, *Occupational and Environmental Medicine,* Vol. 61 (2004) No. 5, pp. 419-425, ISSN 1351-0711

[2] Azeez, M.; Gambatese, J. & Hernandez, S.: What do construction workers really want? A study about representation, importance, and perception of US construction occupational rewards, *Journal of Construction Engineering and Management,* Vol. 145 (2019) No. 7, pp. 04019040-1-12, ISSN 0733-9364

[3] Brucker Juricic, B.; Galic, M. & Marenjak, S.: Review of the Construction Labour Demand and Shortages in the EU, *Buildings,* Vol. 11 (2021) No. 17, pp. 1-17, ISSN 2075-5309

[4] Butković, H.; Samardžija, V. & Rukavina, I.: *Foreign Workers in Croatia: Challenges and Opportunities for Economic and Social Development,* Institute for Development and International Relations – IRMO, ISBN 978-953-6096-95-4, Zagreb, (2022)

[5] Chan, A.P.C.; Wong, F.K.W.; Hon, C.K.H.; Ali Javed, A. & Lyu, S.: Construction safety and health problems of ethnic minority workers in Hong Kong, *Engineering, Construction and Architectural Management,* Vol. 24 (2017) No. 6, pp. 901-919, ISSN 0969-9988

[6] Hare, B.; Cameron, I.; Real, K. & Maloney, W.: Exploratory case study of pictorial aids for communicating health and safety for migrant construction workers, *Journal of Construction Engineering and Management,* Vol. 139 (2013) No. 7, pp. 818-825, ISSN 0733-9364

[7] Ho, P.H.K.: Labour and skill shortages in Hong Kong's construction industry, *Engineering, Construction and Architectural Management*, Vol. 23 (2016) No. 4, pp. 533-550, ISSN 0969-9988

[8] Madera, J.M. & Chang, Y.: Job injury issues among Hispanic immigrant employees in hospitality operations, *Worldwide Hospitality and Tourism Themes,* Vol. 3 (2011) No. 4, pp. 354-364, ISSN 1755-4217

[9] Ministarstvo unutarnjih poslova Republike Hrvatske: Statistike izdanih dozvola za boravak i rad za 2023. godinu, *Available from* https://mup.gov.hr/gradjani-281562/moji-dokumenti-281563/stranci-333/statistika-169019/169019 *Accessed: 2024-6-12.*

[10] Ninan, J.: Construction safety in media: an overview of its interpretation and strategic use, *International Journal of Construction Management,* Vol. 23 (2021) No. 6, pp. 945-953, ISSN 1562-3599

[11] Welton, M.; Shen, Y.; Ebell, M.; DeJoy, D. & Robb, S.W.: Construction employment mortality among Mexican immigrants in the South Eastern United States, 2003-2013, *International Journal of Migration, Health and Social Care,* Vol. 16 (2020) No. 4, pp. 349-358, ISSN 1747-9894

TRAINING OF HEALTHCARE WORKERS TO WORK IN A SAFE WAY AND USE OF PERSONAL PROTECTIVE EQUIPMENT

Goranka Škeva [1]; Bojana Knežević [2]; Željko Otmačić [3]; Anamarija Vonić Lukinec [1]

[1] Health center Zagreb County , Lj. Gaja 37, Samobor, Croatia, goranka.skeva@gmail.com

[2] Clinical hospital center Zagreb, Kišpatićeva 12, Zagreb, Croatia,

[3] Energo inspekt doo, J. Jelačića 47a, Samobor, Croatia

ABSTRACT: *The Occupational Safety and Health Act prescribes the employer's obligation to train workers to work safely before starting work, but also during work in case of changed circumstances, for example, another workplace, new technology or new work equipment. The training of healthcare workers to work safely also includes the use of personal protective equipment. During the COVID-19 pandemic, we conducted an anonymous survey among primary care health workers with questions about previous training to work safely and their opinions on whether they need to be further educated on the use of personal protective equipment. The questionnaire was filled out by 184 healthcare professionals, most of them (56%) employed in family medicine practices. 101 respondents were trained to work safely for their current job, 50 of whom were also trained in using personal protective equipment and believe that this helped them in their work during the epidemic (47 respondents). The majority of respondents (166 respondents) expressed a desire for additional education on using personal protective equipment. Occupational health protection of healthcare workers is an important factor in preserving the functionality of the healthcare system in Croatia. It is one of the measures to prevent occupational injuries and occupational diseases, where quality training for safe work and the use of personal protective equipment also play an important role.*

KEYWORDS: *training to work safely, healthcare workers, personal protective equipment*

1. INTRODUCTION

Training workers to work safely is a legal obligation of every employer and is carried out before the very start of work, but also in the case of changes in the work procedure, introduction of new work equipment, technology, referral to a new workplace, in the case of established damage to health due to hazards, harmfulness and workplace effort [1,2]. The risk assessment of a specific workplace and jobs is a basic document when creating a training program and determining the need for preventive examinations of workers if they are employed at a workplace with special working conditions [3]. As a rule, health workers employed in primary health care offices are referred for preventive examinations in selected occupational medicine offices according to point 56 of the Rule on jobs with special working conditions (jobs where the worker is exposed to biological agents) [4]. Biological agents are microorganisms (bacteria, viruses, fungi, parasites) that can cause infections, allergies and malignant diseases due to direct action or toxins. The European

Agency for Safety and Health at Work recognised the dangers of exposure to biological agents in the workplace. A comprehensive report gave recommendations for safer work and prevention of hazards for the most exposed occupational groups, including health workers [5]. Doctors, nurses and technicians as well as laboratory staff in offices and laboratories as part of primary health care are exposed to biological agents either in direct contact with their patients (examination of the patient, swabbing of the pharynx/ nasopharynx /wounds, parenteral treatment, venipuncture when taking blood samples, wound toilets, minor surgical procedures) or with body fluids (blood, urine). Regular and correct use of personal protective equipment should prevent contact of health workers with biological agents and the dangers they carry. Therefore, training health workers to work safely and properly using personal protective equipment (PPE) is an important measure to prevent injuries at work and the development of occupational diseases [6].

2. AIM

In this paper, we analyse the data obtained from health workers employed in surgeries and laboratories at the level of primary health care in Croatia to find out whether work training is carried out safely and whether this education includes learning about the use of personal protective equipment.

3. METHOD AND RESULTS

The research was cross-sectional, and conducted during the COVID-19 pandemic [7]. An anonymous questionnaire with an explanation of the research was sent by e-mail to health workers employed in primary health care in the period from October 1, 2020. to January 3, 2021 [7]. The first part of the questionnaire contained general questions about age, gender, level of education and workplace, and the second part of the question referred to previous education on the use of personal protective equipment and training for safe work, as well as the opinion on the need for additional education on the use of personal protective equipment.

Table 1: Working place and profession of respondents (N=184)

WORKING PLACE	N (%)	PROFESSION	N (%)
family medicine office	103 (56%)	doctor	146 (79.3%)
occupational medicine office	35 (19%)	laboratory technician	18 (9.8%)
medical biochemical laboratory	18 (9.8%)	nurse	12 (6.5%)
dental office	9 (4.9%)	dentist	5 (2.7%)
radiology department of the health centre	3 (1.6%)	radiology engineer	3 (1.6%)
they didn't answer	16 (8.7%)		

The questionnaire was filled out by 184 respondents, of whom 146 were doctors, 18 laboratory technicians, 12 nurses, 5 dentists and 3 radiological technology engineers (Table 1).
Out of 184 respondents, 101 of them were trained to work safely for their current position in primary health care, of which 50 were also trained in the use of personal protective equipment. When asked if they would like to attend additional training on the use of PPE, 166 of them answered yes.

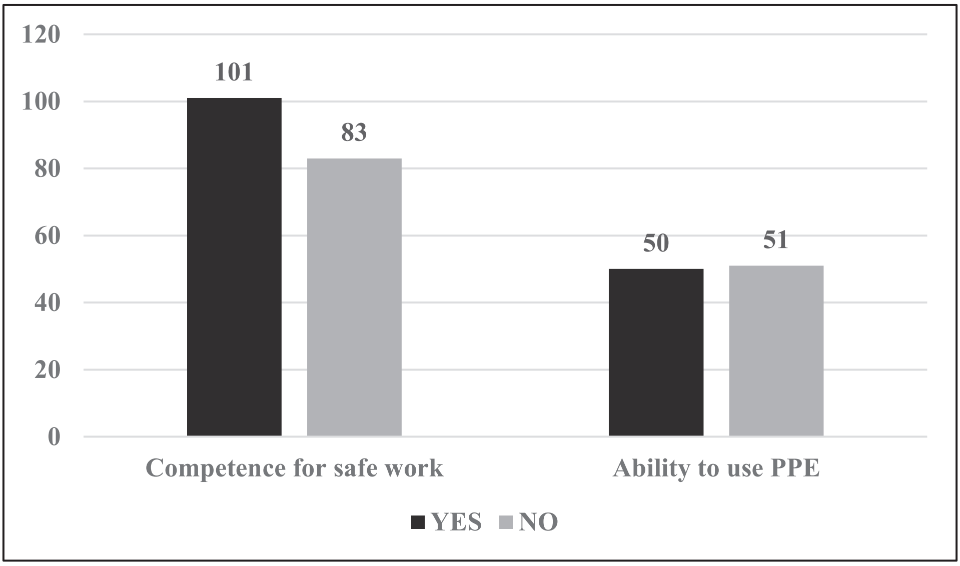


Figure 1: Competence of respondents to work safely and use PPE

The collected data show that despite the legal obligation by which the employer must train all its workers to work safely, at the level of primary health care, 55% of respondents fulfilled this obligation, while the other 45% of health workers did not (Figure 1). Out of our 184 respondents, 50 of them had as part of training for safe work and education on the use of personal protective equipment, and when asked if this education was sufficient for them to work safely during the epidemic, 26 of them answered that it was not. 166 of our respondents (92%) expressed a desire for education about PPE.

4. DISCUSSION AND CONCLUSION

Our questionnaire showed the willingness and need of health workers in primary health care to be additionally educated on the proper use of personal protective equipment. Exposure to biological agents and occupational hazards associated with them can be prevented by proper use of personal protective equipment. Annex III of the Rulebook on personal protective equipment lists examples of work activities and sectors where appropriate personal protective equipment is required [8]. For the health care sector for protection against biological agents, there are personal protective equipment for the protection of the respiratory system (breathing devices for protection against particles), hands (protective gloves against microorganisms), forearms (protective gloves against microorganisms), the whole body or part of the body (protective clothing against biological agents), feet (protective boots and shoes) and eyes and face (safety glasses and face shields) [8]. Health care at the primary level is provided through the activities of general/family medicine, health care for preschool children, health care for women, patronage nursing, health care in the patient's home, dental health care, hygiene-epidemiological services, preventive and educational measures for the health care of school children and students, laboratory diagnostics, pharmacy and emergency medical assistance [9]. When training health workers on the use of PPE, it is necessary to take into account the specificity of the workplace and work tasks and the dangers it carries out the risk assessment of workplaces and the assessment of the risk of infection transmission[10]. It is necessary to pay attention to the following jobs in healthcare:

- Emergency medical care workers perform field work in all weather conditions, on unknown terrain and with unknown patients. They also take part in the care of victims of major natural disasters or traffic accidents, when one often forgets about one's safety and protection of one's health. The highest level of personal protection is required and personal protective equipment.
- Nurses/medical technicians in-home care and outpatient work take care of patients with whom they are well acquainted, and who can be very difficult and complex patients; immobile, in the terminal stages of serious diseases, with open body wounds, stomas, permanent urinary catheters and completely dependent on other people's help, and depending on the individual assessment, sometimes the highest level of personal protective equipment is required.
- Health workers of hygiene and epidemiological services collect samples for further diagnostic processing, for example, urine or stool, but they also participate in taking samples, for example, swabs of the pharynx, nasopharynx, or conjunctiva of the eye.

Education on the proper use of personal protective equipment should include general knowledge for all healthcare workers and specific knowledge depending on the employee's workplace. The training should include (Figure 2): a theoretical part (types of protective equipment, application, method of use) and a practical part (exercises on putting on, using, removing and disposing of protective equipment), and it would be desirable to renew this theoretical and practical knowledge. In the event of an injury at work or the development of an occupational disease caused by a biological agent, e.g. in the case of a stabbing incident, a renewal of training is proposed for the entire department (e.g. a stabbing incident among laboratory staff - knowledge renewal must be carried out for all staff of that laboratory).

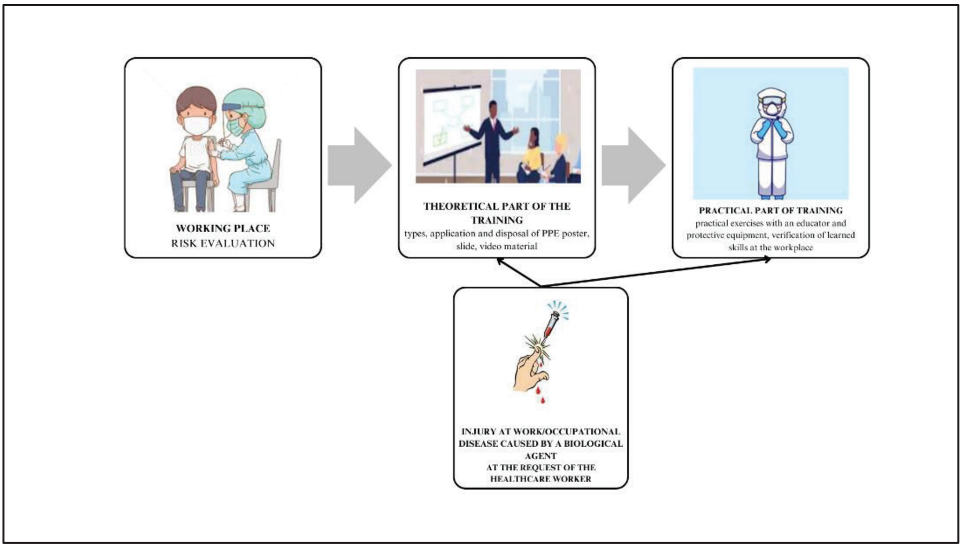


Figure 2: Proposal of a training model for healthcare workers for the use of PPE

We can conclude that the consistent implementation of the legal obligation of employers to carry out the training of healthcare professionals to work safely and use personal protective equipment is an important measure to protect the health of healthcare professionals and at the same time an important measure to preserve the functionality of the healthcare system in Croatia, while taking into account the specifics of workplaces [11]. Employers should plan a theoretical and practical part in the training plan, knowledge testing and periodic knowledge renewal to ensure the prerequisites for health protection at work for their employees.

REFERENCES:

[1] Zakon o zaštiti na radu, N.N.br. 71/14, 118/14, 154/14, 94/18, 96/18.
[2] Pravilnik o osposobljavanju i usavršavanju iz zaštite na radu te polaganju stručnog ispita, N.N. br. 142/21
[3] Pravilnik o izradi procjene rizika, N.N.br. 112/14, 129/19
[4] Pravilnik o poslovima s posebnim uvjetima rada N.N. br. 5/84
[5] EU-OSHA (European Agency for Safety and Health at Work), 2020. Biological agents and work-related diseases. Final report.
[6] Videc,I.: Sigurnost na radu za radnike u zdravstvu, ZIRS, Zagreb, 2019.
[7] Škeva,G.; Knežević,B.; Balint,I.; Otmačić,Ž: Stavovi zdravstvenih radnika o edukaciji u primarnoj zdravstvenoj zaštiti tijekom pandemije COVID-19; Sigurnost 64 (1) 27-34 (2022)

[8] Pravilnik o uporabi osobne zaštitne opreme, N.N.br. 5/21
[9] https://hzzo.hr/pravni-akti/opis-zdravstvenog-sustava
[10] Pravilnikom o načinu provođenja i mjerama zaštite radi sprječavanja nastanka ozljeda oštrim predmetima N.N. br. 39/2020
[11] Škeva,G.; Radošević,T.; Knežević,B.: Zdravlje na radu zdravstvenih radnika zaposlenih u primarnoj zdravstvenoj zaštiti.; 13. Kongres koordinacije hrvatske obiteljske medicine Šibenik 19-22.6.2022.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

STATISTICS OF OCCUPATIONAL ACCIDENTS IN THE REPUBLIC OF SLOVENIA FROM 2008 TO 2022

Leon Vedenik[1], Marjan Lukežič[2]

[1] Ministry of the interior of the Republic of Slovenia, Police,
Police Directorate Murska Sobota, Arhitekta Novaka 5, 9000 Murska Sobota, Slovenia, leon.vedenik@policija.si

[2] Municipality of Ljubljana, Streliška cesta 14, 1000 Ljubljana, Slovenia, marjan.lukezic@ljubljana.si

Abstract: *The article presents statistics on occupational accidents in the Republic of Slovenia from 2008 to 2022 according to official statistical records. It also discusses the normative regulations in the field. The findings based on the statistical data and conclusions on occupational accidents are presented.*

Keyword: *occupational safety and health, occupational injuries, occupational accidents, Republic of Slovenia*

1. INTRODUCTION

Occupational injuries are a serious problem worldwide and also in Slovenia. As a result, work-related health monitoring is a matter of urgency and is receiving increasing attention. Occupational injuries are an indicator of occupational safety and health. They are one of the main social and economic problems and one of the most important negative indicators of the health status of the working population. Authors who have studied occupational injuries state that economic trends, whether growth or recession, have an impact on the number of injuries, and that occupational injuries also have major economic consequences [9].

An accident and injury at work is an unforeseen or unexpected event in the workplace or work environment, occurring in the course of or arising out of work, which causes injury to a worker. The employer must report to the Labour Inspectorate of the Republic of Slovenia (IRSD) any fatal accident, any accident at work resulting in more than three days of absence of the worker from work, any collective accident at work (several workers are injured, regardless of the number of days of absence from work) [4].

Employers and the self-employed report work-related injuries to employees in the course of their work, while travelling on business, and on the way to and from work, if transport is organised by the employer. An injury must be reported if the worker is absent from work for at least one day as a result of the injury. The employer's notification of the injury and the doctor's confirmation means that the worker is entitled to 100% sick pay. Fatal injuries must also be reported, as the reporting of such injuries enables, among other things, the insured person to exercise their rights [5].

Work processes also result in dangerous occurrences, accidents at work and occupational diseases. The number of dangerous occurrences and accidents at work that have taken place in the employer's workplace and the number of work-related illnesses and occupational diseases provide the employer with a means of demonstrating the safety and health situation in his undertaking and, at the same time, a call for a review and reassessment of the occupational safety and health situation [2].

Dangerous occurrences, accidents at work and occupational diseases are also a consequence of the performance of the work process. The number of occupational hazards and accidents that have occurred in the employer's workplace and the number of work-related illnesses and occupational diseases provide the employer with a means of demonstrating the safety and health situation in his undertaking and at the same time, a call for a review and evaluation of the occupational safety and health situation [2].

In Slovenia, 17,214 occupational injuries were reported in 2022, or 18 injuries per 1,000 employees. Of these, 17 resulted in death. The increase in reports compared to the previous year was due to reports of covid-19 infections at work. Each year, around 2.5 million workers are reported in EU Member States as suffering from work-related injuries requiring more than 3 days off work. Around 3,000 employees are fatally injured at work in EU Member States each year [9].

2. REGULATORY FRAMEWORK

The concept of occupational safety and health includes the rights and obligations of employers and workers to ensure, in accordance with the law and other regulations, and by establishing and taking into account safety precautions, a level of occupational safety and health which, in the light of the nature of the work, gives the worker the greatest possible degree of health and psycho-physical safety. The legislation governing this area is part of the European legal order and follows the conventions of the International Labour Organisation. It lays down measures to ensure the safety and health of workers, including the prevention, elimination and control of hazards and injuries at work, the information and training of workers, and the appropriate organisation and necessary material resources. Workplace health promotion programmes are also covered by the legislation, and the identification of occupational diseases is an important priority. Ensuring health and safety at work must not entail financial obligations for the worker [2].

The Occupational Safety and Health Act defines an occupational accident as an unforeseen or unexpected occurrence at the workplace or in the work environment, which happens in the course of work or arises out of work, and which causes injury to a worker [8].

The Regulations on the Reporting of Accidents and Injuries at Work state that an accident at work is an accident as defined under the Occupational Safety and Health

Regulations. An occupational injury is an injury as defined by the law governing pension and invalidity insurance or other sectoral laws and resulting in at least one day's absence from work or death of the injured person [3].

The Law on Pension and Disability Insurance in 66. Article 66 provides, inter alia, that an occupational injury shall be deemed to be an injury resulting from a direct and short-lasting mechanical, physical or chemical effect, as well as an injury resulting from a rapid change in the position of the body, a sudden strain on the body or other changes in the physiological state of the organism, if such injury is causally related to the performance of the work or activity on the basis of which the injured person is insured, an injury, an injury caused in the manner referred to in the preceding indent which is sustained by the insured person on a regular journey from his home to his place of work or vice versa, if the transport is organized by the employer, and an injury caused in the manner referred to in the preceding indent which is sustained by the insured person on a business trip and an illness which is the direct and exclusive result of an accident or force majeure in the course of the work or activity in respect of which the person concerned is an insured person [7].

2. INJURY STATISTICS

Strategic objectives aimed at ensuring safety at work are based on the understanding that the prevention of accidents at work is one of the main tasks of ensuring safety at work [6].

In this context, it is particularly important to keep adequate statistics on occupational injuries, as this gives us a direct view of the occupational safety and health situation in the organisation, which in turn provides us with an indication for setting appropriate strategic objectives and necessary actions.

Two graphs had been described by covering workplace injuries from 2008 to 2022. The first graph categorizes injuries by work environment, while the second focuses on the mechanism of injury. In both graphs, the ordinate represents time in years, covering the period from 2008 to 2022 [10].

A second-degree polynomial trend and its associated R^2 value are used in data analysis to model and evaluate non-linear relationships in data [1]. Second-Degree Polynomial Trend:

Calculation Procedure:

a) Data Preparation: Organize your data into (x,y) pairs.

b) Least Squares Method: Use the method of least squares to find the best-fitting curve. This involves minimizing the sum of the squared residuals (the differences between observed y-values and the values predicted by the model).

c) Solve the Normal Equations: This typically involves solving a system of equations to find the coefficients a, b, and c.

R^2 (Coefficient of Determination):

R^2 measures how well the polynomial fits the data. It ranges from 0 to 1, where 1 indicates a perfect fit. R^2 is calculated as:

$R^2 = 1 - (SSres / SStot)$

Where:

- SSres is the sum of squared residuals

- SStot is the total sum of squares

Interpretation:

- R^2 closer to 1 indicates a better fit. In the document, R^2 values > 0.9 were considered to effectively describe the trend. In the context of the workplace injury data:

- The equation $y = 159.25x^2 - 3031.3x + 27575$ describes the overall trend of injuries over time.

- The R^2 value of 0.906 suggests that this polynomial explains about 90.6% of the variability in the data, indicating a good fit.

This method allows for modeling non-linear trends in the data, which can be particularly useful when analyzing complex phenomena like workplace injuries over time, where various factors might contribute to non-linear patterns. The first graph presents workplace injuries categorized by the type of work environment, while the second graph focuses on injuries by the mechanism of injury.

1. Work Environment Trends (Graph 1):

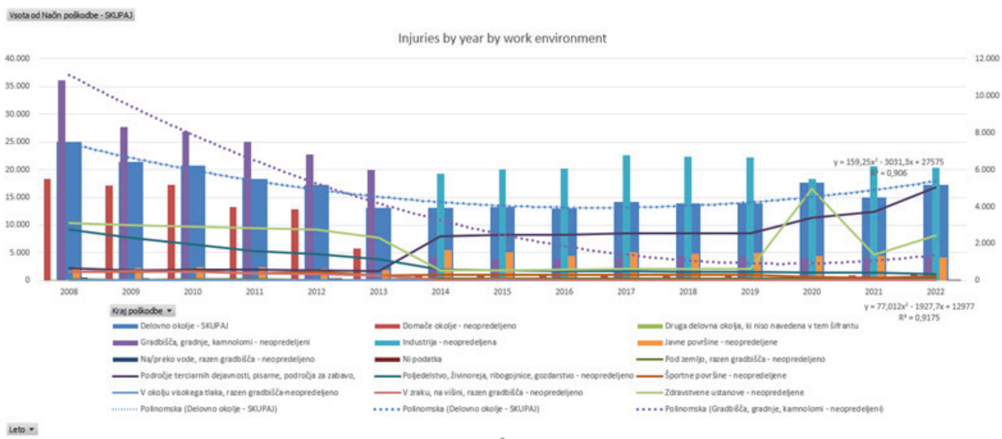
The primary axis shows all injuries over time, categorized by work environment (blue line). A second-degree polynomial equation was fitted to this data:

$y = 159.25x^2 - 3031.3x + 27575$, with an R^2 value of 0.906.

The high R^2 value (>0.9) indicates that the polynomial effectively describes the overall injury trend.

Injuries related to construction sites, building, and quarries show a decreasing trend, described by:

$y = 77.012x^2 - 1927.7x + 12977$, with an R^2 value of 0.9175.



Graph 1: Work Environment Trends

2. Other Work Environments (Secondary Axis):

The secondary axis shows injuries in other work environments (green line).

From 2014 to 2022, injuries in industry ranged between 6,000 and 7,000 per year.

3. Unspecified Health Institution Accidents (Light Green Line):

Accidents in unspecified health institutions declined from 3,129 cases in 2008 to 571 cases in 2014. In 2020, likely due to the COVID-19 pandemic, there was a significant increase to 4,977 cases, which decreased to 1,405 cases in 2021.

4. Domestic Environment and Public Areas:

Injuries in the domestic environment (dark red line) decreased significantly.

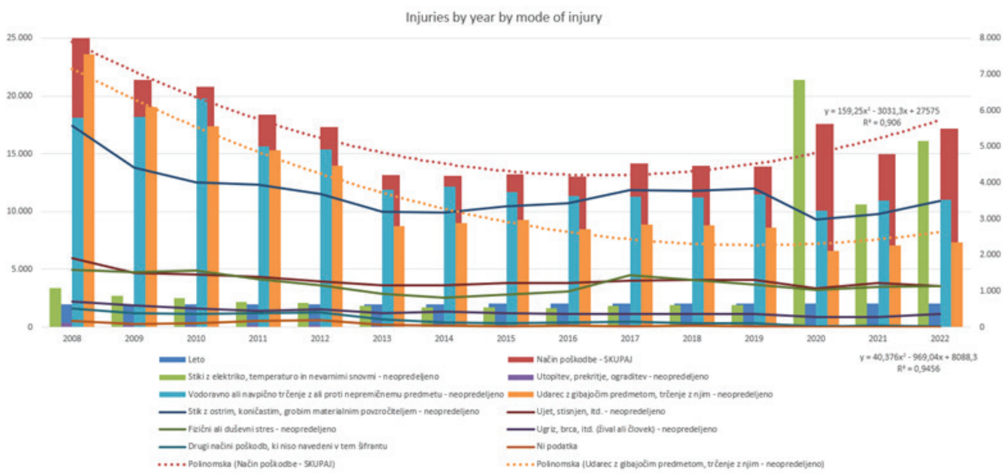
Injuries in public areas (orange line) increased from 2014 onwards.

5. Mechanism of Injury Trends (Graph 2):

The second graph focuses on injuries by mechanism over the same period.

The polynomial equation describing the overall trend is the same as in the first graph:

$y = 159.25x^2 - 3031.3x + 27575$, with an R^2 value of 0.906.



Graph 2: Mechanism of Injury Trends

The lowest injury values occurred between 2013 and 2016, possibly influenced by economic recessions. Injuries due to impact with moving objects decreased significantly. Injuries related to electrical contact, temperature, and hazardous substances increased in 2022, possibly due to the pandemic. In summary, these trends provide valuable insights into workplace injuries over time, emphasizing the importance of safety measures and targeted interventions.

3. CONCLUSION

A modern occupational safety and health system, based on the promotion of a culture of safety and health at work and oriented towards the prevention of occupational accidents, occupational diseases and work-related illnesses, is the cornerstone of any efficient economy. A well-organised and well-established occupational safety and health system at all levels, complemented by programmes to promote physical and mental health at work, contributes to the well-being of workers at work. Safer and healthier workplaces contribute to the economic efficiency of the economy and the sustainability of social coffers.

Although the level of occupational safety and health in Slovenia has been improving in recent years, the number of accidents at work is still high. They are a burden on the workers who are injured, their relatives, the organisations where the injury occurred, the health and pension funds, the economy and society as a whole. The damage caused by work-related injuries is in addition to the damage suffered by all of the above as a result of work-related illnesses.

Health and safety and well-being at work are a top priority in the workplace and a cornerstone of sustained business success. The effective provision of occupational safety and health free from occupational accidents, occupational diseases and work-related illnesses is a national and worker interest and an obligation for employers. Efforts to raise the level of prevention culture in the working environment must become a joint commitment of the Government of the Republic of Slovenia, the social partners, enterprises, companies and workers [6].

Given the state of occupational accidents and injuries in Slovenia, the level of safety culture in the field of occupational safety and health should be raised to a higher level. This represents a major new systemic challenge for the future, particularly in the system of a comprehensive education system at all levels of education. An appropriate level of education also means a higher safety culture and, as a consequence, fewer accidents and injuries at work, which is also the mission of the occupational safety and health profession.

REFERENCES

[1] AI tool: https://claude.ai/chat/5faa3a16-aa40-45ee-ad7c-04b93b297df3 *Accessed:* 15.6.2024

[2] Nezgode pri delu, nevarni pojavi, poklicne bolezni https://www.gov.si/teme/nezgode-pri-delu-nevarni-pojavi-poklicne-bolezni/ *Accessed:* 3.6.2024

[3] Pravilnik o prijavi nezgode in poškodbe pri delu Official Gazette of the Republic of Slovenia, No.. 78/22 with changers and amendment

[4] Prijava nezgode in poškodbe pri delu https://spot.gov.si/sl/poslovanje/zaposlovanje-in-delovno-razmerje/poskodbe-pri-delu/ *Accessed:* 11.6.2024

[5] Prijava poškodbe pri delu https://nijz.si/podatki/podatkovne-zbirke-in-raziskave/prijava-poskodbe-pri-delu/ *Accessed:* 11.6.2024

[6] Resolucija o nacionalnem programu varnosti in zdravja pri delu 2018-2027, Official Gazette of the Republic of Slovenia, No. 23/18

[7] Zakon o pokojninskem in invalidskem zavarovanju (ZPIZ-2) Official Gazette of the Republic of Slovenia, No. 48/22 with changers and amendment

[8] Zakon o varnosti in zdravju pri delu (ZVZD-1) Official Gazette of the Republic of Slovenia, No. 43/11

[9] Zdravstveni statistični letopis 2022 https://nijz.si/publikacije/zdravstveni-statisticni-letopis-2022/ *Accessed:* 1.6.2024

[10] 15: Število prijavljenih poškodb pri delu po načinu poškodbe in delovnem okolju, Slovenija, letno, https://podatki.nijz.si/pxweb/sl/NIJZ%20podatkovni%20portal/NIJZ%20podatkovni%20portal__1%20Zdravstveno%20stanje%20prebivalstva__08%20Po%C5%A1kodbe__1%20Po%C5%A1kodbe%20pri%20delu/PPD15.px/ *Accessed:* 25.5.2024

CAUSES OF ACCIDENTS AND PROTECTION MEASURES WHEN WORKING IN WAREHOUSES

Suzana Z. Zikovska[1], Cvetanka T. Mitrevska[1], Lidija Lj. Bureska[1], Slobodan Bundalevski[1]

[1]International Slavic University „St.Nicholas". Marsal Tito 77, Sveti Nikole, MACEDONIA, suzana.zikovska@msu.edu.mk

Abstract: *A large number of accidents occur when working in warehouses and various storage areas. Such accidents are regularly followed by injuries, sometimes also victims of warehouse employees and as well as the occurrence of material damages. The causes of injuries that happen in warehouses can be different. They are the following: forklift accident, hit by an object, pressed between objects, slips, trips and falls, injury from hazardous materials, an overexertion injuries, repetitive stress injuries and etc.*

Statistical data for the period 2012 to 2021 have been analyzed and presented, which indicate the possible dangers and seriousness when working in warehouses. There are also prescribed measures for protection when working in warehouses, rules are defined and advice are given, which should be respected by the employees in the warehouses.

Key words: *warehouses, accidents, causes of injuries, protection measures.*

INTRODUCTION

Warehouses, with their large space, equipment, many products and the large number of workers who work there, significantly increase the possibility of workplace injuries. The analysis of the statistical data on injuries in warehouses, tells about the severity and different types of accidents that happen in these logistics centers.

Since the start of the coronavirus pandemic, online shopping has increased significantly, and warehouse workers are loaded. As a consequence of the longer working hours in the warehouses, the workers are exhausted. So they have a higher probability to suffer from workplace injuries.

According to the Occupational Safety and Health Administration (OSHA), the fatal injury rate in the warehousing industry is higher than the national average for all industries. [1]

Safety in warehouses is of great importance, not only for the employees who perform their work, but also for the goods themselves. The introduction of appropriate security measures reduces the risks. Thus, the regulations require certain preventive obligations, both for employers and managers, as well as for workers in the warehouse.

1. TYPES OF ACCIDENTS WHEN WORKING IN WAREHOUSES

Injuries at work in warehouses can be different. According to statistical data on injuries at work in warehouses, they are divided into several categories. It is:[2]

1. Forklift Accidents

Every year, 100 people are killed and 95,000 people are injured in forklift accidents. The most common accidents involve overturned forklifts, which can crush and seriously injure or kill the employee.

When working with a forklift, the following faults and omissions can often cause serious and fatal injuries:[3] the operator does not know the basics of the operation and functioning of the forklift, the operator is not trained and does not know the technology of lifting a load, operates the forklift carelessly, uses a defective forklift or a forklift that is missing parts.

2. Hit by an object

In addition to forklifts, objects stacked high on pallets put workers at risk of being hit by an object. Pallet collapses and falling objects often result in concussions, back injuries, shoulder injuries, and worse.

3. Caught between objects

Warehouse work puts hands, fingers, feet, and even whole bodies at risk of being caught between pieces of equipment, between heavy objects, or even between a truck and the loading dock.

4. Slips. trips and falls

The four-foot drop between the loading dock and the ground below presents a serious hazard to worker safety. Other potential hazards that result in workers slipping, tripping, or falling may include spilled powders, oils, or water. Uneven walking surfaces, inadequate lighting, and exposed cords also put worker safety at risk.

5. Hazardous materials

When shipments containing hazardous materials become damaged and spill, it can result in chemical burns, fire, convulsions, and even long-term effects such as cancer or organ damage.

6. Overexertion injuries

Tasks involving lifting, pulling, carrying, and lowering heavy objects can result in overexertion injuries including back and neck injuries, muscle strain, and joint injuries.

7. Repetitive stress injuries

Similarly, a job that requires a significant amount of repetitive motion over a long period of time puts the employee at risk of repetitive stress injuries. These may include carpal tunnel, muscle strain, and joint injuries.

8. Incidents involving fire

A large number of injuries at work also occur as a result of fires in warehouses.

On average, there are around 22,000 workplace fires each year in the United Kingdom and 423 every week.[4]

To avoid such incidents in warehouses, the importance of fire safety should be known and fire safety regulations should be followed.

Also, warehouses should be provided with fire extinguishing equipment and to have training for employees on fire protection.`

2. STATISTICS ON WORK INJURIES IN WAREHOUSES AND DISCUSSION

2.1 Worldwide warehouse injury statistics, in general

Injuries at work in warehouses and injuries in general have a negative impact on the economy of a country. For this purpose, they will analyze the statistical data on injuries at work in warehouses in the world and in our country.

Highlights: Warehouse Injury Statistics[5]

- In 2012, the warehousing and storage industry reported 17,700 instances of nonfatal occupational injury and illness.
- In 2019, there were 5.3 injuries per 100 full-time workers in the warehousing and storage industry.
- Over 38,000 incidents occur in warehouses annually according to US Bureau of Labor Statistics (2017).
- Up to 80% of accidents involving forklifts result in injury to a pedestrian.
- According to OSHA, slips, trips, and falls cause the majority of general industry accidents, resulting in 15% of all accidental deaths.
- The lost workday rate for nonfatal occupational injuries and illnesses in warehouse workers in 2019 was 98.4.
- In 2020, overexertion injuries were the largest category of injury among warehouse workers at 32.9%.
- About 2% of fatal warehouse injuries are due to exposure to harmful substances or environments.
- Struck-by injuries are the second highest cause of warehouse fatalities accounting for 16% in the year 2020.
- Men made up 94% of fatal injury victims in the Transportation, Warehouse, and Utilities industry in 2019.

All the data above indicate the severity of the risks faced by warehouse employees on a daily basis That means the urgent need to improve the safety measures and regulations for the protection of these workers..

Rising product demand has prompted employers to expand their production and storage capacities. This growth has led to the construction of more warehouses or distribution centers and increased warehouse employment. According to the U.S. Bureau of Labor Statistics, the number of employees has doubled from 645,200 in 2010 to 1,304,900 in 2020. Projections indicate that this trend will continue, with nearly 2 million employees expected by 2030. With such growth, the responsibility of employers to ensure employee safety and comply with OSHA guidelines becomes even more critical and challenging, given the larger workforce to manage.[6]

2.2 Statistics on storage injuries in Europe[7]

This article presents a set of main statistical findings in relation to indicators concerning non-fatal and fatal accidents at work in the European Union (EU). The statistics presented have been collected as part of the European statistics on accidents at work (ESAW) administrative data collection exercise.

According to the European data, injuries during work in warehouses are selected as injuries during transport and storage.

The number of injuries during transport and storage was analyzed in relation to the total number of injuries at work (fatal and non-fatal). For a better comparison of the data, the percentage of this type of injuries is given in relation to the total number of injuries.

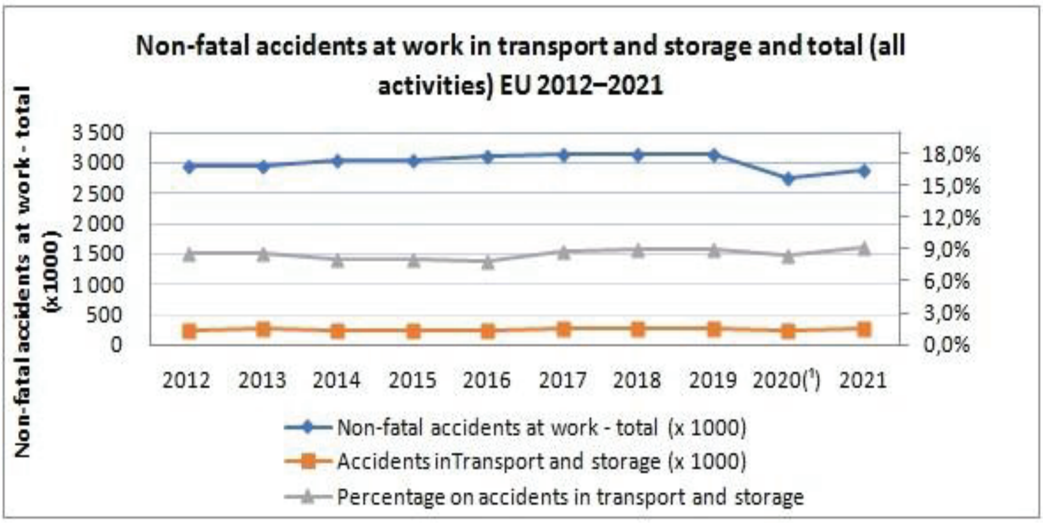


Figure 1: Non-fatal accidents at work in transport and storage and total (all activities) EU 2012–2021

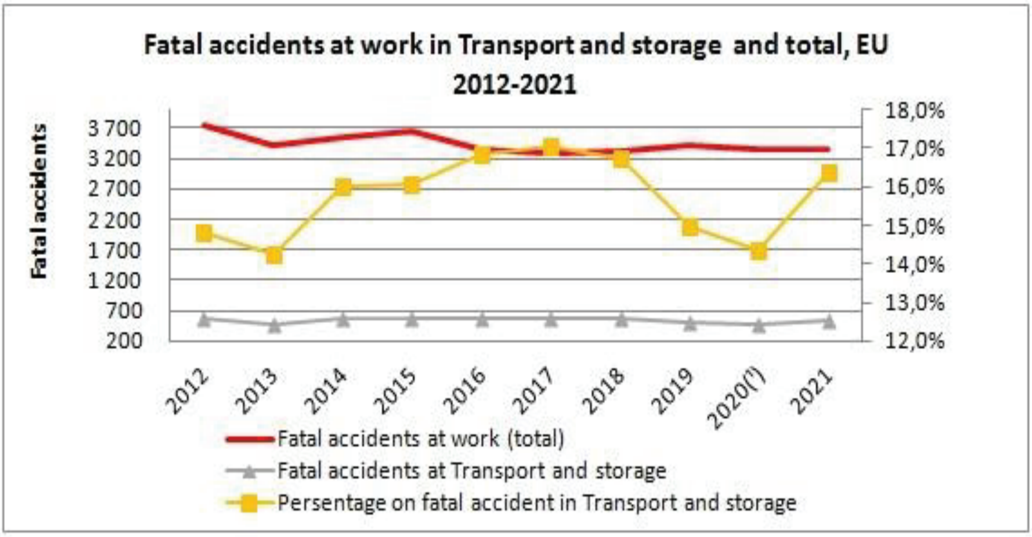


Figure 2: Fatal accidents at work in transport and storage and total (all activities), EU 2012–2021

2.3 Analysis of statistical data on injuries at work in warehouses in the Republic of North Macedonia

For a better comparison of injuries at work in warehouses in the Republic of Macedonia with the EU, the data will be analyzed in the same way as in the EU.

The analysis was made on the basis of data taken from the Annual Reports of the Macedonian Association for Safety at Work, for the period 2012-2021.[8]

Only data on injuries at work (fatal and non-fatal) in the area of transport and storage are analyzed in relation to the total number of injuries in the Republic of North Macedonia.

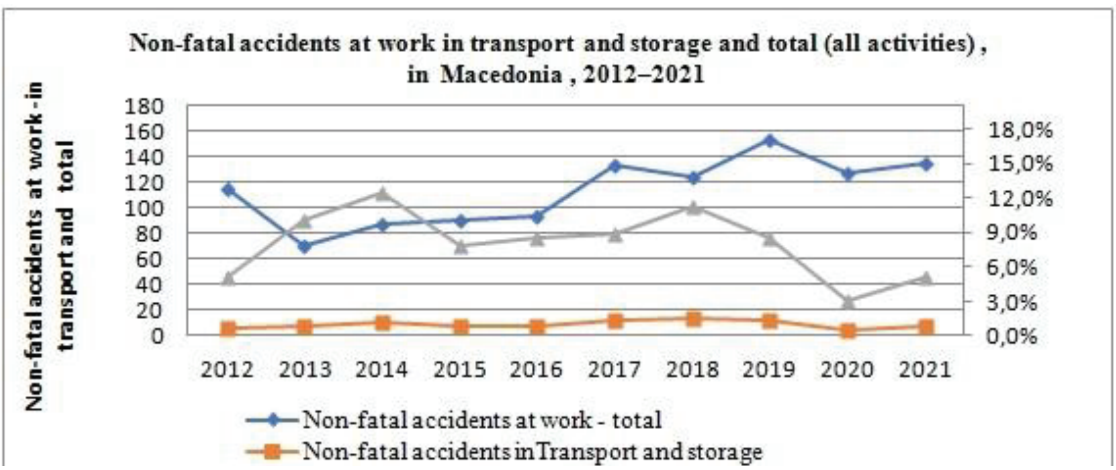


Figure 3: Non-fatal accidents at work in transport and storage and total (all activities) in the Republic of North Macedonia, 2012–2021

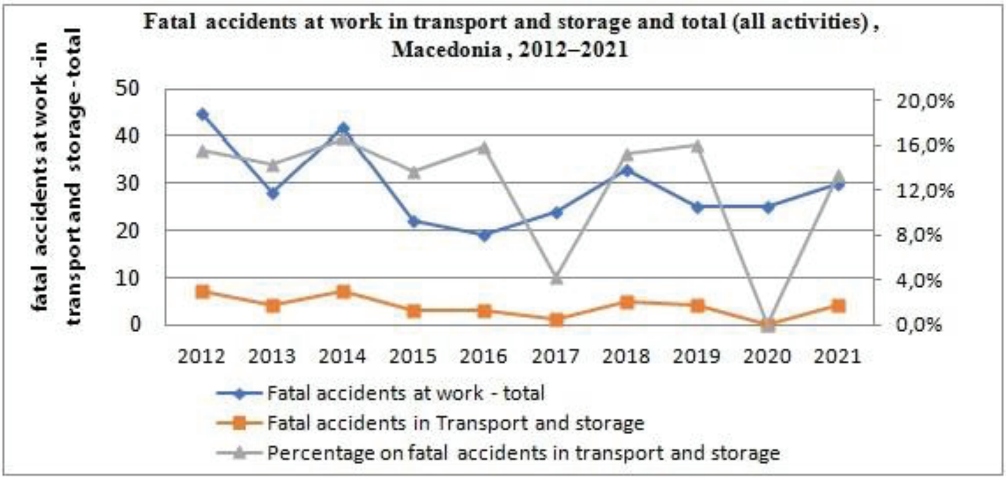


Figure 4: Fatal accidents at work in transport and storage and total (all activities) in the Republic of North Macedonia, 2012–2021

Analyzing the results for the Republic of North Macedonia and comparing the same results from the EU, it can be concluded:

- The percentage of non-fatal injuries in the field of transport and storage (for the period 2012- 2021) in the Republic of Macedonia is approximately the same as the analyzed data in the EU, mentioned above.
- The percentage of fatal injuries in the field of transport and storage (average) for the period 2012-2021 in the Republic of Macedonia is lower according to the data in the EU, mentioned above.

All previous analyses, in general, point to the fact that the number of injuries at work (fatal and non-fatal) is high, which has a negative impact on costs.

According to the International Labour Organization (ILO), the costs of workplace accidents and illnesses worldwide amount to almost 3 trillion dollars. This figure represents 3.94% of the global Gross Domestic Product (GDP)[9], reflecting the magnitude of the problem.

CONCLUSION

The analysis of statistical data on the number of injuries at work, especially in the area of storage, shows that they are high both in the world and in the Republic of North Macedonia. Which also brings to an increase in the costs of injuries.

Therefore, it is necessary to make a precise categorization of injuries in warehouses, in order to take appropriate specific protection measures. This will reduce the number of injuries and eventually eliminate them.

While there are no explicit OSHA warehousing regulations, warehouse operations fall under the general industry requirements which include the following OSHA standards [10]: Hazard Communication, Emergency Action Plan (EAP), Fire Safety, Exit Routes, Walking / Working Surfaces, Medical and First Aid.

REFERENCES

[1] The Law Office of Matew E.Russel: *7 most common warehouse injuries,* San Diego, CA https://workerscomplawsd.com/7-most-common-warehouse-injuries/

[2] ibid

[3] Зиковска, С.;Јолеска,.Б.,Л.; Бундалевски, С.; Митревска, Ц.: *Причини за несреќи при работа со вилушкари и мерки за заштита,*" Меѓународен дијалог: исток – запад", Свети Николе, Р.Северна Македонија, 2023.

[4] The top 8 most common werehouse injuries and accidents to defend against, Toyota, November 21, 2022. https://blog.toyota-forklifts.co.uk/most-common-warehouse-injuries-and-accidents-to-defend-against

[5] Lindner, J.: *Must-Know Warehouse Injury Statistics [Latest Report],* Gitnux:A Global Commerce Media LLC Company: December 20, 2023. https://gitnux.org/warehouse-injury-statistics/

[6] Fade, A.,: *5 Surpraising Werehouze Safety Statistics,* Damotech, September 27, 2023 https://www.damotech.com/blog/5-insightful-statistics-related-to-warehouse-safety

[7] Accidents at work - statistics by economic activity, Eurostat, October 2023

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Accidents_at_work_-_statistics_by_economic_activity&oldid=635656

[8] Macedonian Association for Safety at Work, Annual Reports (2012-2021)

[9] COSTS OF WORKPLACE ACCIDENTS AND ILLNESSES WORLDWIDE https://www.ludusglobal.com/en/blog/costs-of-workplace-accidents-and-illnesses-worldwide

[10] Tarlengco, J.:**Warehouse Safety,** April,2024 https://safetyculture.com/topics/warehouse-safety/

3

OCCUPATIONAL HEALTH

INJURY AT WORK AND OCCUPATIONAL DISEASE IN THE LEGISLATION OF THE FEDERATION OF BOSNIA AND HERZEGOVINA

Jasmina Beslagic, PhD,[1] Atif Hodzic, PhD[2], Esad Bajramovic, PhD[3],

[1] Law faculty of University of Bihac, Dzanica mahala 77 000 Bihac, B&H, e-mail: jasmina.beslagic@unbi.ba
[2] Tehnical faculty of University of Bihac, Dr. Irfana Ljubijankica bb, 77 000 Bihac, B&H, e-mail: atif.hodzicc@gmail.com
[3] Tehnical faculty of University of Bihac, Dr. Irfana Ljubijankica bb, 77 000 Bihac, B&H, e-mail: bajramovic_e@yahoo.com

Summary: *Considering the importance of the safety of workers and the workplace for the life and health of employees within the employment relationship, as well as the specificity of work injuries and occupational diseases as social risks, and their fragmented and selective treatment in the legislation of Bosnia and Herzegovina, including specific divisions of jurisdiction about this area when it comes to different levels of government in Bosnia and Herzegovina, this paper problematizes the mentioned social risks in the context of their specific normative regulation in Bosnia and Herzegovina with a special emphasis on the legislation of the Federation of Bosnia and Herzegovina.*

Bearing in mind the above, this paper analyzes the provisions of the Labor Law of the Federation of Bosnia and Herzegovina, the Law on Occupational Safety of the Federation of Bosnia and Herzegovina, the Law on Pension and Disability Insurance of the Federation of Bosnia and Herzegovina, the Law on Health Insurance of the Federation of Bosnia and Herzegovina and the Law on Health protection of the Federation of Bosnia and Herzegovina, as well as implementing regulations in the context of the legislative approach to the normative regulation of work injuries and occupational diseases as social risks.

Keywords: *social risk, injury at work, occupational disease, protection at work, legislation of the Federation of Bosnia and Herzegovina*

1. INTRODUCTION

Injury at work and occupational disease can be the cause of disability and death at work or in connection with work, and disability and death represent the most drastic forms of insured risks. The labor protection legislation in the Federation of Bosnia and Herzegovina defines that the employer is obliged to assess the risks to the life and health of workers and other persons at work, especially in relation to the means of work, the working environment, technology, physical risks, chemicals and biological agents used, the place of work, organization of work processes, workload and other risks, in order to prevent or reduce those risks. During this assessment, the employer is obliged, in accordance with the risk assessment, to apply all occupational safety rules and to take all preventive measures in order to eliminate or minimize the possibility of occupational injury, occupational disease or work-related illness measure.

The principle of prevention in social law applies to the employee's right to working conditions that ensure his physical and moral integrity and safety, as well as the right to health care, as well as other types of protection and personal safety at work.[1] Prevention of injuries at work or occupational diseases should be imperative for every employer, as well as every person involved in the work process. In doing so, it is necessary to be well aware of the regulations in the subject area, and to educate employers and employees about them, as well as to keep in mind that the routine work that a certain employee performs should be done in accordance with the rules of occupational safety, all with the aim of the safety of the employee himself and ultimately the employer.

2. SAFETY AND PROTECTION AT WORK

In the Federation of Bosnia and Herzegovina, the Law on Occupational Safety of the Federation of Bosnia and Herzegovina[2] was adopted in 2020, with the aim of preventing injuries at work, occupational diseases, as well as other diseases related to work, and protection of the working environment.[3] In addition, the Labor Law of the Federation of Bosnia and Herzegovina[4] stipulates that the employer is obliged to enable the employee to familiarize himself with the regulations on labor relations and regulations in the field of occupational safety. When talking about occupational safety and health, it is necessary to mention that it is a multidisciplinary area in which there are a large number of regulations that relate to different specific activities and work processes. Therefore, it can be said that it is a set of legal, technical, health, psychological and other activities that are used to detect and eliminate dangers and damages that can endanger the life and health of persons at work.[5] This set of legal rules establishes measures, procedures and rules that serve to eliminate or reduce certain dangers and harm to the life and health of employees and other persons participating in the work process. Therefore, we consider occupational safety as a system of rules, principles, measures, procedures and activities, the organized application of which achieves and improves safety and health protection at work, as well as the possibility of compensation for certain damages in connection with the occurrence thereof.

In the active work process, an individual can be exposed to many harmful influences to a greater or lesser extent, so the protection of the human environment plays an important role as well as the protection of the person in the working environment. Thus, a very wide range of mechanisms for protecting the human environment is also part of the human protection system in the working environment.[6]

2.1. OBLIGATIONS OF THE EMPLOYER IN ACHIEVING PROTECTION AT WORK

---

[1] Dedic, S.; Gradascević-Sijeric, J; *Social Law*, Third Revised and Expanded Edition, Faculty of Law, University of Sarajevo, ISBN 9958-627-24-2, Sarajevo, 2005., p. 83.

[2] Law on Occupational Safety of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 79/20.

[3] Until the adoption of the aforementioned regulation, occupational health and safety was regulated by the so-called by a republican regulation that was taken over from the earlier system of organization of state power before Bosnia and Herzegovina became an independent state.

[4] Labor Law of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 26/16, 89/18, 23/20 - US decision, 49/21 - dr. law, 103/21 - Ph.D. law and 44/22.

[5] The concept of persons at work primarily refers to workers, but also to other persons such as volunteers, pupils and students who carry out certain training related to the profession, and persons who perform the activity through personal work and other persons. (Article 5, paragraph 1 of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina).

[6] Article 21 paragraph 1 point k and Article 22 paragraph 1 point g of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina.

First of all, the employer is obliged to prepare a risk assessment on the basis of which he applies the rules by means of which risks and harms are eliminated or reduced, and for this purpose he provides all the necessary material and other resources. Business conditions in market economies also require new approaches to occupational safety, especially since the employer is in any case responsible for the implementation of occupational safety and all costs of occupational injuries and occupational diseases fall on him. In order for the employer to be insured in the event of certain dangers to the life and health of the employees, as well as the possible harmfulness of the activities he performs, it is necessary to prepare the above mentioned risk assessment. Risk assessment is the main starting point for the implementation of occupational safety. The assessment of danger and the determined level of risk should show how many deviations there are between the actual state of occupational safety at the employer and the prescribed state for a certain activity of the employer.

On the other hand, the employer must not allow employees who have not previously been trained to perform work without endangering their own life and health, as well as the life and health of other employees, to perform tasks independently, unless the risk assessment shows that there are no risks to their safety and health. Until they are trained to work in a safe manner, the employer must ensure that the employees work under the supervision of employees trained to work in a safe manner. Training employees to work in a safe manner is one of the institutes of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina. The process of training employees to work in a safe way means familiarizing employees in a theoretical and practical sense with all the dangers present in the workplace and with all the protective measures that should be taken in terms of preventing injuries at work and occupational diseases.

3. INJURY AT WORK AND OCCUPATIONAL DISEASE

Issues related to injuries at work and occupational diseases are subject to the regulation of the aforementioned Labor Law of the Federation of Bosnia and Herzegovina and the Law on Occupational Safety of the Federation of Bosnia and Herzegovina, as well as the Law on Pension and Disability Insurance of the Federation of Bosnia and Herzegovina[7], the Law on Health Insurance of the Federation of Bosnia and Herzegovina[8] and the Law on Health Care of the Federation of Bosnia and Herzegovina[9], as well as implementing regulations.

3.1. INJURY AT WORK

Injuries at work are injuries that are caused by immediate and short-term mechanical, physical or chemical action, as well as injuries that are caused by sudden changes in body position, excessive body load and other changes in the physiological state of the human body, if the same injury is related to the performance of work based on which is the injured person, the insured employee.[10] An illness that would occur directly and exclusively as a result of an accident or any force majeure during work, during the performance of the

[7] Law on pension and disability insurance of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No.13/18, 93/19 - US decision, 90/21, 19/22 and 42/23 - US decision.
[8] Law on Health Insurance of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 30/97, 7/02, 70/08, 48/11, 36/18 and 61/22.
[9] Law on Health Care of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 6/10 and 75/13.
[10] Article 49 paragraph 1 of the Law on Pension and Disability Insurance of the Federation of Bosnia and Herzegovina.

activity on the basis of which the person is insured, will also be considered an injury at work. Therefore, it is important that there is an injury, and that it is causally connected with the activity, that is, the duties of the workplace on the basis of which a certain person has the capacity of insured. An injury at work can even be considered an injury that occurs in the manner already described, but the insured person suffers it on the way to or from the place of work, on the way to perform tasks and on the way to start work. An injury that occurred in the manner already provided for, and which the insured person suffers in connection with the exercise of the right to health care, as well as an injury that a person suffers in connection with the determination of health capacity when it is required by law in order to establish an employment relationship, are also considered injuries to work and in connection with work. Also, injuries that occurred during participation in organized sports competitions organized by the employer can be characterized as work-related injuries. An injury to a farmer according to the same definition as stated above is also considered an occupational injury, if the injury is causally related to the performance of work in the agricultural activity. Injury at work is also considered to be an injury to the insured that he suffered while performing his duties during the time that counts towards his pensionable service in double duration.[11]

The legislator also specifically enumerates the circumstances that cannot be said to be an injury at work, so injuries at work are not considered injuries if they are caused intentionally or due to gross negligence of the insured who was performing work duties, as well as on the regular way from apartment to the place of work and vice versa, due to drunkenness of the insured person, the sole responsibility of a third party, due to force majeure, due to the performance of activities that are not related to the performance of work activities, due to the intentional infliction of injury on the insured person by another person caused by a personal relationship with the insured person, which is not can result in labor law activities, as well as due to deliberate non-use of occupational safety equipment and non-compliance with occupational safety regulations.[12]

In the case of a dispute about whether an injury occurred at work or not, the burden of proof is on the employer. The legislator does not talk about what is considered a minor and what is a serious injury at work. That evaluation is the responsibility of the authorized health institution. In this regard, after a doctor's examination and treatment, the employees's full working capacity is determined, or a reduced working capacity or complete inability to work is determined, that is, a danger to the worker's health is determined by continuing to work at a certain workplace.

3.2. OCCUPATIONAL DISEASE

An occupational disease is considered to be a disease that is proven to be a consequence of harmful effects in the work process or working conditions, and the intensity of the harmfulness and duration of exposure to such circumstances is at a level that is known to cause certain damage to health. Occupational diseases are diseases that are caused by a longer, direct harmful influence of processes and working conditions, and they are characterized by a special connection with the occupation. It is most often caused by one factor that can be proven to have an impact on the occupational disease. The severity of the disease corresponds to the level and duration of exposure, and occupational

[11] Dedic, S.; Gradascević-Sijeric, J; *Social Law*, Third Revised and Expanded Edition, Faculty of Law, University of Sarajevo, ISBN 9958-627-24-2, Sarajevo, 2005., p. 166.
[12] Article 49 paragraph 2 of the Law on Pension and Disability Insurance of the Federation of Bosnia and Herzegovina.

diseases generally appear after long-term exposure to that factor. When we talk about occupational diseases, it is important to know the difference between work-related diseases and work-exacerbated diseases, since the latter do not have special rights in the health and pension insurance system. So, as far as work-related diseases are concerned, they are caused by several causative factors, with the workplace being only one of the possible factors. Taking into account that working conditions are not the only and main factor of health damage, such diseases are not considered occupational, but work-related diseases. Work-aggravated diseases are those that are not directly related to the workplace, but can be significantly aggravated by them.[13]

In 2003, the European Commission adopted a new Recommendation on the European List of Occupational Diseases.[14] The new Recommendation is composed of two lists, one listing occupational diseases and the other with other diseases suspected to be of an occupational nature. Occupational diseases and workplaces where these diseases occur, as well as the conditions under which they are considered occupational diseases, are determined by a special act, according to the previously obtained opinion of the appropriate professional and scientific organizations, with the consent of the Federal Ministry of Labor and Social Policy. Jobs where occupational diseases occur are considered jobs where workers are exposed to chemical, physical and biological occupational hazards and stresses specified in the Rulebook on the List of Occupational Diseases.[15] The list of occupational diseases, as well as workplaces and jobs where such diseases appear, and the conditions under which they are considered occupational, are prescribed by the aforementioned Rulebook, and the Institute for Medical Expertise of the Health Condition of the Federation of Bosnia and Herzegovina performs medical expert work at the request of natural and legal persons. , court or other institutions and authorities, and makes an assessment, finding and opinion on the basis of which the competent authority decides on the exercise of rights in accordance with the legal regulations under its jurisdiction. The Institute also carries out medical expertise on working capacity, incapacity for work and earning, incapacity for independent living and work, and the degree of physical impairment. The verified list of occupational diseases in the Federation of Bosnia and Herzegovina includes diseases caused by certain chemical compounds, diseases caused by physical factors, diseases caused by biological factors, diseases of respiratory organs, skin diseases and malignant diseases.

4. RIGHTS AND OBLIGATIONS OF THE INSURED DUE TO INJURY AT WORK OR OCCUPATIONAL DISEASE

According to the Labor Law of the Federation of Bosnia and Herzegovina, it is stipulated that the employer may not cancel the employment contract concluded for an indefinite or fixed period of time for a worker who has suffered an injury at work or has been diagnosed with an occupational disease, during the temporary inability to work for treatment or recovery, unless the worker himself has committed a serious crime or a serious violation of the obligations established by the employment contract.[16] In the case of work-related injuries or occupational diseases, workers must be provided with health care and the implementation of measures to detect and prevent work-related injuries and

[13] Dedic, S.; Gradascević-Sijeric, J; *Social Law*, Third Revised and Expanded Edition, Faculty of Law, University of Sarajevo, ISBN 9958-627-24-2, Sarajevo, 2005., p. 167.
[14] The full text of the Recommendation on the European List of Occupational Diseases is available at: https://www.hzzzsr.hr/wp-content/uploads/2016/11/Europska-lista-prof-bol-.pdf (13.03.2024.)
[15] Rulebook on the list of occupational diseases, "Official Journal of F B&H" No. 45/19.
[16] Article 71 paragraph 1 of the Labor Law of the Federation of Bosnia and Herzegovina.

occupational diseases, appropriate medical assistance and the right to orthopedic aids for treatment and medical rehabilitation as a result of work-related injuries and diseases from occupational diseases for the purpose of establishing work capacity, reimbursement of travel expenses in connection with the use of health care and rehabilitation caused by an injury at work, i.e. illness from an occupational disease, salary compensation for the entire duration of sick leave caused by an injury at work, i.e. illness from an occupational disease.[17] Furthermore, it is prescribed that the insured person has the right to compensation for the period of absence from work for the reasons stipulated by the law, cantonal regulation, employment contract or work regulations. During temporary incapacity for work, when it is a work-related injury or occupational disease, salary compensation is calculated and paid to the insured based on the funds of the legal entity for the first 42 days of sick leave, after which salary compensation is made through the cantonal health insurance institute.[18] The amount of salary compensation and the maximum amount of salary compensation paid at the expense of the cantonal insurance institute is determined by the administrative council of the cantonal insurance institute. During the temporary inability to work due to an injury at work or illness from an occupational disease, the salary compensation amounts to 100% of the compensation base. The worker has the right to health protection equal to the risks to which he is exposed at work, in accordance with the regulations governing health protection measures related to work.

The Law on Health Care of the Federation of Bosnia and Herzegovina prescribes specific health care measures that the employer must ensure in order to create conditions for the health protection of workers at the workplace. Previous and periodic medical examinations of workers who perform tasks with increased risk are carried out in the manner, according to the procedure and within the deadlines determined by a special rulebook. The employer also organizes and provides health care for workers from its own funds, and it includes medical examinations to determine the ability to work at the employer's order, preventive examinations of workers, implementation of measures to protect the health of workers exposed to health risks during the work process, and the like. The specific health protection of workers is achieved on the basis of a contract between the employer and a health institution that has occupational medicine as part of its composition, or a contract with an occupational medicine specialist in private practice.[19]

5. CONCLUSION

Taking into account that the prevention of injuries at work and occupational diseases is one of the basic tasks of employers and workers, it is very important to know the mechanisms of protection at work and to apply them, and in this connection to educate the workers themselves as best as possible about ways to protect their lives and health in to the work process. Also, it is necessary to develop an awareness that even routine jobs can cause serious injuries at work or occupational diseases. A prerequisite for the complete health of workers is to ensure a healthy working environment. In occupational safety, in addition to education, it is also necessary to invest material resources, including the purchase of protective equipment, health care, and training of workers. In doing so, it is

[17] Article 36 of the Law on Health Insurance of the Federation of Bosnia and Herzegovina.
[18] Article 56 of the Law on Health Insurance of the Federation of Bosnia and Herzegovina.
[19] Article 54 of the Law on Occupational Safety of the Federation of Bosnia and Herzegovina.

important to take care of maintaining a healthy human environment, an integral part of which is a (healthy) living environment.

6. REFERENCES

[1] Dedic, S.; Gradascević-Sijeric, J; *Social Law*, Third Revised and Expanded Edition, Faculty of Law, University of Sarajevo, ISBN 9958-627-24-2, Sarajevo, 2005.

[2] https://www.hzzzsr.hr/wp-content/uploads/2016/11/Europska-lista-prof-bol-.pdf

[3] Rulebook on the list of occupational diseases, "Official Journal of F B&H" No. 45/19.

[4] Recommendation on the European List of Occupational Diseases.

[5] Law on pension and disability insurance of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No.13/18, 93/19 - US decision, 90/21, 19/22 and 42/23 - US decision.

[6] Labor Law of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 26/16, 89/18, 23/20 - US decision, 49/21 - dr. law, 103/21 - Ph.D. law and 44/22.

[7] Law on Occupational Safety of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 79/20.

[8] Law on Health Care of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 6/10 and 75/13.

[9] Law on Health Insurance of the Federation of Bosnia and Herzegovina, "Official Journal of F B&H" No. 30/97, 7/02, 70/08, 48/11, 36/18 and 61/22.

ZERO WASTE PRACTICES IN FINE DINING RESTAURANTS

Marijana Blažić[1], Karmen Matković Melki[2], Monika Ćubela[2], Elizabeta Zandona[1], Ines Cindrić[1], Martina Stvorić[2]

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, mblazic@vuka.hr

[2] Aspira University of Applied Sciences, Ulica Domovinskog rata 65, Split, CROATIA, karmen.matkovic@aspira.hr

[2]Aspira University of Applied Sciences, Ulica Domovinskog rata 65, Split, CROATIA, monikacubela774@gmail.com

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, ezandona@vuka.hr

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, icindric@vuka.hr

[2]Aspira University of Applied Sciences, Ulica Domovinskog rata 65, Split, CROATIA, martina.stvoric@aspira.hr

Abstract: *Approximately one-third of the food produced worldwide is thrown away, implying that many of the negative effects on the environment are caused by food waste. Now more than ever, climate change and sustainability are the biggest issues and challenges in the entire world politics, economy, and therefore also in gastronomy. Reducing food waste in restaurants is a very important contribution to sustainability and overcoming climate change. Zero waste is the answer to economic, humanitarian and environmental issues. For this purpose, many fine dining restaurants are developing a sustainable menu and zero waste concept. This final thesis describes how food waste is generated in fine dining and commercial restaurants, and how livestock, fishing and agriculture for the purpose of human consumption negatively affects climate change.*

Keywords: *zero waste, fine dining, Hiša Franko, climate change, sustainable restaurant*

1. INTRODUCTION

Food waste results in resource loss as well as a numerous negative environmental effects. According to the UN, a third of the food produced worldwide is lost or wasted, meaning that 1.3 billion tonnes of food waste are produced annually worldwide. [1]. Food waste is not only associated with economic and environmental issues, but it also poses a serious humanitarian threat because the amount of food wasted worldwide provides enough calories to feed every person suffering from malnutrition. [2]. Food loss and food wastage are not the same as food waste. Food losses can include things like milk loss from mastitis in dairy animals and livestock loss prior to slaughter (dead animals during rearing or transportation) [3]. Food wastage transpires at a different level, the one involving foodservice providers, retailers, end users, i.e., households. Food products that were once edible and intended for human consumption are referred to as food losses and food waste. [4].

The Zero Waste International Alliance (ZWIA) was founded in 2002, and in 2004 it adopted the first definition of zero waste. "Zero waste: conserving all resources through responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and without discharges to land, water, or air that threaten the environment or human health" [5]. Within the foodservice and hospitality sector, restaurants are the largest waste producers, so it is extremely important to comprehend and implement the zero waste concept. According to WRAP (Waste and Resources Action Programme), there are three main sources of food waste in restaurants: food preparation (constituting 45% of total waste generated), food spoilage (constituting 21% of total waste generated), and guests' returned food (constituting 34% of total waste generated) [6]. However, studies indicate that the amount of waste generated in restaurants depends on numerous factors. The amount of waste generated is influenced by various factors, including the business model, the manager's awareness and commitment to the zero waste concept, sociodemographics, the establishment's size and specialisation, and others. For example, an à la carte restaurant (where food is prepared to order) produces less waste than a hotel with a buffet. Women and returning visitors, for example, generate more waste than do men and first-time visitors [7] [8].

2. FOOD WASTE AND ZERO WASTE IN FINE DINING KITCHENS

The dynamics of operation in fine dining kitchens differ greatly from those in commercial kitchens. Stricter rules for food preparation, serving, and storage are enforced in fine dining kitchens. Because quality is valued above quantity in these types of kitchens, ingredients that are not satisfactory from the beginning are thrown away. A significant amount of waste is generated from the packaging in which ingredients are delivered, and further waste occurs during the storage process, where food is discarded due to spoilage. Restaurants often fail to adhere to essential, basic rules; for example, a large number of restaurants do not follow the FIFO system (first in, first out), which significantly reduces food spoilage and waste. The largest amounts of waste occur during the preparation process, which includes: cutting and peeling, preparation of side dishes (mayonnaise, emulsions, gels, stocks, purees, sauces), meat cleaning and fish filleting, meat and fish portioning, preparation of microgreens for plating, and similar tasks. The majority of food waste comes from fruits and vegetables [9], then meat, fish, and dairy products.

Staff in restaurants, especially chefs in the kitchen or managers of the food and beverage departments, are an important source of information about how to reduce waste in the restaurant. It is crucial that they understand how much waste they produce, so it would be ideal to have self-assessment scales that classify waste as large, medium, or small. Many restaurateurs categorize themselves as small or medium waste producers because they fear presenting their business in a negative light. Here, the chef's or manager's experience is crucial because it provides a sense of ingredients and quantities, which can have a big impact on the amount of waste [10].

2.1. Hiša Franko is an example of a fine- dining restaurant which practices zero waste

The fine dining establishment called Hiša Franko, situated in Slovenia, is the focus of the study. The restaurant was founded in 1860, and Ana Roš took over the kitchen in 2000. Despite having no formal culinary training, Ana Roš chooses a different approach to gastronomy after studying under renowned chefs. As a self-taught individual with a distinct style, this exceptional person chooses a different approach in the culinary arts. Different for that period, she makes the decision to use zero waste techniques and to develop a menu using products that can be found locally. They employed a zero waste concept called "kilometre zero waste," which means that all of the ingredients used in the restaurant can be found nearby [11].

The aesthetics of ingredients is crucial in fine dining restaurants. Ingredients that do not look appealing enough to be used in fine dining restaurants are thrown away. In an effort to decrease waste and improve sustainability, the Michelin Guide started creating a list of the "greenest" restaurants. The Green Star by Michelin is awarded based on the following criteria: eco-responsibility, creativity, commitment to sustainable cooking, origin and seasonality of ingredients, responsible waste management, contribution to the local economy, balance in the menu, energy self-sufficiency, and commitment to sustainable cooking [12]. Hiša Franko is a fine dining restaurant that has been awarded 2 Michelin stars and one green Michelin star for zero waste.

The main features of the fine dining establishment Hiša Franko, which implements zero waste concepts, are resource preservation and appropriate disposal of waste. They have an on-site garden and trout pond, and they place a high value on supporting local farmers. Despite being a rare fish on restaurant menus, Hiša Franko has managed to introduce and popularise trout to guests. The fish is aged for two days in a dry ager following catching and cleaning. Local farmers who raise livestock twenty minutes away from the restaurant provide the meat on the menu, and they use the entire animal.

On their menus, you will not find typical cuts of meat; instead, they use parts like deer heart and rabbit meat, which are characteristic of Slovenia and Kobarid. They are a unique fine dining restaurant because, unlike other restaurants of their class, they do not import meat from places like New Zealand, they do not buy Wagyu beef, and they do not exclusively work with fish like sole; in other words, they do not aim to work solely with "elite" ingredients. They also have their own forager, who brings them "forest jewels" like asparagus, mushrooms, and wild herbs from the forests near the restaurant on a weekly basis. They make broth and jus from vegetable scraps and bones and occasionally dehydrate them to make powder. They offer a wide variety of garums, syrups, and fermented goods, including lacto-fermented cherry tomatoes and sweet syrup made with violet and magnolia flowers. According to the latest San Pellegrino World's 50 Best Restaurants list from 2023, Hiša Franko ranks 32nd [13].

2.2. Zero waste methods in Hiša Franko

The sustainability of a restaurant depends not only on reducing food and plastic waste, but also on the seasonality of ingredients, supply chain, and menu. Hiša Franko has a well-organized restaurant and an exceptionally developed network of suppliers. The zero waste methods at Hiša Franko include menu design, minimal food waste, food recycling, composting, fermentation and preservation, local supplier chain, and resource saving.

Because the menu acts as a communicator which presents the restaurant and its offerings, menu design is crucial. To minimise food waste and guest dissatisfaction, the menu needs to include accurate descriptions of the dishes. It is more than just a material indicator, despite popular belief. Chefs at Hiša Franko present each dish to guests, explaining recipes and ingredients and requesting feedback in order to improve quality and reduce waste. Feedback from guests helps cut down on food waste and highlights areas for improvement. Hiša Franko's menu is composed of local ingredients such as trout from the Soča Valley, Tolmin and Krištof cheese from the local Orešnik farm, local apricots and pears, beeswax, fermented tomatoes, and wild herbs from local forests. The menu consists of 16 courses meticulously calculated to minimize waste.

The best way to implement the zero waste concept is by minimizing food waste, meaning maximizing ingredient usage. Efficient storage and organization, using the FIFO (First In, First Out) system, are crucial. To guarantee proper ordering, regular inventory is required. Organization is key at Hiša Franko, with each box in the restaurant's fridge labeled: the name of the ingredient in the upper left corner, date in the lower left corner, and initials of the person who stored the ingredient in the lower right corner. This way, when the fridge is opened, it's immediately clear where each ingredient is, who stored it, saving time, and ensuring older ingredients are used first. Hiša Franko only takes reservations, so that it can be properly organised, ready for the precise number of guests, and avoid having too much inventory that goes to waste.

Food recycling is an excellent method for reducing waste by utilizing every part of the ingredient. The goal is to use the food as much as possible [14]. Fruit and vegetable leftovers and other ingredients that are not typically used for human consumption are included in recycled food. Around $400 billion is lost annually as a result of food waste, according to the UN [15]. Food that has been recycled recovers this value and is used to build a robust and sustainable food system, mostly for human consumption but also for animal feed. Ideally, 100% of the ingredient should be used. Thinking ahead about what to do with leftover ingredients can successfully avoid waste. For instance, suggestions for maximizing meat usage are stock and jus (French sauce) or staff meal (a meal for staff), which is one of the simple methods of food waste recycling. Hiša Franko provides its employees two meals a day that are made from surplus food, with leftovers typically going to compost.

A rich source of fertiliser for the soil, composting is a natural process of recycling organic matter [16]. At Hiša Franko restaurant, organic waste is converted into compost, which improves the garden above the restaurant and provides it with vegetables and microgreens. At Hiša Franko, all waste is recycled, enabling a natural cycle.

Fermentation and preservation are also excellent methods for waste reduction. Hiša Franko has two spaces for fermentation: a dark room and a fermentation room. Numerous projects and experiments with various ingredients take place there, such as preserved magnolia flowers, lacto-fermented tomatoes, various kombuchas, fermentation of grains, fruits, and vegetables characteristic of the seasonal period. Fermentation is an anaerobic biochemical process of breaking down monosaccharides, i.e., sugars (glucose, fructose), into alcohol ethanol and carbon dioxide, releasing thermal energy [17]. Fermenting ingredients creates distinctive flavours and aromas and increases their shelf life. Because it preserves ingredients for later use and allows for a variety of vegetable variations, fermentation is a great zero waste method. Any surplus or aesthetically unappealing vegetables could be preserved, minimizing food waste.

Hiša Franko strongly believes in buying from local suppliers; they have a well-established network of suppliers with whom they have worked together for many years. However, chef Ana Roš mentions that developing successful business relationships with local suppliers was a challenging journey. The most challenging part was convincing local small farms to collaborate with restaurants and creating a chain of local suppliers. Purchasing locally reduces waste because food is less likely to spoil due to shorter transit times between the farm and the restaurant. Since Hiša Franko cultivates strong relationships with its suppliers, a return of packaging agreement has been reached. Delivered ingredients are placed in plastic containers, which are then returned to the suppliers and so on, a nearly endless cycle. By doing this, plastic packaging is avoided, which reduces waste.

Reducing overall energy consumption not only lowers expenses but also benefits the environment. This is known as resource saving. Over the past decade, Hiša Franko has adopted efficient resource-saving methods, including reducing water consumption, using energy-efficient equipment, and, importantly, staff training. Trained staff members who understand their impact on the environment and adhere to zero waste protocols will implement all these practices. Every restaurant should make a point of highlighting its zero waste and energy-saving guidelines. Employees can be assisted in remembering the protocols by posting reminders about these guidelines above sinks, light switches, and other locations in the kitchen.

2.3. The challenges of zero waste at Hiša Franko include

Although Hiša Franko is committed to the zero waste idea, it is unable to carry it out completely. Plastic and plastic containers from cleaning products and detergents, toilet paper, and plastic wrap are the main sources of waste—items that pile up quickly and are challenging to recycle. To tackle excessive paper towel consumption, they encourage staff to use cotton towels and microfiber cloths. Because plastic waste is mostly recyclable and has few other uses, it poses a problem. While some recipes call for plastic wrap and vacuum bags, Hiša Franko works hard to minimise waste of any kind.

The manner in which that guests view the zero waste idea presents another difficulty. It's a common misperception that they'll receive inferior food, but this is untrue. When waste is eliminated, more creative and superior food is served because each product is carefully considered and made.

3. CONCLUSION

In conclusion, this study has demonstrated that fine dining restaurants can run even more successfully under the zero waste concept than commercial kitchens. The application of the zero waste concept in fine dining kitchens yields new and inventive dishes and has a positive impact on the environment. It also allows for maximum utilisation of ingredients and minimal waste generation. Thus, restaurants that provide excellent culinary experiences can also be sustainable.

As waste can be efficiently managed and its quantity decreased using the zero waste strategy, adopting this practice is a response to climate change. Hiša Franko is a pioneer in the practice of zero waste and one of the first fine dining establishments to be awarded a green Michelin star. However, zero waste is still a relatively new concept worldwide, and changes must occur. To achieve significant results, education and a willingness to change are necessary.

Proofreading: Ivana Šalinović univ. mag. philol.ang.et univ. mag. philol. franc.

Acknowledgment: This study was supported by Erasmus EDU – 2021 –PEX – COVE – **AgriNext** (n°101056023), European Structural and Investment Fund project **SIRENA** (KK.01.1.1.04.0096), by European Union – Next Generation EU project **SIROFONIJA** (Class: 602-01/23-01/392, Reg. no.: 2133-61-01-23-11), and performed using the facilities and equipment funded within the European Regional Development Fund project **Atrium of Knowledge** (KK.01.1.1.02.0005).

REFERENCES

[1] FAO*: Global food losses and food waste – Extent, causes and prevention, FAO,* 978-92-5-107205-9, Rome, (2011)
[2] World Food Programme, *Available from*: https://www.wfp.org/stories/5-facts-about-food-waste-and-hunger. *Accessed:2024-05-25*
[3] [3] WWF Food Practice: Driven to waste: the global food loss on farms, *Available from*: https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/4jqn8wgjtl_driven_to_waste_summary.pdf. *Accessed:2024-05-25*.
[4] Food Use for Social Innovation by Optimising Waste Prevention Strategies, *Available from*: https://www.eu-fusions.org/index.php/about-fusions *Accessed:2024-05-25*.
[5] Zero Waste International Alliance, *Available from*: https://zwia.org/zero-waste-definition *Accessed:2024-05-25*.
[6] Willshee's waste recycling, Willshee's waste and recycling, *Available from:* https://www.willshees.co.uk/news/how-to-reduce-food-waste-in-restaurants/ *Accessed:2024-05-25*.
[7] GRC, *Available from:* https://grc.berkeley.edu/the-unsustainability-of-buffet-food-waste/ *Accessed:2024-05-25*.
[8] WRAP, *Available from:* https://www.sustainabilityexchange.ac.uk/files/wrap_hafsa_food_waste_prevention_at_events.pdf *Accessed:2024-05-25*.
[9] Ventour, L. : *The Food We Waste*, WRAP, 1-84405-383-0, UK, (2008)

6

[10] Smart kitchen, Digital solution to reduce food waste, *Available from:* https://smartkitchen.solutions/en/food-waste-reducing/. *Accessed:2024-05-25*.
[11] JRE, *Available from:* https://www.jre.eu/en/restaurants/hisafranko *Accessed:2024-05-25*.
[12] Michelin, Michelin guide, *Available from:* https://guide-michelin-com.translate.goog/gb/en?_x_tr_sl=en&_x_tr_tl=hr&_x_tr_hl=hr&_x_tr_pto=sc *Accessed:2024-05-25*.
[13] 50 Best, The World's 50 Best Restaurants, *Available from:* https://www.theworlds50best.com/list/1-50 *Accessed:2024-05-25*.
[14] Discover the History of Recycling: How Did We Get Here? *Available from:* https://resources.pepsicorecycling.com/resources/history-of-recycling-1/ *Accessed:2024-05-25*.
[15] Food Waste – communication materials, *Available from:* https://food.ec.europa.eu/safety/food-waste/food-waste-communication-materials_en https://resources.pepsicorecycling.com/resources/history-of-recycling-1/ *Accessed:2024-05-25*.
[16] Home O Garden, Kompost – sve male tajne pravilnog kompostiranja, *Available from:* https://homeogarden.com/hr/savjeti/kompost-sve-male-tajne-pravilnog-kompostiranja/ *Accessed:2024-05-25*.
[17] Malakar, S., Paul, S. K., & Pou, K. J.: Biotechnological interventions in beverage production, In *Biotechnological progress and beverage consumption*, Academic Press, 978-0-12-816678-9, 19(2020), pp. 1-37, https://doi.org/10.1016/B978-0-12-816678-9.00001-1

FINDINGS OF THE MINDBOT PROJECT AS GUIDELINES FOR PROMOTING MENTAL HEALTH AT WORK AND IMPROVING COBOT-WORKER WELL-BEING

Marina Borić[1]; Snježana Štefok[2]

[1] Ministry of Labour, Pension System, Family and Social Policy, Ulica grada Vukovara 78, Zagreb, REPUBLIC OF CROATIA, marina.boric@mrosp.hr

[2] Ministry of Labour, Pension System, Family and Social Policy, Ulica grada Vukovara 78, Zagreb, REPUBLIC OF CROATIA, snjezana.stefok@mrosp.hr

Abstract: *The analysis of baseline findings of the research that was conducted in the MindBot project showed that the introduction of cobots in the workplace positively impacted on the quality of the production process and thereby the productivity. The MindBot project contributed to the identification of factors that are related to the mental health of workers in small and medium-sized companies using cobots in their production lines: generally, working with cobots was related to relatively high indicators of mental health and positive work experiences. Workers had above average psychological and emotional well-being and somewhat lower social well-being. They were highly satisfied both with their job and with working with a cobot.*

Keywords: *MindBot, cobot, cobot-worker, mental health, well-being*

1. INTRODUCTION

How to improve the job tasks of workers interacting with collaborative robots, as well as workers' efficiency and satisfaction? How to organize work in companies in the Industry 4.0 in such a way as to fully achieve mental and physical well-being? In order to answer these questions, nine partners from Italy, Germany, Belgium and Croatia gathered and designed the MindBot project. The project guiding idea was to design workplaces where level of challenges and difficulty of job tasks are matched with the workers' abilities and skills, with the aim to support motivation and engagement of workers interacting with cobots in a flexible and personalized way. The need to achieve this goal was recognized by the European Commission, which approved the project Mental Health promotion of cobot Workers in Industry 4.0 - MindBot (ID 847926) for funding under the EU Framework Programme for Research and Innovation Horizon 2020.

The project partnership included the scientific research and academic community: three technical and medical research centres and three universities, as well as one of the world's largest robotics manufacturers, a SME and, finally, the Croatian Ministry of Labour and Pension System, Family and Social Policy as the proposer of the law and

adopter of national implementing regulations in the field of safety and health at work. The project partners were:
1) IRCCS – Associazione la Nostra Famiglia 'Instituto scientifico Eugenio Medea' (Italy),
2) Università degli studi di Milano (Italy),
3) Consiglio Nazionale delle Ricerche (Italy),
4) Biorics NV (Belgium),
5) Deutsches Forschungszentrum fuer Kunstliche Intelligenz GmbH (Germany),
6) KUKA Deutshland GmbH (Germany),
7) Universitaet Augsburg (Germany),
8) University of Rijeka, Faculty of Humanities and Social Sciences (Croatia),
9) Croatian Ministry of Labour and Pension System, Family and Social Policy (Croatia).

MindBot, a 45 months-long project worth almost 4 million Euros, which ended in September 2023, aimed at identifying methods and implementing solutions to promote good mental health in the emerging industry 4.0 within the specific context of manufacturing enterprises that adopt collaborative robots (cobots) in their production lines. As planned, key results have been achieved:

1. The organizational guidelines for the design of a cobot-based manufacturing workplace able to promote workers' mental health

2. The technical guidelines for the design of a "mental health friendly" cobots, including the MindBot prototype development

3. The proposal of an employment model for persons diagnosed with autism spectrum disorders (ASD) working in the frame of manufacturing SMEs adopting cobot.

The results of the MindBot project facilitate the transition from Industry 4.0 to Industry 5.0, which is focused on workplace well-being and employee satisfaction at work. They are available at: https://cordis.europa.eu/project/id/847926/results , the section: Deliverables.

2. DESIGNING A COBOT-BASED FRIENDLY WORKPLACE

How to design a cobot-based workplace able to promote workers' mental health? Through research into the quality of everyday experience and the well-being of workers, MindBot researchers sought a solution to exploit the cobots not only for their efficiency, but also for their role in reducing psychological stress and promoting optimal work experiences for workers working with them. The aim was to facilitate an active and positive attitude of workers, promote their positive mental health and prevent negative experiences which can lead to mental illnesses. SHELLO model (Software-Hardware-Environment-Liveware-Liveware-Organization) was used in all studies within the project. The conceptual SHELLO model was the central model for clustering the results of qualitative and quantitative studies of workers' mental health carried out under the MindBot project. Based on it, the interactions between the central human component and hardware, software, environment, organization and liveware were described.

Although the project findings are based on a small number of workers and companies due to COVID-19 pandemic, which has greatly affected some of the project tasks and hindered more extensive research in factory workplaces, they are indicative and significant. The MindBot results showed potential benefits, but also risks to mental health of cobot-workers.

The conclusions of the project public document titled "Psychological, psychosocial and organizational data integration report using SHELLO model" [1] pointed out that MindBot contributed to the identification of factors related to the mental health of workers in small and medium-sized companies using cobots in their production lines. In general, working with cobots is linked to relatively high indicators of mental health and positive work experiences. Workers had above average psychological and emotional well-being and a slightly lower social well-being. They were highly satisfied with both their job and work with the cobot. Interaction with the cobot was mainly associated with positive experiences characterized by concentration, cognitive engagement, high challenges matched with adequate skills and low level of negative emotions.

Given their interaction with the cobot, the workers did not express any fear for their safety. The integration of the cobot into the production did not negatively affect the relationship with coworkers. At the organizational level, qualitative data suggeste that introduction of the cobot has increased variety of tasks and that the work has become less difficult and repetitive. It is also noted that all companies included in the research have proven to be very open to workplaces adaption to improve ergonomics for the workers, so that interaction with the cobot was in no way hindered.

Based on these results, MindBot researchers proposed methods for optimal integration of the cobot into the workers' working situations, improvement of overall work experience and mental well-being as well as design of future cobots to achieve these goals.

As some negative experiences of working with cobots have been noted, the guidelines suggest activities to mitigate or prevent them:

Increase the level of control and autonomy - considering that the common cobot has strictly programmed interaction patterns, the improved MindBot cobot with its capability to adjust rhythms and interaction to workers' feeling and needs, could positively impact on such negative experiences (for example, the MindBot prototype tries to adjust the work speed to the worker's fatigue);

Improve workers' training - special attention should be paid to workers' training as better training would enable employees to address problems and to define/craft a technological solution along all phases of the technological design and implementation. The employees should be offered the opportunity to learn and apply robot programming and application skills, not just to learn how to work with cobot. Such additional training would allow higher levels of tasks rotation resulting in more work variety, control and autonomy.

Pay special attention to factors that contribute to lower satisfaction in working with cobot - although many benefits of working with cobots were identified, certain conditions may cause problems for workers. It is necessary to pay attention to, for example, environmental conditions or organizational procedures with purpose to design a cobot-based workplace able to promote workers' mental health.

The project "Organizational guidelines for the design of an adequate manufacturing workplace adopting advanced cobots" [2] offer suggestions and practical advice at worker and organization level. The first part focuses on well-being related to work, such as job satisfaction, job involvement and work engagement. It is recommended how to improve workers' work experience and mental health. At the organizational level, it is proposed how to improve aspects of work and organizational design to enhance the well-being of workers interacting with cobots.

How to improve overall work experience and mental well-being of workers who interact and communicate with cobots and how to design future cobots to achieve these goals? The answer was sought by quantitative measurement and qualitative assessment – questionnaires and semi-structured interviews with workers. Taking into account the safety of cobots as perceived by the workers, environmental issues, meeting basic psychological needs, control, autonomy, monotony at work, training of the workers and satisfaction with the cobot as well as the attitudes and emotions of workers towards the cobot, positive and negative aspects of working with cobot were noted.

For example, workers were above average satisfied with their jobs and had a high level of continuance and affective commitment and work engagement. Working with cobots, employees were in the state of flow, as evidenced by their high concentration, cognitive engagement and high challenges matched with adequate skills. On the other side, even during the most positive daily experience workers reported feeling highly obliged and constrained. Or their job involvement was slightly below the average on the scale.

The findings could help managers, who should take into account not only positive effects of introducing cobots on their employees, but also the negative ones. Therefore, the following is recommended:
Ensure that workers feel safe in interacting with the cobot;
Take care of the environmental issues;
Increase the level of control and autonomy;
Improve workers' competencies;
Ensure optimal balance between perceived challenges and personal skills at work;
Reduce monotony at work;
Make cobot capable of adjusting the rhythms and interaction patterns to workers' feelings and needs;
Pay attention to factors related to satisfaction with the cobot;
Take into account possible worker's negative attitudes and emotions toward cobots;
Involve employees in the cobot introduction process;
Implement the new available software to improve cobots.

These recommendations may raise awareness of all interested stakeholders about the key challenges for workers' well-being and possible solutions to address them.

The guidelines at organization level offer suggestions and practical advice on how to improve aspects of work and organizational design and as a result have a direct impact on the well-being of workers interacting with the cobots. It points out what needs to be done in practice. The following would contribute to well-being at work: investing in raising awareness and train managers to understand how to create higher quality work; organizing work differently to improve workers' learning and skill variety; developing human resource policies and culture to align with enriched work design; offering employees the opportunity to learn and apply robot programming and application skills; creating 'joint and participative' solutions during design and implementation of cobot technology; encouraging employee participation; promulgating the benefits of broad participation and joint design; supporting the use of collective bargaining strategies; and, finally, beyond changes within the organization, work and organization design is embedded within a broader public policy and legislative context.

3. COBOTS ABLE TO INCREASE WORKER WELL-BEING

The research carried out within the project and the baseline findings gave the direction for the development, testing and refinement of an innovative cobot platform which included the prototype of a new cobot generation – a "mental health friendly" cobot MindBot. Technological modules of the platform included wearable devices, a biomechanical module, an affective user model and an avatar for the cobot. Finally, the prototype was tested in a controlled laboratory environment on neurotypical and neurodivergent volunteers, to check and validate the system's impact on workers' mental health. The results were systematized and analysed within a conceptual socio-technical system model, proposed to assess risks related to working conditions. Interactions between the central human component and hardware, software, environment, organization and liveware were described.

The project public document titled "Technical guidelines for the design of cobots able to increase workers' state of well-being" [3] stresses that in Industry 4.0 cobots play an increasingly important role in factories both because of their specific skills and because ability to free workers from tedious, repetitive and dangerous tasks. Thanks to their adaptability to human working behavior, cobots can be fruitfully integrated in production line activities not just for their efficiency, but also for their potential in transforming the workplace in a healthy environment, counterbalancing job demands and promoting workers' well-being.

The MindBot technology experts have developed the "mental health friendly" cobot. Very simplified, this prototype of an improved cobot consists of a cobot platform and the cobot itself with an avatar, which is able to friendly interact and communicate with the worker. The following general functionalities were embedded in the robotic platform: User-Friendly Interface (intuitive, with clear and simple instructions); Personalization, which can enhance users' sense of control and ownership by allowing them to personalize the settings and behavior of the robotic platform; Empathic Interaction and Affective Expressivity, which can enhance ability to empathize with users, build rapport and trust as well as provide emotional support by enabling the robotic platform to express affect appropriately and signal understanding of the affective experience of the user; Active Listening and Communication (a robotic platform that actively listens and engages in meaningful conversations is essential for promoting mental well-being); Positive Reinforcement (meaning that the robotic platform can offer verbal affirmations, rewards, or acknowledgments for achievements or progress made by the user; this positive feedback can serve as motivation and boost self-confidence); Safety and Security (to ensure the safety and security of user data is paramount for establishing trust and promoting peace of mind).

4. MINDBOT EMPLOYMENT MODEL FOR PERSONS WITH ASD

In addition to methods for optimal integration of cobots into the workflow with the aim of improving workers' experience and mental well-being of employees, the MindBot project helped define the employment model of persons diagnosed with autism spectrum disorders (ASD) who work in companies that adopt collaborative robots. With appropriate adjustments, they may be fruitfully employed in tasks of cooperation within production lines, at the same time having from their job mental well-being and optimal experiences.

The project public document titled "MindBot employment model for persons diagnosed with ASD" [4] highlights that up to 90% of adults with ASD are unemployed, and studies show that rates among adults with autism are significantly higher than among adults with intellectual disabilities or other developmental disorders. Economic analyses suggest that costs associated to unemployment of the ASD population has reached in the USA and the UK $175 billion and £32 billion per year, respectively, more than the cost of cancer, strokes and heart disease combined. These costs are associated to the loss in productivity due to lack of employment. Throughout Europe, there is a lack of adapted education and training that could allow people with ASD to gain the necessary skills for employment. Difficulties in communication and social interaction are often seen by employers as signs that they are not suitable employees. Also, after managing to gain the job, inherent difficulties such as lack of support and social attitudes can be serious issues in maintaining employment.

Technology nowdays offers support to facilitate work inclusion for adults diagnosed with ASD. Among the expected outcomes of the Mindbot project there is the definition of a new generation of "mental health friendly" cobots, that might promote mental health and support employment opportunities both for neurotypical and ASD employees: this approach is supported by the idea that each individual has equal rights, dignity and treatment.

Starting with careful preparations with the purpose of introducing ASD volunteers to collaborative assembly tasks with the cobot, such as training of Mindbot staff, on-site visit of volunteers, task analysis and providing volunteers with supporting material (brochures), the experimental week in working with the cobot showed good results. Overall, the findings provide new insights into the psychological and physiological correlations of human-cobot interaction among highly functional persons with ASD. During lab activities, volunteers had to deal with several demanding tasks, including adaptation to both an unfamiliar scenario and unknown activities to be performed in interaction with the cobot. Although cobot-assisted activities were perceived as high-challenging experiences, volunteers with ASD could globally face them with the right skills, linking them with positive and engaging experiences.

Similarly to real production line assembly tasks, however, lab activities are characterized by defined and repetitive patterns, which contributed to volunteers' overall perception of negative feelings of boredom, obligation and low happiness. Interestingly, these negative feelings disappeared when flow experience was reported during lab tasks. This specific finding suggests that an improved cobot like MindBot, able to adjust assembly rhythms to human needs, could positively impact on the negative aspects of the production line experience, by dynamically balancing task challenges with operators.

The practical tips were provided to facilitate the interaction with an ASD worker on the job to make the workflow as smooth as possible:
Prefer a written form of communication, e.g. emails to assign tasks;
Avoid the use of metaphors or figurative language, preferring literal language;
Contain the use of irony that may not be understood or misinterpreted;
Do not use very complex sentences, preferring short periods;
Facilitate rest breaks during the working hours: breaks are part of the structured routine;

Avoid sudden interruptions: this can lead to stress and delays;
Create a custom work environment, respecting the specific sensory needs;
Explicit the procedures, without leaving too much freedom when organizing activities;
Communicate priorities, ensuring that they are specific and clear;
Provide frequent feedback;
Be explicit regarding social rules and in work activities;
Plan the working days, ensuring an organized and visible planning to the work team;
If there are structural changes at work communicate them only when they are certain;
Prefer activities for which specific and highly specialized skills have been developed, allowing for variation in tasks to avoid boredom and increase motivation;
Respect rules, because people with ASD can have strong attachments to morality and attribute extreme meanings and values to the concepts of defeat, order and friendship.

The experts of Medea, a project coordinator, have demonstrated that people with ASD can be employed in collaborative tasks within the production lines, while at the same time fostering their mental well-being. Only appropriate adjustment is required.

5. CONCLUSION

The main goal of the MindBot project has been achieved. It was to design human-robot model of co-working, characterized by levels of challenge and difficulty matched with the workers' abilities and skills, in order to support workers' motivation and engagement in a flexible and personalized way. The research within the project encompassed technological, relational and organizational aspects of the cobot-based work, where the cobots should be exploited not only for their efficiency, but also for their role in reducing psychological strain and promoting optimal job experiences of workers working with them. People with ASD could be employed in collaborative tasks within cobot-manufacturing lines.

Along with further development of the improved MindBot cobot prototype, the results of the project could facilitate an active and positive attitude of workers, promote their positive mental health and prevent negative experiences that can lead to mental illnesses. The project approach and procedures could also be usefully applied to Industry 5.0, where people work together with advanced technology and AI-driven robots, a condition that sets additional requirements for the physical and mental health of employees.

REFERENCES

[1] Brdar, I.; et al.: Psychological, psychosocial and organizational data integration report using SHEL model, *Available from* https://cordis.europa.eu/project/id/847926/results, section: Deliverables, *Accessed:* 2024-06-06.

[2] Brdar, I.; Rijavec, M.; Shaba, E.; Lazazzara, A.: Organizational guidelines for the design of an adequate manufacturing workplace adopting advanced cobots, *Available*

from https://cordis.europa.eu/project/id/847926/results, section: Deliverables, *Accessed:* 2024-06-06.

[3] André, E.; et al.: Technical guidelines for the design of cobots able to increase workers' state of well-being, *Available from* https://cordis.europa.eu/project/id/847926/results, section: Deliverables, *Accessed:* 2024-06-06.

[4] Chiappini, M.; et al.: MindBot employment model for persons diagnosed with ASD, *Available from* https://cordis.europa.eu/project/id/847926/results, section: Deliverables, *Accessed:* 2024-06-06.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

IMPLEMENTATION OF TECHNICAL PROTECTION IN SAFETY AND HEALTH PROTECTION

Iva Čehak
Zagreb, CROATIA, ivacsehak@gmail.com

Abstract:

Technical protection systems are widely used safety at work, i.e., they ensure complete control over processes related to the safety of employees and premises. The paper deals with dangers that can be reduced by using technical protection. The question always arises whether the employer is allowed to use the video surveillance system indefinitely. It is allowed, but... This paper deals with the legal framework that regulates/allows the use of video surveillance systems at work, as well as with the identity of persons who are not connected to the workplace and are not employees, and the question of whether the identification of "people passing by" as shown in film works. The paper also discusses the high level of organizational security that can be achieved by using the systems such as access control, anti-burglary, and EAS systems for protection against theft. At the end of the paper, the issue of profitability of installing a technical protection system is raised.

Keywords: *technical protection, video surveillance system, anti-burglary system, EAS system, access control*

1. INTRODUCTION

The old health-related saying that "prevention is better than cure" also fully applies to safety and health protection at work. It is better to undertake all the necessary actions and procedures, no matter the cost, than to pay ten times higher price, even with human life, for not knowing them.

The basic goal of technical protection is the protection of people, facilities, and everything material. Safety and health protection at work is not only measured by invested resources, technological development, and level of protection, but also by the culture of behaviour in all segments of work and social relations. The permanent task of preventive action in the field of safety and health protection at work is the investment and constant progress of technical protection systems, their regular maintenance, as well as education and constant informing of people on the possible consequences of their improper functioning.

According to the Ordinance on Conditions and Methods of Implementation of Technical Protection - NN nr. 198/03 (hereinafter referred to as: the Ordinance), technical protection is a set of actions that directly or indirectly protect people and their assets and is carried out by technical means and devices. [1] The basic purpose of technical protection systems is to prevent illegal actions aimed at protected persons or assets, such as: anti-burglary, anti-raid, and anti-sabotage activities. The technical protection system represents the connection of two or more means, apparatus and devices that together form a functional unit.

The technical protection systems discussed in this paper are video surveillance system, access control, anti-burglary, and EAS system.

2. TECHNICAL PROTECTION

There are many dangers that can be reduced by applying technical protection. The identification, analysis, and recognition of things and persons and final processing of the collected information results in automatic generation of warnings and activation of safety protocols in case of potential hazards of work injuries or damage and theft of all tangible assets. In this way, the level of workplace safety is increased and the cost of doing business is reduced. In today's dynamic environment, technical protection is becoming an increasingly important component of business and investing in technical protection systems represents a smart step towards long-term business.

In order to know which hazards are present in a certain work environment, it is necessary to analyse work tasks, inspect the work environment, follow statistics and reports on injuries/accidents, talk to workers and use various tools for hazard identification (e.g. checklists).

2.1. Video surveillance system

Video surveillance, in addition to cameras (that are visible), also consists of recorders, hard drives, installations, applications for reviewing recordings and other parts.

Today, one can no longer hear the sentence: "Digital identification of people exists only in film." Today, more and more questions are being asked: "Is there a database of all citizens?" and "How does my cell phone recognize me?"

Regarding the safety and health protection of workers, the question always arises: "May the employer use the video surveillance system indefinitely?"

In accordance with the Occupational Health and Safety Act [1] and Article 43, the employer may use monitoring devices as a means of occupational health and safety. The use of surveillance devices is permitted to control entry and exit from work rooms and spaces and to reduce the exposure of workers to the risk of robbery, burglary, violence, theft, and similar events at work or in connection with work. Installation of monitoring devices in rooms for personal hygiene and changing of workers is prohibited. If monitoring devices monitor all the movements of workers during the entire working time, i.e., if the monitoring devices are installed in such a way that the workers are in their field of vision the entire time during work, the employer may use the monitoring devices only with prior consent of the works council. When hiring, the employer is obliged to inform the employee in writing that he/she will be monitored by surveillance audio or video devices. The employer may not use the recorded materials for the purposes that are not prescribed by the Act, may not broadcast them in public or in front of persons who are not authorized to supervise general safety and security at work, and is obliged to ensure that the recorded materials are not accessible to unauthorized persons. [2]

In addition to the above-mentioned Act, the Act on Implementation of the General Data Protection Regulation also defines that the employer is obliged to mark the facility, i.e., certain premises in the facility and the outdoor area of the facility under video surveillance and the mark must be visible at the latest when entering the recording perimeter. [2]

Legislation also defines what can be recorded without being outside the workplace or the supervised facility. Recording of private property that does not belong to the monitored facility is prohibited. In practice, for example, illegal recording of entrances and/or exits to/from the facilities in the immediate vicinity of the monitored facility is often mentioned.

2.2. Anti-burglary system

The anti-burglary system consists of an anti-burglary control panel, various types of detectors, communicators (for forwarding alarms to the central notification system), installations, keyboards, sirens, and other parts.

The Ordinance on Conditions and Implementation of Technical Protection that specifies the categories of facilities at risk, also defines technical protection systems that must be incorporated into each individual category a certain facility belongs to. [2]

The first technical protection that is not mechanical and is specified for the V. risk category is technical protection that signals unauthorized entry into the protected area by sound or light. [2] The said refers to anti-burglary system.

Interpreting the Ordinance, the technical protection system that must be installed first in the facilities is precisely the anti-burglary system. In the lower risk categories, the mentioned system is incorporated without alarm forwarding to the central notification system, while the facilities classified in the higher categories of threat must have an anti-burglary system installed with alarm forwarding to the central notification system.

Central notification system is the central point of interaction between physical and technical protection. A company with such a system organizes the help that the protected facility receives in the shortest possible time from (0-24) after the notification via a communicator that is part of the anti-burglary system.

In "layman's terms", when talking about detectors as part of an anti-burglary system, - one mostly refers to motion detectors. There are also vibration detectors (e.g. of broken glass, for safes and vaults), water, carbon monoxide, smoke, temperature, seismic detectors, etc.

2.3. Access control

Access control, as a technical protection system, is one of the most important technical protection systems. Such systems serve to monitor entrances from unauthorized entrances or passages or to protect separate areas such as server rooms, control rooms, parking lots, and vaults.

For its functionality, the system requires a controller, electric or electromagnetic locks, software, and a reader with the use of RFID contactless cards, contactless pendants, contact chip cards, magnetic and barcode cards.

The use of access control reduces the security problem of losing or stealing a classic key. Each user has a unique card or identification element, which enables control of the user himself and monitoring of activities. In case if the user leaves the company permanently, it is sufficient to cancel the identification card/ element.

Access control can also be used for working time records, biometric recognition, and the like.

2.4. EAS system

The basic part of the EAS system are detection antennas that enable light and sound signalling of shoplifting attempts. The antennas are adjusted to different widths of the passage. Besides the antennas, the basic parts of the system include detection elements for different types of articles (stickers, tags, pins) and deactivators that are used to remove or deactivate protective elements.

3. CONCLUSION

As many as possible integrated technical protection systems enable effective prevention of various crimes (burglary, theft, vandalism, fraud), and video verification of alarm signals enables the reduction of security intervention costs.

In addition to the prevention of various criminal acts, the use of technical protection system enables recognition, monitoring and identification of existing dangers, harms, and efforts in the workplace.

Depending on the system, in general technical protection systems today provide protection of items from theft (customers, workers, suppliers), they provide information on the number of customers, the number of individual items on the shelves (not only in a specific store but also in dislocated warehouse facilities), provides supply chain monitoring and monitoring the validity of goods with a limited shelf life and data analysis in the sales process.

Through video surveillance system and today's video analytics, it is possible to signal an alarm in various situations, such as the movement of a person in a prohibited area or items left behind. In addition to the aforementioned, video analytics enables functions such as face recognition and identification of elements (numbers).

The appearance of technical protection, such as the of antennas of the EAS system, is also especially important to retailers, as they are often used to advertise companies and products in the offer.

Of all technical protection systems, video surveillance is considered the most cost-effective technical protection system. The application of video surveillance reduces damage from robbery by up to 4.5 times, since the facilities protected by video surveillance are rarely the target of criminals, and that video surveillance reduces theft by employees and suppliers.

The profitability of installing a technical protection system is not questionable.

REFERENCES

[1] Ordinance on Conditions and Implementation of Technical Protection (NN nr. 198/03)
[2] Occupational Health and Safety Act (NN nr. 71/14, 118/14, 154/14, 94/18, 96/18)

THE IMPACT OF OCCUPATIONAL PHYSICAL ACTIVITY ON HEALTH

Tamara Fehervari[1], Marko Prahović[2]

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, tamara.fehervari@vuka.hr
[2] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, marko.prahovic@vuka.hr

Abstract: *The health benefits of regular physical activity are irrefutable: it is proven that regular physical activity helps to prevent noncommunicable diseases such as heart disease, diabetes, stroke, hypertension. Physical activity also maintains healthy body weight and can improve mental health and quality of life.*
There are two principal categories of physical activity: leisure-time physical activity and occupational physical activity. Leisure-time physical activity is the type of activity that people participate during their free time. Occupational physical activity is the type of activity that is associated with job and it is usually referenced to an 8-hour work time.
The aim of this study is to determinate the impact of occupational physical activity on health and to give guidelines for improving the quality of life.

Keywords: *workplace, health outcomes, leisure time physical activity, guidelines*

1. INTRODUCTION

World Health Organization (WHO) defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work or domestic activities.[1] Also, physical activity (PA) includes a large number of different categories. The two principal categories of physical activity are leasure-time physical activity and occupational physical activity.[2]

Leisure-time physical activity (LTPA) is a term used to describe an activity that people do in their free time. LTPA has been defined as physical activity performed during exercise, recreation or any time other than those associated with one's regular occupation, housework, or transportation.[3] Regular LTPA is defined as engaging in moderate or vigorous physical activity during leisure time for at least several times a week.[4] The World Health Organization (WHO) currently recommends that adults do at least 150 minutes of moderate to vigorous intensity physical activity every week. Moderate-intensity PA such as brisk walking and gardening require a moderate amount of effort and noticeably increase the heart rate. Vigorous-intensity PA such as running or fast swimming require a large amount of effort and cause rapid breathing and a substantial heart rate inrease.

Occupational physical activity (OPA) is the type of activity that is associated with a job and is usually within the timeframe of how long a person works, such as an 8-hour work shift. OPA refers to the PA perfomed during work hours, encompassing a wide range of tasks and movements. These activities vary greatly depending on the job type, from manual labor and construction to walking and standing for extended periods. Jobs with high OPA are construction workes, waitstaff, farmers, factory workers, nurses etc. Workers' occupation defines work activity that is closely related to the levels and intensities of physical activity (PA) and health outcomes.[5]

The aim of this study is to determinate the impact of occupational physical activity on health and to give guidelines for improving the quality of life.

2. THE IMPACT OF OPA (HEALTH RISKS)

Increasing evidence shows that occupational physical activity (OPA) does not improve health. Occupational activities include heavy lifting and construction work. Heavy contractions of skeletal muscles increase blood pressure, and increased blood pressure is a risk for cardiovascular diseases (CVD)[6]. Another factor that could be influential is the high intensity of OPA which could lead to overuse injuries. Mechanical load has been proposed as a key component to cause overuse occupational injuries. Heavy load, handling tools and repetitive movements all have an influence on the tendon and may lead to tendinopathies.[7] Joints and the spine are particularly at risk, and the sick leave indicators warn of a large number of absences from the workplace due to disturbances and pain in the movement system.[8] In Croatia, they are in second place in terms of the frequency of going on sick leave for diseases of the locomotor system.[9]

Some authors report that high OPA increases the risk for all-cause mortality among male workers. Among the male labourers with the highest OPA, the risk of all-cause death almost doubled, indicating that OPA may have a considerable impact on the life span of male labourers.[10] Furhermore, during OPA, heart rate is elevated and when it's elevated for a long period of time it can be a risk factor for cardivascular diseases.

Muscle contractions during manual material handling and prolonged static working postures instantaneously elevate blood pressure. Prolonged exposure to static OPA may cause sustained elevated blood pressure, even after working hours. Sustained elevated blood pressure is an important CVD risk factor. OPA is often perfomed without sufficient recovery time and it can cause fatigue and exhaustion. Limited control over work tasks, speed, schedule, protective clothing, psychosocial stressors and the surrounding environment may contribute to the detrimental effects of OPA. For example, about 50% of the global working population works outdoors with little control over climate, shade, hydration and access to rest, leading to increased heat stress, risk of fatal heat stroke and CVD. OPA increases levels of inflammation and without recovery time it can cause sustained inflammation.[6, 11]

3. GUIDELINES FOR IMPROVING THE QUALITY OF LIFE

Many workplaces require a lot of PA to finish the assignments of the day. This is also a reason many individuals think that they do not need to do additional LTPA since 'they are active enough in their jobs'. Straker *et al* propose that designing workplaces with the right amount and type of PA can correct these problems.[12] Workplace modifications like designing a practical exercise training programme to complement OPA is needed to generate a positive imact health-wise.

Lowering the work intensity through the day could have a positive impact on creating a balance between the high work demands a person experiences during the work shift. Heavy lifting and construction work require guided risk-free movements through the physical tasks. Futhermore, the workers should take short breaks between high intensity tasks. Evidence suggests that LTPA is beneficial for all workers, but with larger risk reductions among those with low compared to high OPA jobs. This suggests that, in our attempts to improve the health of workers through LTPA, tailored interventions for different occupational groups may be required.[13] A moderate-to-high intensity of LTPA was able to confer a significant protection against having abnormal levels of BMI, waist circumference and triglycerides and main features of the metabolic syndrome.[14]

Regular physical activity offers numerous health benefits. It helps reduce inflammation, enhance strenght, lower blood pressure, improve lipid profile and boost cardiorespiratory fitness. Studies have shown that higher levels of physical activity are associated with significant risk reductions for all-cause mortality, cardiovascular disease, and type 2 diabetes. To maximize these benefits, it is important to incorporate leisure-time exercise into daily routines. Leisure-time exercise refers to physical activity that is intentionally performed outside of occupational activities. This includes activities like jogging, cycling, swimming, playing sports, or participating in fitness classes. By engaging in leisure-time exercise, individuals can further enhance their overall physical fitness, increase their cardiovascular endurance, and promote better health outcomes.

Considering that in Croatia diseases of the locomotor system are in second place in terms of frequency of going on sick leave, it indicates the importance of preventive exercise programs to improve the functions of the locomotor system.

4. CONCLUSION

Physical activity is well documented to improve health and has substantial benefits across a range of health outcomes. In adults, PA contributes to prevention and management of noncommunicable diseases such as cardiovascular diseases, cancer and diabetes and reduces symptoms of depression and anxiety, enhances brain health, and can improve overall well-being.

Investing in the health of workers is a long-term investment that cannot be measured only by economic parameters, but is a reflection of the employer's humane approach in order to establish and maintain the quality of work and life of workers. It is extremely importat to apply a quality improvement strategy in the work, but also outside the work. The kinesiologists create exercise programs for different needs and for different conditions and can contribute to solving at least part of the problems and consequences of work load. The action of the physical activity program can improve the work itself, and especially the status of the worker in the psychophysical sense. That is why it is necessary to involve in LTPA that will contribute to improve health and increase the level of quality of life.

REFERENCES

[1] World Health Organization. Global action plan on physical activity 2018-2030: more activ people for a healthier world. Geneva, CH: World Health Organization;2018. Dostupno na: https://apps.who.int/iris/bitstream/handle/10665/272722/9789241514187-eng.pdf. Datum pristupa 14.5.2024.

[2] Howley ET. Type of activity: resistance, aerobic and leisure versus occupational physical activity. Med Sci Sports Exerc. 2001 Jun;33(6 Suppl):S364-9; discussion S419-20. doi: 10.1097/00005768-200106001-00005. PMID: 11427761.

[3] Kandula NR, Lauderdale DS. Leisure time, non-leisure time, and occupational physical activity in Asian Americans. Ann Epidemiol. 2005;15(4):257–65.

[4] Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports & Exerc. 1993;25(1):71–80.

[5] Yu X, Hao L, Crainiceanu C, Leroux A. Occupational determinants of physical activity at work: Evidence from wearable accelerometer in 2005-2006 NHANES. SSM Popul Health. 2021 Dec 4;17:100989. doi: 10.1016/j.ssmph.2021.100989. PMID: 34977325; PMCID: PMC8688871.

[6]Holtermann A , Krause N , van der Beek AJ , *et al* . The physical activity paradox: six reasons why occupational physical activity (opa) does not confer the cardiovascular health benefits that leisure time physical activity does. *Br J Sports Med* 2018;**52**:149–50.doi:10.1136/bjsports2017097965 pmid:http://www.ncbi.nlm.nih.gov/pubmed/2879840.

[7] Coombes BK , Bisset L , Vicenzino B . Management of lateral elbow tendinopathy: one size does not fit all. J Orthop Sports Phys Ther 2015;45:938-49.

[8] Jajić I. Reumatologija: priručnik za liječnike specijaliste reumatologije, specijaliste drugih graničnih struka i studente medicine. Zagreb: Medicinska naklada; 1995.

[9] Zenić D. Bolesti kralježnice i psihički poremećaji otvaraju vrata za lažna bolovanja. Slobodna Dalmacija *2009.* [pristup 13. svibnja 2012.]. Dostupno nahttp://www.slobodnadalmacija.hr/Hrvatska/tabid/66/articleType/ArticleView/articleId/45072/Default.aspx

[10] Holtermann A, Burr H, Hansen JV, et al. Occupational physical activity and mortality among Danish workers. *Int Arch Occup Environ Health* 2012;85:305-10

[11] Shala R.'I'm active enough in my job.' Why is occupational physical activity not enough?*British Journal of Sports Medicine* 2022;**56:**897-898.

[12] Straker L , Holtermann A , Lee I-M , *et al* . Privileging the privileged: the public health focus on leisure time physical activity has contributed to widening socioeconomic inequalities in health. Br J Sports Med 2021;**55**:525–6.doi:10.1136/bjsports-2020-103356

[13] Prince, S.A., Rasmussen, C.L., Biswas, A. *et al.* The effect of leisure time physical activity and sedentary behaviour on the health of workers with different occupational physical activity demands: a systematic review. *Int J Behav Nutr Phys Act* **18**, 100 (2021). https://doi.org/10.1186/s12966-021-01166-z

[14] Sofi F, Capalbo A, Marcucci R, Gori AM, Fedi S, Macchi C, Casini A, Surrenti C, Abbate R, Gensini GF. Leisure time but not occupational physical activity significantly affects cardiovascular risk factors in an adult population. Eur J Clin Invest. 2007 Dec;37(12):947-53. doi: 10.1111/j.1365-2362.2007.01884.x. Epub 2007 Nov 1. PMID: 17976196.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

OCCUPATIONAL EXPOSURE TO BTEX: A CONDENSED REVIEW

Tatjana Golubović[1], Ana Bijelić[2]

[1] University of Niš, Faculty of Occupational Safety, Niš, Čarnojevića 10a, Niš, Serbia, tatjana.golubovic@znrfak.ni.ac.rs

[2] University of Niš, Faculty of Occupational Safety, Niš, Čarnojevića 10a, Niš, Serbia, ana.miltojevic@znrfak.ni.ac.rs

Abstract: BTEX is a group of volatile organic compounds consisting of benzene, toluene, ethylbenzene and xylenes. Some of these compounds are used largely in a number of manufacturing processes, such as production of fuel additives, synthetic materials, paints, paint thinners, adhesives, lacquers, rubber, etc. Accordingly, gas and oil workers, spray painters, and individuals involved in gluing operations may be exposed to some of these substances. They are directly exposed to BTEX via inhalation and dermal absorption. However, the major route of exposure is the respiratory system. Exposure to BTEX has numerous health consequences for humans. For example, aplastic anemia and leukemia in exposed workers can be caused by high-level benzene exposure. The International Agency for Research on Cancer (IARC) classifies benzene as a Group 1 carcinogen (carcinogenic to humans). Bearing in mind previously mentioned facts, the assessment of human exposure to BTEX chemicals is a required step in the determination of health risk and its management.

Keywords: *benzene, toluene, ethylbenzene, xylenes, occupational exposure, health*

1. INTRODUCTION

Monoaromatic hydrocarbons, benzene and its alkyl derivates (toluene, ethylbenzene, and isomers of xylene) are known as BTEX compounds [1]. They are recognized as toxic, mutagenic and/or carcinogenic [2-4]. The International Agency for Research on Cancer (IARC) has classified benzene as "carcinogenic to humans" (Group 1) based on sufficient evidence that this compound causes acute myeloid leukemia. Toluene, as well as xylenes, have been classified within Group 3 (not classifiable as to its carcinogenicity to humans), while ethylbenzene has been classified within Group 2B (possibly carcinogenic to humans) [5,6]. BTEX compounds occur naturally in crude oil and can be found in sea water in the vicinity of natural gas and petroleum deposits. Also, gas emissions from volcanoes and forest fires are natural sources of BTEX [7]. The major man-made releases of BTEX compounds include combustion of gasoline and diesel fuels, especially for motor vehicles, as well as emissions from gas stations and small-scale industries that use BTEX-containing materials. In addition, benzene, toluene, ethylbenzene and xylenes are common additives to some chemical intermediates, consumer products (cosmetics, inks, paints and lacquers, thinners, rubber products, adhesives), and pharmaceutical products [7]. These compounds tend to accumulate in the indoor occupational environment, exposing the workers to risks. BTEX are absorbed mainly through the respiratory and dermal routes. It is estimated that at least 80% of these compounds are metabolized in the body and eliminated by urine. Just a small amount is excreted unmodified in the exhaled air. Biological monitoring, as a way of assessing BTEX compound exposures by measuring the BTEX or their metabolites in a biological sample (usually urine, blood or breath), is very important [8]. Early detection of elevated exposures or signs of adverse health effects contribute to implementation timely remedial and preventative actions that minimize further harmful exposures.

2. BTEX: CHEMICAL STRUCTURE AND PHYSICO-CHEMICAL PROPERTIES

BTEX compounds (Figure 1) are aromatic hydrocarbons that include benzene and its alkyl derivatives. The toluene and ethylbenzene rings are monosubstituted with a methyl group and an ethyl group, respectively; the xylene ring is disubstituted with methyl groups, so that the xylene mixture comprises ortho-, meta- and para- (*o*-, *m*- and *p*-) compounds, according to the position of the ring substituents.

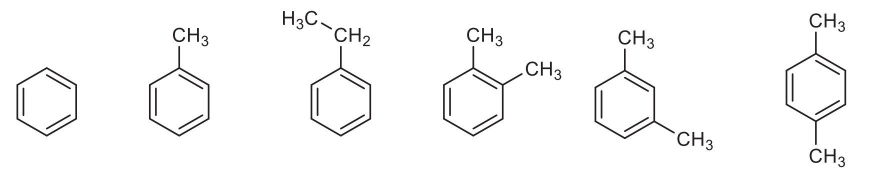


Figure 1: Chemical structure of BTEX

The BTEX compounds are widely present in the environment due to their physico-chemical properties (Table 1). Comparing all the compounds from this group, benzene is expected to be the most easily evaporated owing to its low molecular weight, low boiling point and high vapor pressure. Also, benzene is more soluble in water. Due to their physical and chemical properties, BTEX have significant dispersion capacity, and once they are released into the environment, they can volatilize, dissolve in water, or adsorbe to soil particles [2].

Within the volatile organic compounds (VOCs), benzene, toluene, ethylbenzene, and xylene, are present at high concentrations in many indoor environments because of their high vapor pressure [9]. The greatest exposure to these agents occurs in the work environment. Gas station workers, as well as those in chemical, petroleum, and rubber industries, workers in the production and use of paints, solvents, varnishes, and adhesives, are the most exposed to BTEX.

Table 1: Physico-chemical properties of BTEX compounds

BTEX compound	Benzene	Toluene	Ethylbenzene	*o*-Xylene	*m*-Xylene	*p*-Xylene
Molecular weight (g $mole^{-1}$)	78	92	106	106	106	106

Boiling point (°C)	80.1	110.8	136.2	144.4	139	138.4
Water solubility (mg L^{-1})	1780	535	152	175	135	198
Vapor pressure (mm Hg)	76	22	7	5	6	6.5
Log K_{ow}	2.13	2.69	3.15	3.15	3.15	3.15

3. BTEX: OCCUPATIONAL EXPOSURE

Starting from the fact that BTEX are natural components of petroleum, gasoline, and diesel fuel, occupational exposure to these agents may occur during production processes, maintenance of process systems, evaporation, or leaking of poorly maintained underground fuel tanks. BTEX are also used to manufacture fuel additives, synthetic materials, and consumer products.

Due to their structures, good solvent properties and easy volatilization, BTEX compounds can enter organisms through different routes: the most usual is inhalation, followed by dermal and, at a lower percentage, ingestion through polluted water or food. Toxicokinetic studies indicate that these chemicals are well absorbed, and are easily distributed to lipid-rich and highly vascular tissues such as the brain, bone marrow, and body fat due to their lipophilicity, and are rapidly eliminated from the body [10]. BTEX, due to lipophilic properties, have the capability to cross mucous epithelia of the respiratory tract and the cell membranes in various organs. The liver is the organ with the highest activity regarding BTEX biotransformation processes. As slightly reactive compounds, BTEX are characterized by toxicity that is determined by their biotransformation within the body. Biotransformation comprises phase I and phase II processes. The biotransformation of the four BTEX substances is dose-dependent. All BTEX compounds can lead to neurological impairment via parent compound-induced physical and chemical changes in nervous system membranes. In addition, exposure to benzene can generate hematological effects, including aplastic anemia, with subsequent manifestation of acute myelogenous leukemia via the action of reactive metabolites. Because of the interaction of metabolites (originate during biotransformation of BTEX compounds) with macromolecules, it can be presumed that systems will be affected in different ways, contributing to the development of a diversity of diseases [10].

4. BTEX: IMPACT ON HUMAN HEALTH

Exposure to the BTEX compounds may have a significant impact on human health. Table 2 summarizes the acute and chronic effects of BTEX in humans. The International Agency for Research on Cancer (IARC) has classified benzene as “carcinogenic to humans” (Group 1) based on sufficient evidence that this compound causes acute myeloid leukemia. Toluene, as well as xylenes, have been classified within Group 3 (not classifiable as to its carcinogenicity to humans), while ethylbenzene has been classified within Group 2B (possibly carcinogenic to humans). As mentioned before, benzene is the most toxic among BTEX compounds. According to the experimental data, long-term exposure to low concentrations of benzene may increase the frequency of cancer and leukemia, while exposure to higher benzene levels may lead to aplastic anemia [11]. It is important to note that BTEX compounds also form secondary air pollutants (ozone, peroxyacetyl nitrate (PAN), and ultra-fine particulate matter) that contribute to ill health in humans [12].

For that reason, monitoring benzene and the other BTEX compounds in occupational environment is a priority in order to further examination of their impact on humans.

Table 2: The acute and chronic effects of BTEX in humans [13-17]

BTEX compound	Benzene	Toluene	Ethylbenzene	Xylene
Routes of exposure	Inhalation, ingestion, skin, and eye contact	Primarily absorbed through inhalation and ingestion	Inhalation, ingestion, skin, and eye contact	Inhalation, ingestion, skin, and eye contact
Acute effects	Symptoms include drowsiness, dizziness, headaches, skin and respiratory tract irritation, unconsciousness	CNS dysfunction and narcosis, fatigue, sleepiness, headaches, and nausea	Low acute toxicity to humans. Irritation of the eyes and throat, chest tightness, dizziness, vertigo	Irritation of the eyes, nose, and throat, vomiting and diarrhea, and neurological effects
Chronic effects	Reduced red blood cells, aplastic anemia, female reproductive disorders.	CNS depression, irritation of the upper respiratory tract and eyes, sore throat, dizziness, and headache. Newborns/pregnant women: problems with attention and mild abnormalities of the head, face, and limbs	An increase in the mean number of lymphocytes and a decrease in hemoglobin levels	CNS symptoms: headache, dizziness, fatigue, tremors, in-coordination. Affect the respiratory, cardiovascular, and renal systems

5. CONCLUSION

Volatile organic compounds, especially benzene, toluene, ethylbenzene, and xylene (BTEX), are significant pollutants in occupational environment. In view of the fact that BTEX are natural components of petroleum, gasoline, and diesel fuel, occupational exposure to these agents may occur during production processes, maintenance of process systems, evaporation, or leaking of poorly maintained underground fuel tanks. BTEX are also used to manufacture fuel additives, synthetic materials, and consumer products. BTEX concentration levels increase many times in indoor environments, and long-term exposure to these substances can result in carcinogenic, teratogenic, and non-carcinogenic effects on human health. For these reasons, continuous monitoring and evaluation of the health risks caused by them is an important health issue that should be considered.

ACKNOWLEDGEMENT

This research was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia - Agreements on the implementation and financing of scientific research in 2024 [number 451-03-66/2024-03/ 200148].

REFERENCES

[1] Duan, X. & Li, Y.: Sources and Fates of BTEX in the General Environment and Its Distribution in Coastal Cities of China*, Journal of Environmental Science and Public Health,* **1** (2017) No. 2, pp. 86-106

[2] Leusch, F. & Bartkow, M.: *A Short Primer on Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) in the Environment and in Hydraulic Fracturing Fluids*. Griffith University – Smart Water Research Centre, (2010)

[3] Borhani, F. & Noorpoor, A.: Cancer Risk Assessment Benzene, Toluene, Ethylbenzene and Xylene (BTEX) in the Production of Insulation Bituminous, *Environmental Energy and Economic Research*, **1** (2017) No. 3, pp. 311-320. doi: 10.22097/eeer.2017.90292.1010

[4] Masekameni, M. D., Moolla, R., Gulumian, M. & Brouwer, D.: Risk Assessment of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations from the Combustion of Coal in a Controlled Laboratory Environment, *International journal of environmental research and public health,* **16** (2018) No. 1, pp. 95. https://doi.org/10.3390/ijerph16010095

[5] Dehghani, M., Mohammadpour, A., Abbasi, A., Rostami, I., Gharehchahi, E., Derakhshan, Z., Ferrante, M. & Conti, G. O.: Health risks of inhalation exposure to BTEX in a municipal wastewater treatment plant in Middle East city: Shiraz, Iran, *Environmental research*, 204 (2022). 112155. https://doi.org/10.1016/j.envres.2021.112155

[6] International Agency for Research on Cancer. List of agents classified by the IARC monographs. International Agency for Research on Cancer, IARC, Lyon, France, 1–105. https://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf.

[7] Pauline, M. & Buck Louis, G.M.: *Environmental contaminants, female reproductive health and fertility*, In Woodruff, T.J., Janssen, S.J., Guillette, Jr LJ. & Giudice, L.C., eds. *Environmental Impacts on Reproductive Health and Fertility*, Cambridge University Press, (2010)

[8] Hoseini, M., Samaei, M.R., Shahesmaeili, A., Martínez, S.S. & Amiri, H.: Using biomonitoring as a complementary approach in BTEX exposure assessment in the general population and occupational settings: a systematic review and meta-analysis, *Reviews on Environmental Health*, **38** (2023) No. 3, pp. 493-510. DOI: 10.1515/reveh-2022-0042. PMID: 35751850.

[9] Kamani, H., Baniasadi, M., Abdipour, H., Mohammadi, L., Rayegannakhost, S., Moein, H. & Azari, A.: Health risk assessment of BTEX compounds (benzene, toluene, ethylbenzene and xylene) in different indoor air using Monte Carlo simulation in Zahedan city, Iran, *Heliyon*, **9** (2023) No. 9, e20294. https://doi.org/10.1016/j.heliyon.2023.e20294

[10] Montero-Montoya, R., López-Vargas, R., & Arellano-Aguilar, O.: Volatile Organic Compounds in Air: Sources, Distribution, Exposure and Associated Illnesses in Children. *Annals of global health*, **84** (2018), No. 2, pp. 225–238. https://doi.org/10.29024/aogh.910

[11] Barreto, G., Madureira, D., Capani, F., Aon-Bertolino, L., Saraceno, E,. & Alvarez-Giraldez, L.D.: The role of catechols and free radicals in benzene toxicity: An oxidative DNA damage pathway, *Environ Mol Mutagen*. **50** (2009), pp. 771–80. DOI: 10.1002/em.20500

[12] Dehghani, M., Fazlzadeh, M., Sorooshian, A., Tabatabaee, H. R., Miri, M., Baghani, A. N., Delikhoon, M., Mahvi, A. H. & Rashidi, M.: Characteristics and health effects of BTEX in a hot spot for urban pollution, *Ecotoxicology and environmental safety*, **155** (2018) pp. 133–143. https://doi.org/10.1016/j.ecoenv.2018.02.065

[13] Badjagbo, K., Loranger, S., Moore, S., Tardif, R., & Sauvé, S.: BTEX Exposures among Automobile Mechanics and Painters and Their Associated Health Risks, *Human and Ecological Risk Assessment: An International Journal*, **16** (2010) No. 2, pp. 301–316. https://doi.org/10.1080/10807031003670071

[14] Martins, E. M., Borba, P. F. D. S., Dos Santos, N. E., Dos Reis, P. T. B., Silveira, R. S., Felzenszwalb, I., ... & Correa, S. M.: BTEX in an occupational environment, *International Journal of Environmental Impacts*, **2** (2019) No. 2, pp. 174-191, DOI: 10.2495/EI-V2-N2-174-191

[15] Anigilaje, E. A., Nasir, Z. A. & Walton, C.: Exposure to benzene, toluene, ethylbenzene, and xylene (BTEX) at Nigeria's petrol stations: a review of current status, challenges and future directions, *Frontiers in public health*, **12** (2024), 1295758, https://doi.org/10.3389/fpubh.2024.1295758

[16] Zheng, H., Kong, S., Xing, X., Mao, Y., Hu, T., Ding, Y., et al.: Monitoring of volatile organic compounds (VOCs) from an oil and gas station in northwest China for 1 year, *Atmos. Chem. Phys.,* **18** (2018) pp. 4567–95. doi: 10.5194/acp-18-4567-2018

[17] Farshad, A., Oliaei, H. K., Mirkazemi, R. & Bakand, S.: Risk assessment of benzene, toluene, ethyl benzene and xylenes (BTEX) in paint plants of two automotive industries in Iran by using the COSHH guideline, *European Science Journal*, **3** (2013) pp. 270–276.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

PESTICIDES IN FOOD AND THE ENVIRONMENT- IMPACT ON HUMAN HEALTH

Jasna Halambek[1], Iva Putanec[1], Ivana Kolić[1], Sandra Zavadlav[1]

[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47 000 Karlovac, Croatia, jasna.halambek@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47 000 Karlovac, Croatia, studentica

[3] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47 000 Karlovac, Croatia, ivana.kolic@vuka,.hr

[4] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47 000 Karlovac, Croatia, sandra.zavadlav@vuka.hr

Abstract: *Although pesticides are crucial for ensuring the stability and productivity of agricultural systems around the world, their use brings with it a number of complex problems and risks for people and the environment. Long after application, these harmful substances remain in the ecosystem and directly enter the food chain. Fruits and vegetables are most often treated with pesticides, but their traces can also be found in cereals, meat, meat products and animal milk. Therefore, registration, placing on the market and use of pesticides is regulated by strict regulations. Human exposure to pesticides can result in a range of health problems, including acute poisoning, chronic diseases, neurological disorders, reproductive problems and damage to the endocrine system. This paper provides an overview of the most commonly used pesticides whose residues in food lead to damage to human health, but also to the irreversible destruction of the ecosystem.*

Keywords: *food, environment, human health, pesticides*

1. INTRODUCTION

According to the definition of FAO (Food and Agriculture Organization of the United Nations), pesticides are any substance or mixture of substances whose purpose is to prevent, destroy and control any intruder that causes human or animal diseases. They are also used to prevent, destroy and control unwanted plant or animal species that cause damage in the production, storage, transport or sale of food, agricultural crops, wood and wood products, as well as in the production of animal feed [1]. Over the past 60 years, farmers have made significant progress in the use of pesticides in food production. They do this primarily to prevent or reduce agricultural losses due to pest activity, thus increasing yields and food supplies at reasonable costs throughout the season. The use of pesticides in agriculture in most countries has greatly increased the productivity of agricultural production. On the other hand, the use of pesticides causes various environmental problems, including hazards to human and animal welfare. Pesticides after application remain accumulated in plants as well as on their surface, thus entering the food chain of many wild and domestic animals, and ultimately of humans themselves. Food affected by toxic pesticides is associated with serious consequences for human well-being because it is an essential necessity of life. Various complex interactions between pesticides and the environment have been investigated over the years [2]. Given the extensive use of pesticides worldwide, it is important to understand how these chemical compounds affect soil, water, air and human health.

2. SYNTHETIC PESTICIDES IN AGRICULTURE AND FOOD STORAGE

There are different types of pesticides and they include insecticides (used to control insects), herbicides (used to control weeds), fungicides (used to control fungi), rodenticides (used to control rats and mice), as well as other types of specialized pesticides for different purposes. Synthetic pesticides, which are designed and produced in laboratories, are often more effective and last longer than natural pesticides, but they can also be more harmful to the environment and human health. Some of the most well-known synthetic pesticides include organophosphates, organochlorides, and carbamates [3].

Fruits and vegetables are most often treated with pesticides, but their traces can also be found in cereals, meat, meat products and animal milk. Farmers sometimes use pesticides more than 20 times during the cultivation of certain foods, and then other chemicals are often used to keep the foods fresh as long as possible during storage.

Among all groups of pesticides, zoocides that are intended to control harmful organisms of animal origin (insecticides, acaricides, nematocides, rodenticides and limacides) are characterized by the highest toxicity for humans and non-target organisms.

Organochlorine compounds are a class of pesticides that are mostly banned due to their persistent toxicity and ability to bioaccumulation in the environment. Among the most famous pesticides in this group was DDT (dichlorodiphenyltrichloroethane), which was widely used for its effectiveness in controlling insects, while today its use is banned. In addition to DDT, dicofol, aldrin, dieldrin, endrin, endosulfan, lindane and toxaphene were also widely used. All active substances from this group have long been banned in all developed countries. Most insecticides from the group of chlorinated hydrocarbons were quickly and effectively replaced by insecticides from other groups, especially organophosphorus insecticides and carbamates. Lindane and endosulfan remained on the market the longest. In the last years of its application in the EU, lindane was used as a soil insecticide, while endosulfan was used in field crops and vineyards due to its good insecticidal and acaricidal effect.

Organophosphorus insecticides include insecticides such as malathion, parathion, diazinon etc. They work by inhibiting enzymes in the insect's nervous system, resulting in paralysis and death. In Croatia, about 30 years ago, 135 preparations based on 44 active substances of OP insecticides were registered on the market, and today only four active substances are allowed. An example of efforts to ban certain substances from this group of insecticides is the ban on chlorpyrifos and chlorpyrifos-methyl in the EU. Chlorpyrifos is a neurotoxic insecticide that regulates development. It was one of the most widely used insecticides in Europe. As more and more evidence linked it to serious health disorders, it was banned in the EU in 2020 [4].

Carbamates are pesticides that act by inhibiting enzymes in the nervous system of insects, they may be less toxic than organophosphorus compounds, but they still pose a risk to humans and the environment. Monomethyl and dimethylcarboxylic acid esters are very similar to organophosphates in their mode of action. Representatives of this group of compounds are: dioxacarb, methiocarb and propoxur.

Chemical fungicides can be divided into inorganic and organic. Inorganic fungicides act superficially (contact) because they remain on the surface of plant organs after application, preventing infections. The two main groups of inorganic fungicides are copper sulfate and sulfur. Organic fungicides can be divided into two subgroups. The first subgroup is organic fungicides with surface action (non-systemic), such as dithiocarbamates and phthalimides. Some active substances in pesticides and their toxicity and field of application are listed in Table 1.

Table 1: Toxicity and field of application of some active substances in pesticides [5].

Type of pesticides	Active substance	LD_{50} (mg/kg)	Application
Organophosphorus insecticides	Malathion	570	Field crops and Mediterranean fruit
	Parathion	5-10	Fruits, vegetables, nuts, and grains
	Diazinon	17-214	Pest insects in soil, fruit and vegetable field crops
	Pirimiphos-methyl	2000	Stored corn and sorghum grain and seed
	Chlorpyrifos	135	Corn, soybeans, wheat
	Phoksim	1880	Field crops, potatoes; beet oil; carrot
Carbamates insecticides	Carbofuran	8-14	Corn, potatoes, soybeans
	Methiocarb	30	Soil and/or seed treatment
	Pirimicarb	15	For controlling aphids
Systemic fungicide	Difenoconazole	1453	Many fruits, vegetables, cereals and other field crops
	Ipconazole	1800	Seed treatment before planting outdoors
	Captan	5000	Apple, cherry, grape, tomato
	Glufosinat	30-45	Control of many annual

Aminophosphonates herbicides			broadleaf and grass weeds
	Glyphosate	10500	Annual broadleaf weeds and grasses that compete with crops
Triazine herbicides	Atrazine	1000	Pre-emergence broadleaf weeds in crops such as corn, soybean and sugarcane
	Metribuzin	700	Soybeans, potatoes, carrots, corn, and tomatoes.
	Metamitron	1450	Selective pre- and post-emergence herbicide in sugar beets

Selective herbicides and broad-spectrum herbicides are the two main categories of herbicides used for weed control, but they differ in their effectiveness in specific applications. Selective herbicides are formulated to target specific types of weeds or plants while minimizing damage to desired crops or plants. These herbicides are often used in agriculture, horticulture and forestry where it is necessary to control certain weeds without harming crops or other plants. For example, some selective herbicides can target broadleaf weeds in cereal crops while leaving the crop intact [2,5].

2.1. Pesticide residues in food

The use of pesticides on crops and the levels of residues in food are strictly controlled and, when used correctly, do not cause public health or environmental problems. However, if there is inappropriate treatment and non-compliance with safety recommendations, undesirable pesticide residues on agricultural products can be transferred to food intended for human consumption.

According to a list made by the Environmental Working Group from the United States of America, in 2023, which specializes in detecting harmful substances in food (Dirty dosen), the most pesticides are found in the following foods, in the order listed: strawberries, spinach, peaches, pears, nectarines, apples, grapes, peppers and hot peppers, cherries, blueberries and green beans [6]. Citrus fruits are also heavily treated with pesticides, although they are sometimes not on the "most dangerous" food lists because the peel, which contains the highest concentration of toxins, is usually not consumed directly.

Pesticide residue levels on fruits and vegetables can usually be reduced by washing, peeling and heat treatment. Pesticide residues in canned food can be reduced by washing, blanching, peeling and cooking, but they can also increase during processing. Their concentration increases, for example, during the production of oil from oilseeds or in the process of drying fruit and in tomato concentrates due to the loss of water during the processing method.

The Maximum Residue Level (MRL) represents the highest permitted amount of pesticides that is legally allowed in or on food and animal feed. In order to determine the safety of maximum permitted pesticide residues in products of plant or animal origin placed on the market in the EU, a risk assessment is carried out. This risk assessment is carried out by the European Food Safety Authority (EFSA), which uses scientific data and research to assess the impact of pesticides on human health and the environment.

Generally speaking, the members of the European Union consume food without unwanted pesticide residues to the greatest extent. Most of the analyzed samples originate from the countries of the European Union, 67% of them, while a quarter of the samples are from third countries, about 26.4%, while the origin of 6.6% of the samples is unknown. Precisely in the samples of countries that do not belong to the European Union, the percentage of pesticides is three times higher than in the samples of member states [7].

3. PESTICIDES IN THE ENVIRONMENT

When using pesticides, the problem of long-term accumulation and persistence in the environment arises. Some types of pesticides may degrade more slowly or accumulate in soil, water, or plant or animal tissues. This can lead to long-term environmental contamination and potential risks to human health and ecosystems.

Pesticides have a significant impact on the soil, both in the short term and in the long term. Their application can result in soil contamination, which can negatively affect its fertility and biological activity. In the short term, pesticides can act directly on soil microorganisms, including bacteria, fungi, and other organisms that are critical to organic matter decomposition and nutrient cycling. In the long term, pesticides can have accumulative effects in the soil. This can cause problems for subsequent crops or crops grown in contaminated areas, as well as potential risks to the health of humans and animals that consume products from such areas. The use of pesticides can lead to a decrease in the populations of beneficial microorganisms in the soil that are responsible for nitrogen fixation or decomposition of organic matter, which can disrupt natural processes in the soil and reduce its fertility [8].

Pesticides have a significant impact on water resources, including surface water such as rivers, lakes and streams, as well as groundwater. Surface waters are particularly sensitive to pesticide pollution. After application, pesticides can be washed off the soil surface during rainfall or irrigation events and then carried into nearby watercourses. Here, they can cause water contamination and serious ecological damage, including the death of fish and other aquatic organisms, the disruption of aquatic habitat ecosystems, and the reduction of water quality for drinking and other purposes. Pesticides can infiltrate the soil and reach deeper layers, where they can contaminate groundwater. This poses a serious risk to drinking water supplies and may require expensive treatment procedures to remove pesticides from drinking water [9].

When pesticides are sprayed or applied on agricultural land or in urban areas, some of these chemicals can evaporate into the atmosphere and become aerosolized, meaning they are in the form of tiny particles in the air. These pesticide aerosols can travel long distances from the application site, which can result in further spread of pesticide contamination. For example, pesticides released into the atmosphere on agricultural land can be transported by wind to remote areas, where they can contaminate soil, water and plant life. Moreover, some pesticides can react with other pollutants in the air, such as nitrogen oxides or organic compounds present in the atmosphere, under the influence of sunlight and other atmospheric factors. These processes can result in the formation of new compounds, including those harmful to human health and the environment, such as ozone and the lower layers of the atmosphere [5,9].

4. IMPACT OF PESTICIDES ON HUMAN HEALTH

Pesticides are designed to be toxic, so accidental exposure to them is extremely dangerous. Research has shown a connection between exposure to pesticides and various diseases. People are exposed to these dangers because they handle pesticides, but also because they come into contact with the environment that is polluted with pesticides.

Pesticides have various toxic effects on humans. Once introduced into the body, pesticides spread to all organs via the bloodstream, and are excreted through urine, exhalation and skin. While present in the body, they can cause a number of diseases and disorders, the severity of which depends on the toxicity of the pesticide and the level of exposure. Groups such as pregnant women, children and the elderly are particularly vulnerable. Research has shown that exposure to pesticides can be associated with various diseases, including cancer, leukemia, asthma, diabetes, and reduced reproductive capacity in men. Moreover, long-term exposure to low doses of pesticides has been linked to a variety of health problems, including neurological disorders, cancer, hormonal imbalance, and liver and kidney damage. Acute exposure to high concentrations of pesticides can cause immediate health problems such as nausea, vomiting, headaches, dizziness and even death. These incidents often occur in farmers, workers in the pesticide industry, and people living near treated fields [10].

5. CONCLUSION

Although pesticides are crucial for ensuring the stability and productivity of agricultural systems around the world, their use brings with it a number of complex problems and risks for people and the environment. Although many effective pesticides such as DDT, lindane and chlorpyrifos are banned for use in the EU, there are still chemical substances that are widely used to treat plant crops and pose a potential danger to human health. While present in the body, they can cause a number of diseases and disorders such as neurological disorders, cancer, hormonal imbalance, liver and kidney damage, and reduced reproductive capacity in men.

The impact of pesticides on the environment includes soil, water, air and ecosystem contamination. Pesticides can have toxic effects on non-target organisms, including birds, fish, insects and other beneficial organisms. The accumulation of pesticides in the environment can threaten the stability of ecosystems and the sustainability of natural resources in the long term.

Therefore, it is important to conduct detailed research and risk assessments for each pesticide to understand its potential effects and to apply strict regulations and pesticide management practices to minimize their negative effects on the environment and human health.

REFERENCES

[1] Želježić, D., Perković, P.: Uporaba pesticida i postojeće pravne odredbe za njezinu regulaciju, Sigurnost, 53 (2011), 141-150.
[2] Aktar, W., Sengupta, D., Chowdhury, A.: Impact of pesticides use in agriculture: their benefits and hazards, Interdisciplinary toxicology, 2 (2009), 1-12. doi: 10.2478/v10102-009-0001-7
[3] Carvalho, P.F.: Pesticides, environment and food safety, Food and Energy Security (2017) 48-60.
[4] Virić Gašparić, H., Bažok, R.: Tržište zoocida nekad i danas: što se promijenilo u posljednjih 30 godina?, Glasilo biljne zaštite, 18(6), (2018) 550-557.
[5] Kim K. H., Kabir E., Jahan S. A.: Exposure to pesticides and the associated human health effects, Sci. Total Environ., 575, (2017) 525–535.
[6] Dirty Dozen: EW's 2023 Shopper's Guide to Pesticide sin Produce (2023). https://www.ewg.org/foodnews/summary.php
[7] G. Jurak, I. Sabljak: Što o proizvodima biljnog podrijetla na hrvatskom tržištu govore analize ostataka pesticida, Glasilo biljne zaštite, 20 (3), (2020) 333-339.
[8] Arias-Estévez M., López-Periago E., Martínez-Carballo E., Simal-Gándara J., Mejuto C. J., García-Río L.: The mobility and degradation of pesticides in soils and the pollution of groundwater resources, Agric. Ecosyst. Environ.,123(4), (2008) 247–260.
[9] Mosalaei Rad, S., Ray, A.K., Barghi, S.: Water Pollution and Agriculture Pesticide, Clean Technol., 4 (2022) 1088–1102.
[10] Shah, R.: Pesticides and Human Health, in Emerging Contaminants (ed. Nuro, A.) (2021), Doi: 10.5772/intechopen.87857.

THE IMPORTANCE OF MONITORING THE VALUE OF BODY MEASUREMENTS IN THE FUNCTION OF HEALTH

Renata Hrženjak, Ksenija Doležal, Blaženka Brlobašić Šajatović

[1] University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, Zagreb, HRVATSKA, renata.hrzenjak@ttf.unizg.hr; ksenija.dolezal@ttf.unizg.hr; blazenka.brlobasic@ttf.unizg.hr

Abstract: *According to the WHO, the percentage of overweight children and adolescents has increased by almost 50% in the last two decades of the 20th century. It has long been known that about 40% of overweight children continue to gain weight in adolescence and 75-80% of obese adolescents become obese adults. A child with a high body mass index (BMI) has a high risk of being overweight or obese by the age of 35, and this risk increases with age.*

In this study, a sample of 4045 young men aged 13 to 20 years was analysed. The body measurements taken were body height, chest girth, waist girth and hip girth. The young men were also weighed and their BMI was calculated.

Keywords: *body measurements, young men, body mass index, health*

1. INTRODUCTION

Adolescence is a crucial time for the development and establishment of health habits. Habits developed during adolescence are considered a transitional phase and often continue into adulthood, which can influence the development of overweight and obesity [1]. Healthy behaviours started in childhood, such as physical activity and healthy nutrition, should be maintained in adolescence [2-3]. A priority for policy should be to develop a coordinated response to the structural and social determinants of adolescent obesity, food insecurity, poor access to healthy foods and exposure to unhealthy environmental conditions [4].

Early studies from a number of European countries have shown an increase in the prevalence of overweight and obesity or mean body mass index (BMI) in children and adolescents [5]. In addition, a decrease in physical activity and an increase in the consumption of foods high in fat, sugar and salt (HFSS) have been observed [6,7]. These observations emphasise the importance of achieving a better recovery, especially after the COVID-19 pandemic, including the prevention and control of obesity [7].

In this study, the results of measuring the main body measurements of young men in the Republic of Croatia are presented. The body mass index was calculated on the basis of body height and body mass using percentile values. The results obtained were compared with the currently valid WHO percentile curves.

2. EXPERIMENTAL

This study includes a sample of 4,045 young men aged 13 to 20 years measured in the Republic of Croatia. The sample is divided into 8 age groups. The study was conducted by the Faculty of Textile Technology of the University of Zagreb in cooperation with several institutions (Institute of Anthropology in Zagreb, School of National Health "Andrija Štampar" - Faculty of Medicine of the University of Zagreb, Faculty of Medicine of the University of Split, Faculty of Philosophy of the University of Osijek and Faculty of Economics & Business of the University of Zagreb). Body measurements were taken according to the ISO standard, which includes height, chest girth, waist and hips. The body mass index was calculated from the height and body mass.

Body mass index (BMI) is a valuable indicator for assessing whether a person is obese or undernourished. The BMI was calculated according to equation (1) [8]:

$$BMI\ (kg/m^2) = (body\ mass\ in\ kg)/(body\ height\ in\ meters)^2 \quad \textbf{(1)}$$

In older children and adolescents, BMI is closely related to body fat percentage, which is of particular importance. In terms of BMI, children with a BMI value below the 5th percentile are malnourished, children with a value of 85th percentile or more are at risk of obesity, while children with a value of 95th percentile or more are obese. The basic benefits of using BMI are: use for adolescents after puberty, BMI correlates with lab values with body mass, BMI is associated with health risks, 60% of children and adolescents with a BMI above the 95th percentile have at least one risk factor and 20% have two or more risk factors for cardiovascular disease. Obese children have a higher risk of becoming obese adults; the standards for determining obesity and overweight in children and adolescents are the same as for adults [9].

The SPSS statistical package was used to analyse the data in this study. The descriptive statistics include the estimation of the parameters of central tendency and dispersion.

3. RESULTS AND DISCUSSION

Tables 1-4 show descriptive statistics of changes in body measurements of young men, including body height, chest girth, waist girth and hip girth. BMI was calculated and presented by mean, percentile and age in Figure 1.

Analysing the results presented in the table shows that the body measurements of young men change according to age. Body height increases proportionally from 13 to 18 years and then stabilises. The average body height of a 13-year-old boy is 160.8 cm, while that of a 20-year-old boy is 178.9 cm.

Table 1: Descriptive statistics of the body height of young men distributed by age

Age (years)	N [a]	$\overline{x}$ [b]	s [c]	CV [d] (%)	95% CI [e]		Range	
					h1	h2	Min	Max
13	492	160.8	9.3	5.8	160.0	161.7	133.0	190.0
14	526	167.4	9.1	5.4	166.6	168.2	144.0	192.5
15	502	172.8	8.5	4.9	172.1	173.6	147.0	195.0
16	520	176.4	6.8	3.9	175.9	177.0	148.0	194.7
17	504	177.8	7.8	4.4	177.2	178.5	154.0	201.0
18	508	178.6	7.3	4.1	177.9	179.3	153.0	200.5
19	527	179.2	6.9	3.9	178.6	179.8	158.0	198.0
20	466	179.0	7.2	4.0	178.3	179.6	152.0	201.0
Total	4045	174.0	10.1	5.8	173.7	174.3	133.0	201.0

[a] number of subjects, [b] mean, [c] standard deviation, [d] coefficient of variation,
[e] 95% confidence interval

Table 2: Descriptive statistics of the chest girth of young men distributed by age

Age (years)	N [a]	$\overline{x}$ [b]	s [c]	CV [d] (%)	95% CI [e]		Range	
					h1	h2	Min	Max
13	492	78.0	8.7	11.2	77.2	78.8	63.0	114.0
14	526	81.3	8.1	9.9	80.6	82.0	57.5	112.0
15	502	85.8	8.0	9.3	85.1	86.5	66.0	120.0
16	520	88.3	7.3	8.3	87.6	88.9	69.0	124.0
17	504	90.7	7.9	8.7	90.0	91.4	72.0	131.0
18	508	91.5	7.9	8.6	90.8	92.2	70.0	135.0
19	527	93.5	7.5	8.0	92.8	94.1	72.5	135.0
20	466	94.4	7.8	8.3	93.7	88.2	57.5	135.0
Total	4045	87.9	9.6	10.9	87.6	88.2	57.5	135.0

[a] number of subjects, [b] mean, [c] standard deviation, [d] coefficient of variation,
[e] 95% confidence interval

Table 3: Descriptive statistics of the waist girth of young men distributed by age

Age (years)	N [a]	$\overline{x}$ [b]	s [c]	CV [d] (%)	95% CI [e]		Range	
					h1	h2	Min	Max
13	492	71.7	10.0	13.9	70.8	72.6	54.0	114.5
14	526	72.8	8.7	12.0	72.1	73.6	55.0	113.5
15	502	76.2	9.0	11.8	75.4	76.9	55.0	113.0
16	520	77.6	8.6	11.1	76.8	78.3	61.0	117.0
17	504	79.4	9.6	12.1	78.6	80.3	59.0	130.0
18	508	80.8	8.7	10.8	80.0	81.5	62.0	131.0
19	527	82.9	9.3	11.2	82.1	83.7	62.5	130.0
20	466	83.3	9.2	11.0	82.4	84.1	58.0	130.0
Total	4045	78.0	10.0	12.8	77.7	78.4	54.0	131.0

[a] number of subjects, [b] mean, [c] standard deviation, [d] coefficient of variation,
[e] 95% confidence interval

Table 4: Descriptive statistics of the hip girth of young men distributed by age

Age (years)	N [a]	$\overline{x}$ [b]	s [c]	CV [d] (%)	95% CI [e]		Range	
					h1	h2	Min	Max
13	492	86.8	9.3	10.7	86.0	87.6	60.0	126.0
14	526	89.9	8.4	9.3	89.2	90.6	66.0	122.0
15	502	94.1	8.1	8.6	93.3	94.8	68.0	128.0
16	520	96.3	7.5	7.8	95.6	96.9	70.0	127.0
17	504	97.8	8.3	8.5	97.1	98.6	74.0	152.0
18	508	98.6	7.3	7.4	97.9	99.2	81.0	137.0
19	527	99.8	7.9	7.9	99.1	100.5	79.0	155.0
20	466	99.9	7.7	7.7	99.2	100.6	73.0	138.0
Total	4045	95.4	9.2	9.6	95.1	95.7	60.0	155.0

[a] number of subjects, [b] mean, [c] standard deviation, [d] coefficient of variation,
[e] 95% confidence interval

The average values of the measurements of all scales increase with increasing years of life. In this case, the differences in the growth of the chest girth in young men aged 13 to 20 years are 16.4 cm, the waist girth 11.6 cm and the hip girth 13.1 cm.

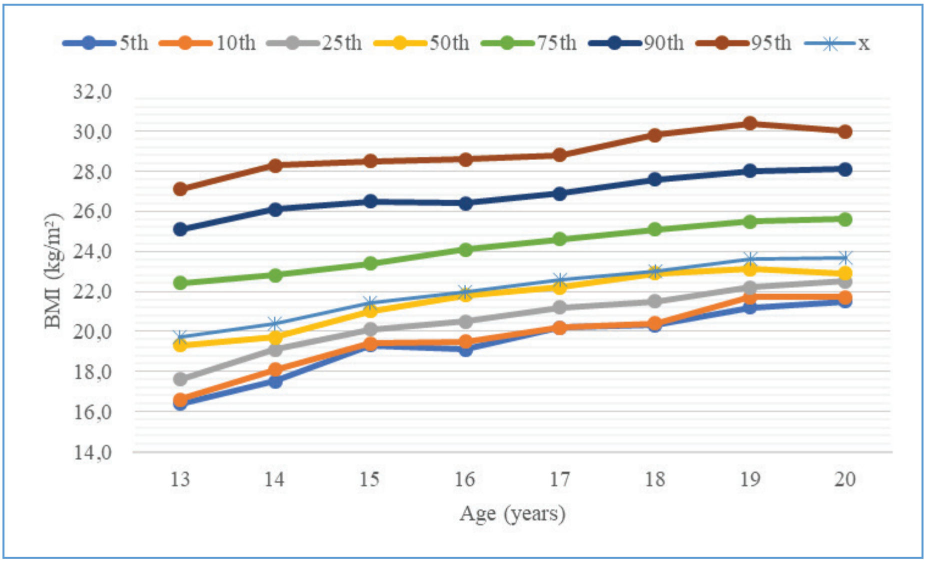


Figure 1: BMI for the young men aged 13 to 20 years

A comparison of Figure 1 with percentile curves [10] shows that the average BMI of Croatian young men is between the 50th and 75th percentile, which corresponds to a normal range. At the same time, 5% of young men aged 13 to 19 years are obese (≥ 95th percentile).

4. CONCLUSION

Although health literacy is important at all stages of life, it is particularly valuable during adolescence as young people begin to make their own decisions regarding their health [11]. Most overweight or obese children today live in developing countries, where the rate of increase is much higher than in industrialised countries and regions, largely due to changing dietary habits and increasingly sedentary lifestyles [12].

The results of this study show that the average BMI of young men in the Republic of Croatia between the ages of 13 and 20 is closer to the 50th percentile, which corresponds to a normal range. In order to prevent overweight and obese adolescents from becoming obese adults, it is necessary to continuously monitor the body measurements and BMI of a specific population group, such as the young men in this study.

Funding

The publication of this work was funded by the University of Zagreb *Monitoring changes in body measurements for the production patterns of children's and women's clothing* (TP10/24).

REFERENCES

[1] Mikkelsen, B. et al.: Life course approach to prevention and control of non-communicable diseases, *BMJ*, (2019);364, doi: 10.1136/bmj.l257, *Accessed:* 2024-05-20

[2] World Health Organization: *Physical activity strategy for the WHO European region 2016-2025.,* WHO Europe, ISBN 978 92 890 5147 7, Copenhagen, Denmark (2016)

[3] World Health Organization: *Investing in children: The European child and adolescent health strategy 2015-2020.*, WHO Europe, Copenhagen, Denmark (2014), *Available from* https://iris.who.int/handle/10665/337284 *Accessed:* 2024-05-20

[4] Inchley, J.: *Adolescent obesity and related behaviours: trends and inequalities in the WHO European region, 2002-2014: Observations from the Health Behavior in School-aged Children (HBSC) WHO Collaborative Cross-national Study*, WHO Europe, ISBN 978 92 890 5240 5, Copenhagen, Denmark (2017)

[5] World Health Organization: *Population-based prevention strategies for childhood obesity*, WHO Europe, Copenhagen, Denmark (2010), *Available from* https://apps.who.int/iris/handle/10665/44312, *Accessed:* 2024-05-25

[6] Allender, S. et al.: Policy change to create supportive environments for physical activity and healthy eating: which options are the most realistic for local government? , *Health Promotion International* **Vol.** 27 (2012) No. 2, pp. 261–274. *Available from* https://doi.org/10.1093/heapro/dar018, *Accessed:* 2024-05-25

[7] World Health Organization: WHO European Regional Obesity Report 2022, ISBN 978-92-890-5773-8, Copenhagen, Denmark (2022)

[8] Meltzer, A. et al: Weight history and hypertension, *Journal of Clinical Epidemiology*, **Vol.** 41 (1988), pp. 867-874

[9] Ujević, D. et al: *Croatian Anthropometric System – Basis for New Croatian Standards of Clothing and Footwear Measurements (in Croatian)*, Faculty of Textile Technology University of Zagreb, ISBN 953-7105-09-1, Zagreb, (2006)

[10] BMI for age, *Available from* https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age, *Accessed:* 2024-06-10

[11] World Health Organization: Shanghai declaration on promoting health in the 2030 agenda for sustainable development, *Report on the 9th Global conference for health promotion*, 21–24 November 2016: all for health, health for all, Shanghai, China, (2017), *Available from* https://www.who.int/publications/i/item/WHO-NMH-PND-17.5, *Accessed:* 2024-06-02

[12] Gupta, N. et al.: Childhood obesity in developing countries: epidemiology, determinants and prevention, *Endocrine Reviews*, **Vol.** 33 (2012) No. 1, pp. 48–70, ISSN (print journal): 0163-769X, ISSN (online): 1945-7189

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

ASSESSMENT OF UNPLEASANT ODORS IN THE WORKING ENVIRONMENT

Marko Kršulja[1]; Dinko Jurjević[2]; Damir Karabaić[3]

[1] Juraj Dobrila University of Pula, Faculty of Engineering, Zagrebačka 30, 52100 Pula, CROATIA, mkrsulja@unipu.hr

[2] Polytechnic in Rijeka, Vukovarska 58, 51000 Rijeka, CROATIA, dinko.jurjevic@gmail.com

[3] Juraj Dobrila University of Pula, Faculty of Engineering, Zagrebačka 30, 52100 Pula, CROATIA, damir.karabaic@unipu.hr

Abstract: *This paper examines unpleasant odors and their impact on workers' health and indirect impact on the production process. Examination of the working environment based on the regulations of the Republic of Croatia, which are harmonized with EU regulations, includes: examinations of physical factors (temperature, relative humidity and speed of air flow, illumination, noise and vibrations), examinations of chemical factors (concentration of gases, steam, dust and aerosols), examinations of biological factors. The results of a survey of workers from various workplaces confirmed that workers are burdened by unpleasant odors, without any measures of occupational safety being recorded. Under the mentioned circumstances, the authors of this paper believe that it is necessary to supplement the risk assessment with the point - unpleasant odors, or rather - unacceptable odors. Unpleasant odors need to be detected sensorially and by survey and then evaluated and, if necessary, measured by the so-called e-nose.*

Keywords: *unpleasant odors, risk assessment, e-nose, occupational safety*

1. INTRODUCTION

The concept of unpleasant odors is an indeterminate term and it is clear that it is the opinion of most people whether something is unpleasant and how much. For this reason, the first indicator of inconvenience is the opinion of people who work or live in this environment. A survey of workers of different activities who encounter unpleasant odors confirmed that unpleasant odors have an impact on them and it was also observed that in no act of occupational safety this disturbance was considered more closely. All the more so because under the term – small risks, a number of spaces is not even assessed on the basis of the Ordinance on risk assessment, such as office spaces, although there the concentration of unpleasant odors from furniture and various cladding can be significant. The regulations of Austria and Germany on this topic provide guidance for the procedures for identifying undesirable odors [1- 4]. The paper also points out that the unpleasant smell of man does not have only harmful substances, nor do all harmful substances have an unpleasant odor or may not have it. In industry and everyday life, substances are used that can have very unpleasant odors, and workers must spend 8 hours a day in such places. Workers who work with unpleasant odors and forcibly linger in such an environment have been found to work under stress, and some odors can cause other health problems [5-12]. Smell is directly related to the limbic system, that is, to feelings, and the hypothalamus, which is responsible for responding to external stimuli [13]. With unpleasant odors, young people are more likely to feel disturbed than older people. This is also due to the fact that the sense of smell decreases with age [14]. Those that cause odors often do not have sensitivity to these stimuli. The baker in the bakery often under high temperature and risk of thermal stress does not notice the smell of bread any more than the peasant does not notice the smell of manure [15]. The brain interprets unpleasant odors as a warning signal [16]. If the brain interprets some smell as threatening, the human organism prepares for fight or flight based on its evolutionary history. This is how people have been rescued from life-threatening situations for thousands of years. But running away today is not always possible or desirable. In any case, those affected must suppress their natural reactions, even though they are irritated or permanently distracted by the smell. It means constant stress [16]. After a while, this can cause health problems such as headaches, nausea, fatigue, high blood pressure or tension. The human nervous system and brain respond directly to odors and irritants. Not only the irritating effect, but also the olfactory effect can affect attention and, in the worst case, lead to the wrong action and accident. For example, worker do not notice the spill of gasoline before or after a truck tanker accident [17]. Many occupational illness or work incidents are occurring and relating them to olfactory disorder [18].

2. THE MOST COMMON SOURCES OF UNPLEASANT ODORS

Chemicals: Odors associated with strong chemical substances, such as solvents, pesticides or industrial chemicals, can be considered unpleasant. Rotten odors: The decomposition of organic matter, such as rot, feces or food rot, often produces specific unpleasant odors. Smoke and flue gases: Smoke from fire, smoke from chimneys or smoke from industrial plants often has a pungent odor that many find unpleasant. Waste and sewage: Wastewater, sewage systems or landfills often produce unpleasant odors due to the presence of various chemicals and organic matter. Gases and exhaust gases: Exhaust gases from vehicles, industrial plants or other sources can produce odors that are perceived as unpleasant. Animal fragrances: Smells associated with pets, farms or industrial animal breeding are also often perceived as unpleasant. Plastics: Some plastic materials, especially those used in industry and packaging, may have a characteristic odor. Plastic odors are often associated with the release of substances such as bisphenol A (BPA) or other additives. Tire: Tires used in car tires or industrial products may have a specific smell. This smell often originates from chemical compounds such as organic sulfur compounds. Textiles: Fragrances related to textiles can come from a variety of sources, including paints, moisture resistance treatments or substances used during the manufacture of fabrics. Paints and solvents: Paints, varnishes and solvents used in construction or art projects can often have strong odors due to the evaporation of organic matter. Cosmetics and personal care products: Some perfumes, lotions, shampoos or other body care products may contain fragrances that may seem uncomfortable to someone. Fertilizers and pesticides: Agricultural products, such as fertilizers and pesticides, can produce strong odors due to the presence of chemicals used in agriculture. Electronic devices: New electronic devices, such as TVs, computers or other electronics, may emit odors due to materials used in their manufacture and substances used for cooling. Volatile organic compounds (VOCs): VOCs are often present in many products and materials used in everyday life, such as paints, varnishes, solvents, building materials, carpets, furniture, beauty products and others. Some VOCs may have a pungent or unpleasant odor that can be disturbing. For example, working with 3D printers is accompanied by unpleasant odors if the process uses plastic that dissolves to be applied by printing. Some of these emissions are harmless unpleasant odors from heated materials, and others are associated with health risks. Particularly worrying are particles and volatile organic compounds (VOCs) coming out of printers – we mean filament-based or resin-based 3D printers [2-3].

Air pollutants: Industrial plants, vehicles, smoke from heating furnaces or other sources of air pollution may emit chemical compounds or particles that have characteristic odors. Mold: Humid and humid environments can promote mold and mold growth, which can result in unpleasant odors. Cleaning chemicals: The use of powerful cleaning or disinfecting chemicals can result in sharp and unpleasant odors that may be present in the air for some time after application. Food decomposition: The presence of rotting or decomposition of food can result in strong and unpleasant odors. This can especially happen in the production of meat, dairy products, fish and other biological materials. Fermentation processes: Fermentation processes used in the production of fermented products such as cheese, yogurt, sauerkraut and other fermented products can produce specific odors that can be considered unpleasant. Oils and greases: Oil and grease heating and processing processes can produce specific odors that can spread in the environment and be perceived as unpleasant. Wastewater treatment processes: In food production plants, wastewater treatment processes can release unpleasant odors due to the presence of organic materials and chemicals in wastewater. Waste: The presence of waste, such as food or packaging scraps, can result in unpleasant odors in the environment of the food processing plant. Hydrogen sulfide (H2S): H2S is a gas with a characteristic smell of egg rot. It can be a by-product of various chemical processes, such as oil and gas production, sulfur production, refineries and others. Ammonia (NH3): Ammonia is a pungent and penetrating odor gas used in many chemical processes, including the production of fertilizers, chemicals, cosmetics and other products. Sulfur dioxide (SO2): SO2 is a pungent-smelling gas that is often released during the fossil fuel combustion process in industry, as well as during the production of sulfur and chemicals. Organic acids: Various organic acids, such as acetic acid or butyric acid, can have harsh and unpleasant odors and are used in a variety of industrial processes, including the production of chemicals, plastics and other products. Aldehydes such as formaldehyde can have a pungent and irritating odor and are used in a variety of industrial processes, including the production of plastics, resins, adhesives and other products [2-3].

3. UNPLEASANT ODOR TESTING

Olfactometry is a method that uses the human sense of smell to assess the intensity of a smell. A panel of trained evaluators can rate olfactory samples and provide subjective grades. Olfactometry is often used in combination with other instrumental methods. Instrumental analysis: Various instruments are used to analyze odor-releasing components. Gas chromatography (GC) and mass spectrometry (MS) are often applied together to identify and quantify the specific compounds responsible for the smell. Electronic noses: These devices use sensors that respond to odorous compounds and create a specific pattern that can be analyzed. Electronic noses are fast and are often used in industry. Chemical analysis: By analyzing the chemical properties of samples, substances that cause odors can be identified. This may include testing for the presence of hydrogen sulfide, ammonia or other chemical compounds. Air analysis: Air testing for the presence of odors can be carried out using air sampling and gas analysis using various instruments. These procedures are often applied in industry, landfills, waste processing plants and other places where unwanted odors can occur [3].

4. ASSESSMENT OF UNPLEASANT ODORS RISK ASSESSMENT PROCESS DUE TO UNPLEASANT ODORS

Odor risk assessment (Table 1) is a key component of managing workers' health and safety and contributes to creating a working environment that minimizes potential adverse effects on workers' health.

Table 1: Risk assessment matrix (source authors)

Probability	Magnitude of consequences (harm)		
	A little harmful unpleasant odor is tolerable	Medium harmful unpleasant odors cause stress for workers who have to stay in that environment. Concentration drops	Unpleasant odors are of such intensity that a longer stay in such an environment is unsustainable, causes health problems
Unlikely unpleasant odors can occur during working hours, but last shorter and this is determined by the survey workers as acceptable	Low risk	Low risk	Medium risk
Unpleasant odors will appear and tarnish less than part-time	Low risk	Medium risk	Big risk
Likely, smells can last until full-time	Medium risk	Big risk	Big risk

Identification of odor sources: Identifying sources of unpleasant odors in the workplace, as well as identifying the substances that cause these odors. This may include chemical substances, organic compounds or other materials that produce specific odors.

Concentration assessment: Measuring or estimating the concentration of odoriferous substances in the air to determine how exposed workers are to these substances. Health risk determination: Analysis of exposure data to assess the risk of health problems arising from exposure to odors. This includes an assessment of the duration of exposure, odor intensity and possible adverse effects on the respiratory system, skin or general health of workers. Identification of control measures: Development and implementation of control measures to reduce workers' exposure to odors. This may include proper maintenance of equipment, the use of personal protective equipment, improvement of ventilation or changes in work procedures. Employee education: Ensuring that workers are educated about potential hazards, exposure symptoms and proper use of personal protective equipment. Monitoring and auditing: Regular monitoring of exposures and revision of control measures to ensure that they are effective and adapted to changing workplace conditions.

5. CONCLUSION

Unpleasant odors should be seen as a separate category and when they are not associated with the presence of harmful gases in the air. Fumes and substances enter respiratory system and brain tissue and can lead to lung diseases, headaches and stress that results with anosmia.

All the dangerous substances used today are not recognized by man by smell. The sense of unpleasant odors exists in man genetically and is formed by long-term evolution. And if unpleasant odors do not originate from an unpleasant substance, they should be considered and tried to be eliminated because they cause negative phenomena and if most workers can conditionally get used to them. The first method is the sensory rating of several people. If confirmed, further testing with measuring equipment is required. Medical examination of respiratory system is also needed and search of work time on a specific job, inquiry on previous jobs. Although smoking can cause olfactory disorders it can be considered but it also should be negligible when there is sufficient occupational exposure.

The notion of short-term exposure cannot be an argument for accepting unpleasant odors acceptable. A person can react to very unpleasant odors in a short time. The authors of this paper believe that the concept of unpleasant odors should be included in the risk assessment based on the knowledge of the survey of workers and the opinion of a group of environmental examiners, and especially the opinion of the team for the preparation of risk assessment, which is obliged to visit all plants and production processes. Measures that can be recommended are use of fume extraction systems for welding or grinding, painting etc. and rotation of person doing the job. Further study will consider different work-related cases with medical records.

REFERENCES

[1] Sucker K., Westphal G., Bünger J., Brüning T., *Gute oder schlechte Luft*, IPA-journal, SSN: ISSN 1612-9857, (2014)
[2] IFA Odor and sense of smell, *Available from* https://www.dguv.de/ifa/praxishilfen/innenraumarbeitsplaetze/geruch-und-geruchssinn/index-2.jsp *Accessed:* 2024-05-10.
[3] Sucker K., *Available from* https://www.haufe.de/arbeitsschutz/arbeitsschutz-office-professional/gerueche-und-reizstoffe-am-arbeitsplatz-13-bewertung-von-geruechen-am-innenraumarbeitsplatz_idesk_PI13633_HI13910353.html *Accessed:* 2024-05-10.
[4] Ermittlungen zum Arbeitsumfeld – Ermittlungsbogen G2, *Available from* https://www.dguv.de/medien/ifa/de/pub/rep/pdf/reports2013/innenraumarbeitsplaetze/ermittlungsbogen_g2.pdf *Accessed:* 2024-05-10.
[5] Occupational Safety Act R20114, H Ordinance on the preparation of risk assessment (OG 112/2014)
[6] Ordinance on environmental testing (OG 016/2016)
[7] Ordinance on the protection of workers from exposure to hazardous chemicals at work, exposure limit values and biological limit values (OG 091/2018)
[8] Ordinance on performance of occupational safety (OG 126/2019)
[9] Ordinance on safety at work places of work (OG 105/2020)
[10] Ordinance on the protection of workers from risks due to exposure to biological hazards at work (OG 129/2020)
[11] Ordinance on the use of personal protective equipment (OG 005/2021)
[12] Ordinance on occupational safety of workers exposed to statodynamic, psychophysiological and other efforts at work (OG 073/2021)
[13] Review on odour pollution, odour measurement, abatement techniques, *Available from* https://dnoses.eu/wp-content/uploads/2019/10/D2.1_Review-on-odour-pollution-measurement-abatement_v3.2.pdf *Accessed:* 2024-04-29.
[14] Is loss of taste and smell normal with aging?, *Available from* https://www.mayoclinic.org/healthy-lifestyle/healthy-aging/expert-answers/loss-of-taste-and-smell/faq-20058455 *Accessed:* 2024-04-29.
[15] Yoshinori Masuo,* Tadaaki Satou, Hiroaki Takemoto, and Kazuo Koike Smell and Stress Response in the Brain: Review of the Connection between Chemistry and Neuropharmacology;doi: 10.3390/molecules26092571, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8124235/ (29.04.2024)
[16] Kršulja Marko ; Bognolo Dario ; Kršulja Aleksandar ; Polić Dominik Prijevoz benzina u cestovnom prometu i taktika gašenja // Vatrogastvo i upravljanje požarima, XI (2021), 2; 81-92
[17] Pupavac, Drago ; Bognolo, Dario ; Kršulja, Marko Statistical analysis and grade of occupational injuries in the Republic of Croatia // Sigurnost : časopis za sigurnost u radnoj i životnoj okolini, 60 (2018), 3; 225-233. doi: 10.31306/s.60.3.5
[18] Bognolo, Dario; Matacin, Marko ; Kršulja, Aleksandar ; Kršulja, Marko Assessment of Temperature Influence at a Bakery workplace // ITE-SAFETY 2015 / Bognolo, Dario ; Ferhatović, Mensur ; Kršulja, Marko (ur.). Rijeka: Quimedia, 2015. str. 1-6

FOOD SAFETY CULTURE: COMMON WAY OF BEHAVING AND THINKING

Bojan Matijević[1]
Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, , bojan.matijevic@vuka.hr

Abstract: *Foodborne diseases is an important public health problem worldwide. The supply of safe and healthy food is crucial to prevent foodborne diseases. Food safety culture is a term introduced by recent literature, although the concept is familiar to most food companies. Food safety culture refers to the shared values, beliefs, and behaviors within an organization or community that prioritize and promote the importance of food safety. It goes beyond simply implementing food safety protocols and procedures; instead, it emphasizes the integration of a safety mindset into the everyday practices and attitudes of individuals involved in the food industry. This concept is of critical importance as it directly affects consumer welfare, the food industry's reputation and regulatory compliance.*

Keywords: *culture, food processing industry, food safety*

1. INTRODUCTION

Pathogenic agents in food, whether they are microbial (such as viruses, bacteria and parasites) or chemical (from toxins and heavy metals), to pesticide residues and veterinary drugs) carry risks to human health.

Each year, an estimated 600 million people fall ill and 420 000 people die from unsafe food, resulting in the loss of 33 million healthy life years. Children under 5 years of age are at particularly high risk, with 125000 children dying from foodborne diseases every year. These illnesses and deaths are largely preventable [1].

Consumers have the right to expect that the food they consume is safe and acceptable for use. Foodborne diseases are unpleasant at the very least and can be fatal at worst. Epidemics caused by food can have many other consequences, such as a negative impact on trade and tourism, can lead to a decrease in the income of primary producers and processors, then to an increase in unemployment and in the end even to court proceedings. Food spoilage has costly consequences and reduces the trust of consumers who expect food to be safe and of good quality.

International food trade and travel abroad are on the rise, bringing very important socio-economic benefits to the world, so the spread of diseases is certainly much, much faster under these circumstances [2].

Food safety is an extensive and complex principle of protecting consumers and their health that includes all stages in the chain "from field to table" and represents the absence or presence of an acceptable and safe level of certain substances in food that can make it harmful to human health on an acute and chronic basis. The basic principles on which the concept of food safety is based are Good Manufacturing Practice (GMP), Good Agricultural Practice (GAP), Good Distribution Practice (GDP), Good Hygienic Practice - GHP), HACCP and risk analysis. GMP, GAP, GDP and HACCP are hazard control strategies that operate at the operational level, while risk analysis represents a management approach at higher levels [2].

Food safety culture is a term introduced by recent literature, although the concept is familiar to most food companies. Food safety culture refers to the shared values, beliefs, and behaviors within an organization or community that prioritize and promote the importance of food safety.

To maintain a strong food safety culture, leaders must not only demonstrate their commitment with their own words and actions, they must also make sure that their company's policies, systems and processes incentivise good food safety decisions and behaviours at every level of the organization [3].

This concept is of critical importance as it directly affects consumer welfare, the food industry's reputation and regulatory compliance.

2. FOODBORNE DISEASE

Foodborne illness can affect anyone who eats contaminated food; however, certain populations are more susceptible to becoming ill with a greater severity of illness. These populations include infants and children, the elderly, pregnant women, people taking certain kinds of medications or immune suppressed (e.g., cancer patients, diabetics).

To prevent foodborne illness, it is necessary to understand how food becomes unsafe to eat and what proactive measures can be taken to keep food safe.

2.1. Causes of foodborne disease

The causes fall into the following 3 categories:

- *Biological hazards* include bacteria, viruses, and parasites. Bacteria and viruses are responsible for mostfoodborne illnesses. Biological hazards are the biggest threat to food safety. They can be inherent in the product or due to mishandling (e.g., time/temperature abuse) [4].
- *Chemical hazards* include natural toxins and chemical contaminants. Some natural toxins are associated with the food itself (i.e., certain mushrooms, PSP in molluscan shellfish), some are made by pathogens in the food when it is time/temperature abused (i.e., histamine development in certain seafood species). Some additives, such as sulfites, can be a hazard to some people. Chemical contamination can occur when products (i.e., cleaners) are not used correctly. Food allergens are a chemical hazard. Some people are sensitive to proteins in foods. Every food is different. Eight

major food allergens include milk, eggs, fish, crustacean shellfish (lobster, crab, shrimp), wheat, soy, peanuts, tree nuts [4].

- *Physical hazards* can include metal shavings from cans and plastic pieces or broken glass [4].

3. FOOD QUALITY AND SAFETY SYSTEMS

Food quality can be defined as a total of traits and criteria which characterize food in respect of its nutritional value, sensory value, convenience as well as safety for a consumer's health. Thus, it is a broader concept than food safety. Food safety (hazard-free) is the most important feature of food quality, hence the food law regulates this issue, in order to assure consumers that the food they purchase meet their expectations as regards safety. It is also an increasingly important public health issue. Governments all over the world are intensifying their efforts to improve food safety in response to an increasing number of food safety problems and growing consumer concerns as regards various food risks [5].

Besides, it is important to distinguish between the terms "food quality" and "food health quality". These two remain in a relationship, namely food health quality embraces only the health-related traits (that is, hazard-free and nutritional value), whilst food quality is a broader concept, covering all the features presented. Thus, in addition to food health quality related attributes, food quality comprises values such as sensory characteristics (e.g. taste of food, smell, etc.) and convenience (e.g. easy in preparation, etc.) [5].

In order to preserve the above quality features in food products, various safety and quality assurance systems have been developed. Any system constitutes systematic approach to assure that food products have particular traits at any stage of production and distribution. Some of the systems are obligatory by law and some voluntary to be implemented by the food chain actors (Figure 1).

Figure 1: Diagram of voluntary vs. obligatory quality and safety systems [6]

Food production particularly comes out of the fact that a food operator must fulfill all requirements that are specified in all law regulations, that refer to parameters of safety and other quality features of consumer demands, e.g. sensory features [5].

Food which is being produced must be completely safe for consumers' health. In connection with that, the applica tion of methods and systems that ensure the production of healthy and safe food and fulfill levels of safety specified in food law is very important.

Full responsibility of a food producer for a product's safety must be displayed in: keeping the law; using GMP//GHP rules; implementing and running the HACCP system; proper labeling of products that allows consumer to make a right choice; and using subsystems, programs, tools that enable identification of raw products used in the food production process [3].

It is obvious that most of enterprises from the food sector have already been implementing systems which are obliga tory by virtue of acts about health conditions of food and nutrition (Good Manufacturing Practice - GMP, Good Hygienic Practice - GHP, and system of Hazard Analysis and Critical Control Point - HACCP). However, the interest in implementing voluntary systems such as quality management system, environment management system or work safety and hygienic management systems is much smaller [5].

4. CULTURE AS FOOD SAFETY UPGRADE

4.1. What Is Culture?

What is culture? Well, one of the best definitions is ''Culture is patterned ways of thought and behavior that characterize a social group, which can be learned through socialization processes and persist through time.'' Accordingly, from food technologists perspective, a food safety culture can then be viewed as how and what the employees in a company or organization think about food safety. It's the food safety behaviors that they routinely practice and demonstrate. According to this definition, employees will learn these thoughts and behaviors by simply becoming part of the company or organizational group. Furthermore, these thoughts or behaviors will permeate throughout the entire organization. And if you truly create a food safety culture, these thoughts and behaviors will be sustained over time as opposed to being the ''program of the month'' or this year's focus [6].

4.2. Who Creates Culture?

In an organization or social group, food safety is a shared responsibility. Thereis no question about it. But when it comes to creating, strengthening, or sustaining a culture within an organization, there is one group of individuals who really own it – they're the leaders [6].

Organizational cultures are created by leaders, and one of the most decisive functions of leadership may well be the creation, the management, and – if and when necessary – the destruction of culture [6].

The strength of an organization's food safety culture is a direct reflection of how important food safety is to its leadership. A food safety culture starts at the top and flows downward. It is not created from the bottom up. If an organization's food safety culture is less than acceptable, it's the leaders who are ultimately responsible and who own it [6].

4.4. How Is Culture Created?

Having a strong food safety culture is a choice. Ideally, the leaders of an organization will proactively choose to have a strong food safety culture because it's the right thing to do. Safety is a firm value of the organization. Priorities can change; values should not (Geller, 2005). The organization chooses to have a strong food safety culture, because it values the safety of its customers and employees. The leaders of the organization have vision and foresight, knowing that having a strong food safety culture is important and that it directly and indirectly benefits the business.

Although less desirable, for other organizations or groups, establishing a strong food safety culture might be driven out of necessity. Their focus on improving their food safety culture is reactionary. It's driven by a significant or major event. They've experienced a food borne illness outbreak, high profile media expose, or an important regulatory issue. They're reacting to pressure [6].

Table 1: Safety culture best practices [6] [7]

Practices and Program	Managers Required to Show Visibility
• Operational Integration • Motivational Program • Behavioral Observation & Feedback • Safety Committees • Case Management • Safety Survey	• Emphasize as a Company Value • Discuss Safety at Employee Meetings • Participate in Safety Committees • Do Frequent "Walk Arounds" • Ensure Adequate Resources • Ensure Employee Training • Create Trusting Relationships • Suspend Unsafe Activities
Front Line Supervisor Responsibilities	**Employee Involvement**
• Encourage Safe/Discourage Unsafe Behaviors • Conduct hazard analysis • Train Employees • Conduct Documented Safety Inspections • Investigate Incidents & Near Misses	• Safety Performance Objectives • Recognition of Superior Safety Performance • Progressive Discipline for Unsafe Practices

3. CONCLUSION

A corporate culture that food safety values demonstrates to employees directly and indirectly a influence to the success of the organization. This influences behavior and helps ensure that employees are doing their jobs properly. Although, or perhaps because cultural standards do not follow formal rules, which are often conveyed in casual conversation and reinforced by thought and action, they become embedded in the subconscious. A subconscious commitment to food safety has an impact. Organizations that have implemented a Food Safety Culture are sure to reduce the risk of food safety incidents. With this in mind, most food professionals believe that establishing a culture of food safety is the most important job of any management.

REFERENCES

[1] World Health Organization: Foodborne Diseases Estimates, *Available from* https://www.who.int/data/gho/data/themes/who-estimates-of-the-global-burden-of-foodborne-diseases *Accessed:* 2024-07-03.
[2] Mačkić, S., Hajrić, Đ., Konjić, E.: *Vodič o sigurnosti hrane za primarne proizvođače*, https://www.undp.org/sites/g/files/zskgke326/files/migration/ba/Vodic-o-sigurnosti-hrane_srpski-jezik.pdf *Accessed:* 2024-07-03.
[3] Jespersen, L., Griffiths, M., Maclaurin, T., Chapman, B., Wallace, C.A.: Measurement of food safety culture using survey and maturity profiling tools, *Food Control*, **66** (2016), pp. 174-182, 0956-7135.
[4] Richard, N., Lanterman, S.: Causes and prevention of foodborne illness, https://web.uri.edu/wp-content/uploads/sites/25/Causes-and-Prevention-of-Foodborne-Illness-1.pdf Accessed: 2024-07-03.
[5] Sikora, T.: Methods and systems of food qualty and safety assurance, *Polish Journal of Food and Nutrition Science*, **14** (2005) 55, pp. 41-48, 1230-0322
[6] Yiannas, F.: *Food Safety Culture: Creating a Behavior-Based Food Safety Management System*, Springer Science, 978-0-387-72866-7, Arkansas (2009)
[7] Griffith, C.J., Livesey, K.M., Clayton, D.: The assessment of food safety culture, *British Food Journal*, **112** (2010) 4, pp. 439-456, 0007-070X

FIRST AID SUPPLIES IN FIRST AID CABINETS

Franjo Mirosavljević[1]
[1] Fina GS d.o.o., Radnička cesta 182, Zagreb, CROATIA,
franjo.mirosavljevic@finags.hr

Abstract: *The written work deals with the issue of the sanitary contents of the first aid cabinet. The Rulebook on providing first aid to workers at work (Official Gazette 56/83) regulates the filling of first aid at the workplace. The said Rulebook is valid and is in force. According to the Ordinance on providing first aid to workers at work (Official Gazette 56/83), the first aid kit/cabinet should contain medical supplies in accordance with Articles 40 and 41 of the Ordinance.*

Despite the current Rulebook, the list of medical supplies listed in the "Draft proposal of the Rulebook on first aid procedures, the means, type and quantity of medical supplies that must be provided at the workplace, and the method and deadlines for training workers to provide first aid" is often advertised and cited " from 2015.

Keywords: *first aid, first aid supplies, first aid cabinets*

1. INTRODUCTION

The Ordinance on providing first aid to workers at work (Official Gazette 56/83) prescribes the procedures for injured and sick persons at work until they are handed over for treatment to the organization of the associated health work, and the type and quantity of medical equipment that must be provided for providing first aid [1].

These are the guidelines for writing the paper for the 9th International Professional and Scientific Conference Occupational Safety and Health. They are written in the format that is being described. Please follow these instructions.

2. FIRST AID SUPPLIES

Article 40 of the Ordinance stipulates that in every place where up to 20 workers perform work and tasks at the same time, basic medical equipment must be provided for providing first aid, namely:

1. 10 sterile first bandages
2. 4 calico bandages 5 m long and 8 cm wide
3. 2 pieces of plaster bandage
4. 4 wraps of sterile gauze
5. 2 cotton wool wraps of 25 g each
6. 1 package of tissue for covering the splint
7. 2 triangular scarves and 4 safety pins

8. 4 elastic bandages for fixing splints of different sizes

9. 4 padded splints of different sizes for immobilizing bone fractures (2 pcs Kramer's 100 cm each and 2 pieces each 50 cm long and 10 cm wide) or the corresponding number pneumatic splints

10. 6 pieces of leather thimbles in three sizes

11. 1 anatomical forceps

12. 1 regular scissors and 1 for cutting bandages with a twisted head

13. 2 bottles of 2% Desol, 250 g of sodium bicarbonate (baking soda), 100 g of salt, paraffin oil, activated carbon, 500 g 70% alcohol.

If more than 20 workers are simultaneously performing work and tasks at the workplace, additional basic sanitary material must be provided for every additional 50 workers in quantities and types depending on the frequency and type of injuries.

In addition to basic medical equipment, Article 40 of the Ordinance on providing first aid for illnesses and injuries that may arise due to the peculiarities of the work process, at the workplace where up to 20 workers perform work and tasks at the same time, additional materials must be provided, namely:

1. where serious injuries, illnesses or poisoning can occur (e.g. injuries to the spine, pelvis, gas poisoning, heat stroke, caisson disease, electric shock):

- stretcher

- 5 pieces of large gauze (possible open injuries to the abdomen and chest, large burns, frostbite and frostbite)

2. during diving works and works in caissons:

- decompression chamber

3. where there is exposure to chlorine, phosgene, nitrogen oxides, ozone:

- 1 apparatus with compressed oxygen and an Ambu respirator

4. where there is exposure to hydrogen cyanide and cyanides:

- ampoules of amyl nitrate (10 ampoules)

- ampoules of 25% sodium thiosulfate (5 - 10 ampoules)

- ampoules of 3% sodium nitrite solution (5 - 10 ampoules)

5. where there is exposure to organophosphorus insecticides and carbamates:

- ampoules of atropine sulfate a 1 mg (200 ampoules)

- 2% sodium bicarbonate solution

- ampoules of pralidoxime (cholinesterase reactivator in poisoning with organophosphorus compounds)

6. where there is exposure to acids and alkalis:

- 2% potassium bicarbonate solution

- 2% sodium bicarbonate solution

- 3% boric acid solution

- sodium sulfate solution and magnesium oxide suspension (exposure to hydrogen fluoride acid)

7. where there is a possibility of being bitten by poisonous insects and poisonous snakes:

- ammonia (100 gr)
- anti-snake serum (5 ampoules)
- anti-allergic ointment.

If more than 20 workers perform work and work tasks at the workplace at the same time, for each additional 50 workers, additional material must be provided by type and quantity depending on the degree of exposure.

On September 21, 2015, the online consultation process for the draft proposal for the Rulebook on the procedures for providing first aid, the means, type and quantity of medical equipment that must be provided at the workplace, and the method and deadlines for training workers to provide first aid began on the central state online portal for consultations with the public "e-Savjetovanja".

All interested parties could submit their proposals, remarks and comments in the period from September 21 to on October 6, 2015 through the central state internet portal for counseling "e-Savjetovanja" or to the e-mail address: savjetovanje@miz.hr [2].

The rationale for the draft proposal for the Ordinance on the procedures for providing first aid, the means, type and quantity of medical equipment that must be provided at the workplace, and the method and deadlines for training workers to provide first aid states that the Draft Ordinance is adopted on the basis of Article 56, Paragraph 4 of the Act on protection at work (Official Gazette 71/2014, 118/2014, 94/2018, 96/2018).

In Article 56, paragraph 6 of the Law, it is stated that the minister responsible for health, with the consent of the minister, prescribes the procedures for providing first aid, means, type and quantity of medical equipment that must be provided at the workplace, as well as the method and deadlines for training workers for Providing first aid [3].

Also, in the explanation, it is stated that this Ordinance proposes to prescribe the procedures for providing first aid in case of injuries and sudden onset of illness, poisoning and other conditions of workers and other persons at work, occurring at work sites until they are handed over to the expert hands of health workers, means, type and the amount of medical equipment that must be provided at the workplace and the method and deadlines for training workers to provide first aid at the workplace.

In Article 6 of the draft proposal of the Ordinance on procedures for providing first aid, the means, type and quantity of medical equipment that must be provided at the place of work and the method and deadlines for training workers to provide first aid, it is proposed that in the employer's premises and at workplaces where at the same time performs work and tasks for up to 20 workers, basic medical equipment must be provided for providing first aid, namely:

1. 2 first turns no. 1: 8 cm x 5 m
2. 2 first turns no. 3: 12 cm x 5 m
3. 3 calico bandages 8 (or 10) cm x 5 m
4. 4 calico bandages 5 cm x 5 m
5. 2 aluplast or aluminum foil (for burns) smaller - sterile
6. 1 aluplast or aluminum foil (for burns) larger 50 x 80 - sterile
7. 1 sterile gauze compresses 5x8 cm (individually packed) package (10 pcs.)
8. 4 compresses of sterile gauze 10 x 10 cm (individually packed)
9. 2 compresses of sterile gauze 0.5 m (individually packed)

10. 1 compresses of sterile gauze 1 m (individually packed)

11. 1 patch - ribbon 2.5 cm x 5 m

12. 1 patch-strip (with gauze) - set - 10 pcs - packaging

13. 4 triangular edges

14. 10 safety pins

15. 1 pair of scissors with a rounded tip

16. 2 gloves (rubber, surgical, sterile, for single use) – pair

17. 2 polyethylene bags (at least 30 cm x 60 cm)

18. 1 metallized foil (at least 100 cm x 200 cm)

19. 1 protective foil for artificial respiration (with filter or non-return valve) - package (10 pcs.)

20. 1 mask for artificial respiration with a non-return valve (compliant with the ISO standard)

21. 2 cotton wool - package of 50 gr.

22. 1 mesh Surgifix no. 4 - pack of 2 m

23. 1 mesh Surgifix no. 7 - package of 2 m

24. 1 Hibisept (5%) 200 ml or a suitable disinfectant

25. 1 physiological solution (0.9%) 500 ml

26. 1 first aid manual at the workplace (recommended by Croatian Institute of Occupational Medicine)

27. 1 specification of the contents of the first aid cabinet (box).

Next to the first aid cabinet should be:

2 Kramer splints 100 cm long - coated, or corresponding pneumatic splints for upper leg and upper arm and 2 Kramer splints 50 cm long - coated, or corresponding pneumatic splints for lower leg and forearm.

If more than 20 workers, and up to 50 workers, perform work and work tasks at the workplace at the same time, another set of additional basic sanitary material must be provided.

The “Safety at Work” website [4] states that providing first aid at the workplace is one of the employer's obligations and adds that every employer is obliged to provide adequate conditions for providing first aid to injured workers until the arrival of emergency medical help or transfer to a hospital or clinic. This includes the provision of basic medical supplies (first aid kit) and the training of employees to provide first aid, in accordance with the Ordinance, and for employers who employ up to 20 workers, the first aid kit must contain the previously mentioned list of medical supplies from the Draft Proposal of the Ordinance on First Aid Procedures, the means, type and quantity of medical equipment that must be provided at the workplace and the method and deadlines for training workers to provide first aid.

The description of filling the first aid cabinet on the website of the LifeLock store [5] states the following content and adds that the content is in accordance with the Occupational Safety and Health Act (Official Gazette 71/14, 118/14, 94/18, 96/18) and valid rules of the Republic of Croatia and EU directives (PPE 89/686/EEC, MDD 93/42/EEC):

1. 5 packs of 25 compresses of sterile hydrophilic gauze (10 x 10 cm)
2. 1 bottle of disinfectant (250 ml)
3. 1 bottle of hydrogen peroxide (250 ml)
4. 1 bag of coolant
5. 1 pack of plasters (20 plasters in 4 different sizes)
6. 1 non-woven sterile cover for burns (60 x 40 cm)
7. 1 patch in a roll (5 m x 1.25 cm)

2 turns (reel, 4 m x 5 cm)

9. 1 bandage (reel, 4 m x 7 cm)
10. 1 container under the chin
11. 6 safety pins ("pins")
12. 1 metal scissors 10 cm long with plastic handles
13. 1 soap of 15 grams
14. 1 rubber band for tightening
15. 1 pair of protective gloves
16. 3 packages of hydrophilic cotton wool, 50 grams each

The same content is stated on the website of the Makromikro Group store [6], while on the website of the Polimer store [7] it is stated that according to the Law on Safety at Work (Official Gazette 71/14, 118/14, 94/18, 96/18) and valid regulations of the Republic of Croatia and EU directives (PPE 89 /686/EEC, MDD 93/42/EEC) must have an adequate amount of sanitary material in the cabinet for first aid and in the event of the need to provide first aid due to an injury at work. In addition to the above, the same content of sanitary material is advertised:

1. 2 packs of 25 compresses of sterile hydrophilic gauze (10 x 10 cm)
2. 1 bottle of disinfectant (250 ml)
3. 1 bottle of hydrogen peroxide (250 ml)
4. 1 bag of coolant
5. 1 rubber band for tightening
6. 1 pack of plasters (20 plasters in 4 different sizes)
7. 1 pair of protective gloves
8. 1 patch in a roll (5 m x 1.25 cm)
9. 1 non-woven sterile cover for burns (60 x 40 cm)
10. 2 turns (reel, 4 m x 5 cm)
11. 1 bandage (reel, 4 m x 7 cm)
12. 1 metal scissors 10 cm long with plastic handles
13. 6 safety pins ("pins")
14. 1 soap of 15 grams
15. 3 packages of hydrophilic cotton wool, 50 grams each

3. CONCLUSION

Given that the contents of first aid cabinets for workplaces are prescribed by Article 40 of the Ordinance on providing first aid to workers at work (Official Gazette 56/83), it is concluded that trading companies that advertise products or medical supplies do not advertise products that are on the list of the Ordinance on providing first aid to workers at work (Official Gazette 56/83). Also, it would be desirable to check the mentioned list from the current Ordinance and determine how safe it is to use certain means on that list, considering the facts that have been collected since 1983, and were collected by experts in the field of medicine and similar sciences.

REFERENCES

[1] Pravilnik o pružanju prve pomoći radnicima na radu, Official Gazette 56/83, *Available from* https://www.hzzzsr.hr/wp-content/uploads/2016/11/Pravilnik-o-pru%C5%BEanju-prve-pomo%C4%87i-radnicima-na-radu.pdf *Accessed:* 2024-05-20.

[2] Republika Hrvatska, Ministarstvo zdravstva, Izvješće o provedenom savjetovanju o Nacrtu prijedloga Pravilnika o postupcima pružanja prve pomoći, sredstvima, vrsti i količini sanitetskog materijala koja mora biti osigurana na mjestu rada te načinu i rokovima osposobljavanja radnika za pružanje prve pomoći, *Available from:* https://zdravstvo.gov.hr/izvjesce-o-provedenom-savjetovanju-o-nacrtu-prijedloga-pravilnika-o-postupcima-pruzanja-prve-pomoci-sredstvima-vrsti-i-kolicini-sanitetskog-materijala-koja-mora-biti-osigurana-na-mjestu-rada-te-nacinu/1633 *Accessed:* 2024-05-20.

[3] Zakon o zaštiti na radu, *Available from* https://www.zakon.hr/z/167/Zakon-o-za%C5%A1titi-na-radu *Accessed:* 2024-05-20.

[4] Zaštita na radu, Pružanje prve pomoći na radnom mjestu – obveze poslodavca, *Available from:* https://www.zastitanaradu.com.hr/novosti/Pruzanje-prve-pomoci-na-radnom-mjestu---obveze-poslodavca-128 *Accessed:* 2024-05-20.

[5] LifeLock trgovina - Trgovina zaštitnom opremom, prometnom opremom, zaštitnim ogradama, sredstvima za zaštitu okoliša, *Available from:* https://trgovina.lifelock.hr/product/punjenje-ormaric-prve-pomoci/ *Accessed:* 2024-05-20.

[6] Makromikro, *Available from:* https://www.makromikrogrupa.hr/ormaric-za-prvu-pomoc-punjenje *Accessed:* 2024-05-20.

[7] Polimer – osobna zaštitna sredstva i oprema, *Available from:* https://www.polimer.hr/proizvod/ormaric-prve-pomoci/ *Accessed:* 2024-05-20.

THE EFFECTS ON EXHAUST GAS EMISSIONS ON WORKERS IN MOTORWAY TOLL BOOTHS

Eduard Missoni[1]; Marin Dugina[2]; Dino Šojat[3];

[1] University of Zagreb Faculty of Transport and Traffic Sciences, Ulica Lavoslava Vukelića 4, Zagreb, CROATIA, emissoni@fpz.unizg.hr

[2] Ivan Seljanec High School, Trg Svetog Florijana 14b, Križevci, CROATIA, mm.dugina@gmail.com

[3] University of Zagreb Faculty of Transport and Traffic Sciences, Ulica Lavoslava Vukelića 4, Zagreb, CROATIA, dsojat@fpz.unizg.hr

Abstract: *Exhaust gas emissions have a negative impact on human health, especially in activities where there are prolonged exposures and high concentrations, such as freeway toll booths. This paper encompasses toll booth employees as target group, such that the impact of exhaust gas emissions is being analyzed. All active employees are included in the target group. The goal of this paper is to investigate the extent of exhaust gases influencing employee respiratory system. The purpose of the paper is to improve the working environment of staff by recommendations for education, preventive activities, and continuous measurement of exhaust gas parameters which influence the employees both directly and indirectly.*

Keywords: *education, exhaust gas emissions, health, motorway toll booth, respiratory system*

1. INTRODUCTION

Urbanization and motorization, which happened over past decades, can have negative impacts on human prosperity and health. The exposure to atmospheric pollution and environmental noise has increased consequently, and most of the population is subject to them daily. In Europe, exhaust gases and environmental noise from different sources, mostly road traffic, railroad traffic, air traffic and industry, have become a great concern.

Air pollution reflects on changes in the environment and human health, especially active employees in road traffic, since the transport network of today and its complementing infrastructure has become an integral part of urban and rural environment. Exhaust gas emissions have a negative influence on the entire global and natural surroundings. This influence is most prevalent in road traffic if compared with other traffic modes [1].

When road transport systems are observed from the perspective of costs and benefits, a usual assumption is when vehicles are stuck in traffic, the ratio of costs and benefits becomes worse. This is true for both external costs and the impact on the environment. However, when limited space is added to this equation, human health becomes a problem as well. One of the places where this is particularly true are toll booths on motorways, where vehicles due to stopping become a problem for the people collecting tolls, especially in highly congested periods. Therefore, this paper particularly observes the air pollution problem in toll booths, its negative impact on human health, provides an overview of research related to the areas and offers the solutions to mitigate the problem.

2. THE EFFECTS OF EXHAUST GAS EMISSIONS ON HUMAN HEALTH

There is no perfect exhaustion in practice, because fuels have additives, and high combustion temperatures are accompanied by chemical reactions which produce gases harmful to the health of respiratory system in humans. In an Otto combustion engine heated to the working temperature with usual load and rotational speed, the harmful substances before the catalytic converter make 1% of the total mass of combustion products [2], and the proportion of each exhaust gas is shown in Figure 1.

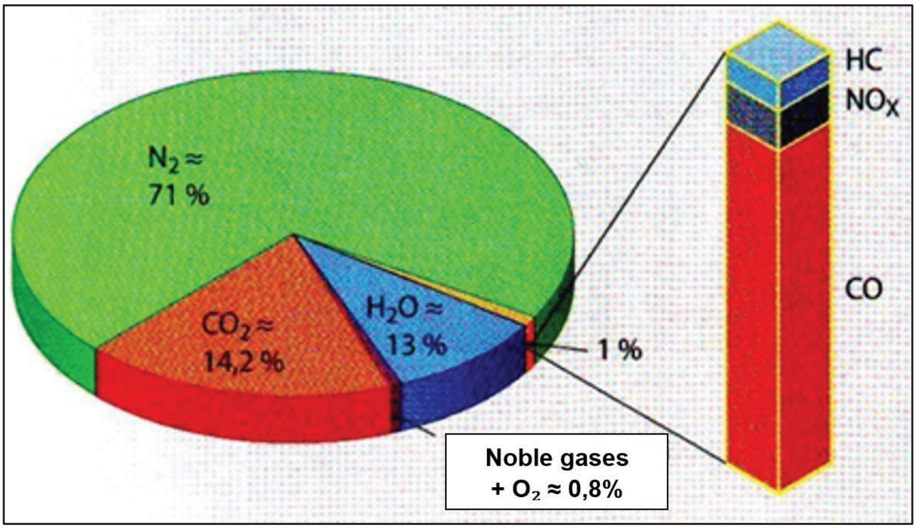


Figure 1*: Types of exhaust gases and their proportions before the catalytic converter*

Maximum values of harmful substances in the exhaust gasses defined by the legislation are shown in Table 1, such that five common harmful substances are shown in grams per kilogram (g/kg), and the number of particles per kilogram (1/kg). These values are mandatory for granting general use license and subsequent testing for harmful gas emissions [2]. The substances are:

- Carbon monoxide (CO)
- Hydrocarbons (HC)
- Nitrogen oxides (NO_x)
- Particulate matter (PM)

- Particle number (PN).

Children as well as people with chronic lung and heart diseases are especially sensitive to polluted air. The most obvious impact of polluted air on human health are diseases of the respiratory organs such as bronchitis, asthma, emphysema, and lung cancer. Polluting substances from the atmosphere enter the human body most easily through the respiratory organs. The effect of different pollutants varies according to the time it takes to detect the first symptoms of the disease. Vehicle exhaust emissions can irritate the eyes and respiratory tract, and are hazardous to health when inhaled [3].

Depending on the duration of exposure to harmful substances, acute and chronic effects of air pollutants are distinguished. Acute effects are manifested already after short-term exposure of a few days, while chronic effects only become visible after a longer period. The long-term effects of polluted air are much more dangerous because it takes a certain amount of time to be detected.

In the total emission of carbon dioxide, transport participates with around 24%, and in this share, road traffic participates with 72%. This means that road traffic is the biggest air polluter within the transport sector. Road traffic emits 98 times more carbon monoxide than rail traffic, and nitrogen oxide emissions are 23 times higher in road traffic than in rail traffic.

Table 1: Exhaust gas limits for private cars (M1 category with less than 2,5t and less than 6 seats) per Euro norm

Category	CO g/kg	HC g/kg	NO_x g/kg	PM g/kg	PN 1/kg
Euro 3 since 2000	2,30	0,20	0,15	-	-
Euro 4 since 2005	1,00	0,10	0,08	-	-
Euro 5 since 2009	1,00	0,10	0,06	0,005	-
Euro 6 since 2014	1,00	0,10	0,06	0,005	$6*10^{-11}$

The emission of hydrocarbons is as much as 95 times higher in road traffic, and when comparing the emission of sulfur dioxide, it is obvious that in road traffic it is 7,4 times higher. The emission of solid particles is also higher in road transport and 17 times higher than in rail transport.

3. STRATEGIES FOR REDUCING CO_2 IN THE EU

The International Agency for Research on Cancer (IARC) has classified diesel engine exhaust as a human carcinogen, based on sufficient evidence that exposure is associated with an increased risk of lung cancer [4]. Gasoline exhaust gases are also classified as possible carcinogens by the IARC.

Alternative fuels are fuels or energy sources used in transport as a substitute for fossil fuels, which should help in the decarbonization of the sector. Among them, the alternative fuels with zero carbon emissions are [5]:

- Electricity, which for cars comes from different sources: fossil fuel power plants, renewable energy sources and nuclear power plants; electric vehicles do not emit harmful substances, while hybrids need less oil and reduce CO_2 emissions
- Hydrogen, which is still in its early stages of use but is often used in trucks, is obtained from water and organic compounds. The impact of hydrogen on the environment and its energy efficiency depends on how it is produced – from renewable energy sources such as the sun, wind and natural gas, or by burning fossil fuels
- Ammonia, which can contribute to a significant reduction of carbon dioxide emissions, because nitrogen and water are the only byproducts of ammonia.

There are various fuels that could help reduce carbon emissions to reach zero CO_2 in road traffic. These are [5]:

- Liquefied petroleum gas (LPG), obtained from crude oil and natural gas, and in the future also from biomass. It emits 35 percent less CO_2 than coal, 12 percent less than oil, and almost no hazardous air particles. Some countries already have a good infrastructure for automotive LPG, but given the increasingly strict standards, LPG will no longer be sufficient to reduce CO_2 levels sufficiently
- Compressed natural gas (CNG), which is produced by compressing natural gas, usually methane
- Liquefied natural gas (LNG), which is produced by refining natural gas, most often methane, and cooling it to turn it into a liquid. It has no significant impact on reducing CO_2, so the members of the European Parliament did not support its use in road traffic.

Renewable fuels are fuels obtained from biomass, synthetic and paraffin fuels, as well as the already mentioned ammonia, and are produced from renewable energy sources. Biofuels are biodegradable fuels, which are produced from vegetable oils, animal fat or recycled fat from restaurants. They are currently among the most important types of alternative fuels, with a share of 4,4 percent in the total consumption in EU road transport. They can also contribute to a significant reduction in CO_2 emissions, if they are produced in a sustainable way. However, there is a risk that land that would otherwise be used for other purposes, such as food and crop production, could be used for this purpose. [5].

4. PROBLEMS AND POTENTIAL FOR REDUCING EXHAUST GAS EMISSIONS AT TOLL BOOTHS

One of the factors that greatly influences air quality at toll booths is the percentage of old vehicles. This is especially problematic in underdeveloped countries with high rates of imported used vehicles, as in the study done in Kenya by Ogur at al. [6]. The most prominent effects for the humans were eye irritations, throw-ups and odor. Asthma and cancer were the most common consequences in the sample.

Certainly, one of the promising prospects of CO_2 emissions at toll booths is electronic toll collection. The research by He at al. [7] showed that electronic toll collection offers lower emissions in contrast to manual toll collection, and that vehicles emit more pollutants in acceleration state. The acceleration of the vehicle that stopped at a pay toll to its cruising speed before stopping at a pay toll is the cause of the greatest percentage of emissions, which was shown by Coelho et al. [8]. There are a few studies comparing manual toll collection with electronic toll collection, such as by Lai et al. [9], which showed in two-week sampling campaign that the concentration of PM particles per 100 vehicles in bus and truck laned were 2 times higher in manual toll collection compared to electronic. In addition, electronic toll collection reduces costs since human work is much more expensive.

Eco driving is one of the ways to protect the environment and save fuel. It is a modern, new style of driving, and it is based on taking care of the awareness of environmental protection. ECO driving allows, above all, to save on fuel consumption, and considering this fact, the emissions of harmful substances are much lower.

5. CONCLUSIONS

It has been scientifically proven that harmful substances, which are produced because of the use of road motor vehicles, have a great impact on the overall state of the environment. Human health at motorway toll booths is threatened by a certain concentration of various toxic substances to a greater or lesser extent.

In addition to toll booths on motorways, there are other risky places in terms of high concentrations and long-term exposure to harmful gas emissions, such as other modes of the transport system (railway, air traffic, industry) and urban environments with school and residential environments. Populations with a higher prevalence of exposure to other harmful sources should be considered in future studies, to obtain a more comprehensive assessment of exposure and to compare the potential differential effects of each source of exposure in all environments on the cognitive and motor and respiratory functions of individual target groups.

We are aware that exposure to exhaust gases is a risk for all employees and the sustainability of the work they do. Therefore, we want to start developing a local system of preventive activities with the aim of removing air pollution on highways and educating all employees. The participation of the workers has been positive so far, and the project has been supported by other employees. Everyone was very interested in developing an effective system of preventive activities to better protect their health. We have already held preparatory activities and preliminary work and we plan to continue with the education of active and passive participants titled Strategies for reducing CO_2 emissions from motor vehicles on highways.

It is our desire to periodically hold educational workshops with the aim of educating employees and their superiors, and if necessary, all interested parties on the issue. We started with preparatory information and individual educations, after which we plan to continue and expand the educational seminars on the prevention of the impact of harmful gases on health.

REFERENCES

[1] Golubić, J.: *Promet i okoliš*, Sveučilište u Zagrebu Fakultet prometnih znanosti, 953-6221-99-3, Zagreb, (1999)

[2] Bohner, M.: *Tehnika motornih vozila*, Pučko otvoreno učilište, 978-953-254-044-4, Zagreb, (2017)

[3] Missoni, E.: *Ljudski čimbenik u prometu*, Sveučilište u Zagrebu Fakultet prometnih znanosti, 978-953-243-086-8, Zagreb, (2017)

[4] IARC Publications.: *Chemical Agents and Related Occupations*, IARC Publications, 978-92-832-1323-9, France, (2012)

[5] Europski parlament.: Alternativna goriva za automobile: kako povećati njihovu upotrebu, *Available from* https://www.europarl.europa.eu/topics/hr/article/20221013STO43019/alternativna-goriva-za-automobile-kako-povecati-njihovu-upotrebu *Accessed:* 2024-06-28.

[6] Ogur, E.; Kariuki, S. : Effect of Car Emissions on Human Health and the Environment, *International Journal of Applied Engineering Research*, **9** (2014) 1, pp. 11121-11128, 0973-4562

[7] He, H.; Lu, D.; Zhao, H.; Peng, Z.: Characterizing CO2 and NOx emission of vehicles crossing toll stations in highway, *Transportation Research Part D: Transport and Environment*, **126** (2024) 1, pp. 104024, 1361-9209

[8] Coelho, M.; Farias, T. L.; Rouphail, N.: Measuring and Modeling Emission Effects for Toll Facilities, *Transportation Research Record*, **1941** (2005) 1, pp. 136-144, 0361-1981

[9] Lai, C.; Hsiao, P.; Yang, Y.; Lin, S.; Lung, S. C.: Effects of the manual and electronic toll collection systems on the particulate pollutant levels on highways in Taiwan, *Atmospheric Pollution Research*, **12** (2021) 3, pp. 25-32, 1309-1042

SWEETENERS AND NO SUGAR FOOD OFFER FOR THE PURPOSE OF PROTECTING HEALTH OF DIABETICS

Sandra Zavadlav[1], Petra Cvetić[2], Ivana Kolić[3], Jasna Halambek[4], Jasminko Saletović[5]

[1]Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia;
sandra.zavadlav@vuka.hr; 00385 91 (0) 39 00 935

[2]Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia;
petra.cvetic@vuka.hr

[3]Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia;
ivana.kolic@vuka.hr

[4] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia;
jasna.halambek@vuka.hr

[5]INA - Industrija nafte, d.d. Ivanić-Grad HR - 10310 Ivanić-Grad, Croatia;
Jasminko.Saletovic@ina.hr

Abstract; *Raising awareness of the dangers of white sugar, the consumption of sugar substitutes is growing, and there are a number of different artificial and natural sweeteners on the market that add food and drink and they are an excellent alternative in the diet of diabetics. They are low-energy substances that provide sweetness of taste and at the same time they do not have or have a very low caloric value because they are organized and are not broken down by the same reactions as sugars. There is food on the market specifically produced for a premature person with diabetes, and this allows for improved control and disease. Usually such products are made from carbohydrate-supplemented foods, before it is necessary to determine which is better enough because they were not equally useful in diabetics. For many people, especially diabetics, it is very important to know the glycemic index of the foods they eat, and so it sweetens what they choose to use.*

Key words: *diabetes, food product, health, sugars, sweetener*

1. INTRODUCTION

Sweeteners play a significant role in a large number of additives, which are indispensable primarily in the production of carbonated drinks, nectars and confectionery products. In most countries of the modern world, sugar is a basic food item along with milk, bread, flour, and oil, and it directly affects the general and nutritional standard of the population, which is why it is under special control and regime of circulation and consumption. Nowadays, people and industry long for alternative natural and artificial sugars primarily because of better technological properties and lower caloric value. Over the years, there have been numerous scientific discussions related to the use of alternative sweeteners and their currently inexplicable impact on consumer health. Studies have shown that it is very important to use artificial sweeteners in moderation and of course the amount that is consumed daily, and if they are consumed in the recommended amounts, there is no evidence that they are dangerous for human health. Diabetes mellitus is a chronic disease in which the levels of glucose (sugar) in the blood are elevated above the permitted levels. Most of the food we consume is converted into glucose, which our body simply uses for energy. The pancreas produces insulin, i.e. a hormone that regulates the level of sugar in the blood by allowing sugar to enter the cells where it is converted into energy, and excess sugar is stored with the help of insulin in the muscles and liver. If there is insufficient insulin, sugar cannot enter the cells and remains in the blood, leading to elevated blood sugar levels and, consequently, the development of disease. Avoiding food rich in simple sugars is a mandatory dietary measure, therefore the food industry is an extremely important factor in the prevention and regulation of this completely harmless disease, and many researches are focused on the development of food products for people suffering from today's disease - diabetes.

2. SWEETENERS IN THE ROLE OF FLAVOR ENHANCER IN FOOD PRODUCTS

According to the Ordinance on Food Additives, food additives are defined as a substance that is not consumed as food by itself, nor is it a recognizable ingredient of a certain food, regardless of its nutritional value. They are added to foods during production, preparation and processing and are used to extend shelf life and to improve the taste, smell or consistency of the product (Vinković et.al., 2010). Additives are labeled with an E-number, a commonly accepted label in the EU and the rest of the world, for easier labeling and recognition, and as a confirmation of the toxicological evaluation and classification of an individual additive. Additives are classified by function into the following groups: dyes E100 – E199, preservatives E200 – E299, antioxidants, acidity regulators E300 – E399, coagulants, stabilizers, emulsifiers E400 – E499, anti-caking agents E500 – E599, flavor enhancers E600 – E699, antibiotics E700 – E799, substances to achieve slipperiness, polishing, propellants, aromas and enzymes E900 – E999, additional chemical compounds E1000 – E1999 (Krtanjek, 2014). Additives in the group of substances for sweetening are in the domain of substitutes for sugar and artificial sweeteners, and in food they are carriers of a sweet taste. The group of sweeteners includes; acesulfame-K (E950), aspartame (E951), cyclamic acid (E952), saccharin (E954), thaumatin (E957) and neohesperidin DC (E959). Sugar substitutes are, for example, sorbitol (E420), mannitol (E421), isomalt (E953), neotame (E961), maltitol (E965), lactitol (E966) and xylitol (E967).
They replace sugar in many products with reduced energy value (Vinković, i sur., 2010).

Figure 1. Food additives (Berg, 2013).

2.1. Sweeteners

Sweeteners or sweeteners are substances that are added to food and drinks to complement and/or create a sweet taste that resembles the natural taste of the original raw material. Due to the large number of obese people in industrialized countries, there is a growing interest in diets with significantly reduced calorie intake, that is, with reduced sugar intake. In contrast to sugar (sucrose), various sweeteners have a lower energy, i.e. caloric value and are desirable for consumers or anyone who wants to avoid sugar, and the reasons for avoiding sugar are numerous - diabetes, weight loss, digestive diseases (Chron's disease), dental health, and the price, because artificial sweeteners are much more cost-effective (Krtanjek, 2014).

Sweeteners are divided into several categories:

1. according to energy value (nutritive and non-nutritive)

They are nutritious: monosaccharides (glucose, fructose), disaccharides (sucrose, maltose, lactose), syrups (sugar beet syrup, corn syrup, molasses...), polyols (xylitol, mannitol, sorbitol), starch-based sweeteners (glucose syrup, high fructose syrup, high maltose syrup), intense sweeteners (aspartame, thaumatin, alitam) (Berg, 2013).

Non-nutritive intensive sweeteners such as: saccharin, cyclamates, acesulfame K, sucralose...

2. according to origin (natural and artificial)
3. according to chemical composition (carbohydrate and non-carbohydrate)
4. according to intensity (intense or high intensity of sweetness and extensive or low intensity of sweetness) (Lacković, 2014).

3. NATURAL SUGARS

The very name sugars means carbohydrates from the group of monosaccharides (glucose and fructose) and oligosaccharides (sucrose, maltose and lactose). According to the mass of sugars produced and consumed in the world, sucrose or ordinary sugar comes first, followed by glucose or grape sugar, invert sugar, fructose - fruit sugar and lactose - milk sugar (Jašić, 2010).

3.1. Monosaccharides

3.1.1. Glucose or grape sugar is also called dextrose. In its free form, it is found in fruit juices or bound in the composition of sucrose and lactose disaccharides, as well as starch, cellulose and glucoside polysaccharides (Šimundić, 2008). Glucose (from greek; sweet) (dextrose, grape sugar, blood sugar, dextroglucose) is the most widespread monosaccharide in nature and is needed for muscle work, for all processes in the body, including brain work, and is the main source of energy for survival. The term glycemic index is naturally associated with sugars, especially glucose. The glycemic index (GI) is a number that shows how much a carbohydrate raises glycemia, taking as a reference value the glycemia caused by pure glucose. The glycemic index represents a scale of 0 - 100, so foods are classified as those with a high glycemic index (GI>69), with a medium glycemic index (50<GI<69) and those with a low glycemic index (50<GI) (Montignac, 2009).

3.1.2. Fructose or fruit sugar is also called levolose, and in nature it always comes with glucose, most often in fruits, vegetables, honey and sucrose. The mentioned sugar has not yet found sufficient importance in the confectionery industry, households and wider consumption. Fructose has enormous possibilities for development in the production of fruit juices, other fruit products, refreshing drinks, replacing honey for diabetics and products with reduced energy value. Fructose has the lowest glycemic index (GI 19) of all natural sugars, so fructose it absorbs significantly slower than glucose and sucrose and causes relatively smaller changes in the level glucose in the blood. For all sorts of reasons, fructose is used as a sweetener in the diet of people with diabetes.

3.2. Disaccharides

3.2.1. Sucrose is also called ordinary sugar or just sugar, it is the most important natural product of photosynthesis in many plants that have chlorophyll in the human diet. It is obtained industrially from sugar beet and cane. It consists of one molecule of glucose and one molecule of fructose. It is a solid crystalline substance that dissolves in water, especially heated water, it dissolves poorly in primary alcohol, while it does not dissolve at all in ethanol (Šimundić, 2008).White sugar is a commonly used sweetener today as it has been throughout history. Sucrose is widely used, and is available on the market in the form of cubes, smaller or coarser crystals, and in powder form.

3.2.2. Maltose or maltobiose is also called malt sugar, because it is formed as an intermediate product during the breakdown of starch, i.e. glycogen. Enzymatic splitting of starch with diastase produces, among other things, the disaccharide maltose, which can be boiled down to alcohol, so this process is widely used in the production of beer and in the industrial production of alcohol from starchy raw materials. It dissolves well in water, while it is insoluble in alcohol (Šimundić, 2008).

3.2.3. Lactose or milk sugar is found in the free state in the milk of mammals. Cow's milk contains 4-5% lactose, unlike women's milk, which contains 5-6%. It is not as sweet as sucrose, but it contains a high caloric value. Lactose is composed of a molecule of glucose and a molecule of galactose, and is broken down by the enzyme lactase in the small intestine into a molecule of glucose and galactose. It has been noticed that a large number of people and children lack this enzyme, so more and more people do not tolerate lactose. Lactose intolerance can appear from childhood to adulthood, even in old age.

4. SUGAR SUBSTITUTES

Sugar substitutes are substances of similar sweetness to sucrose with generally lower caloric value compared to the same amount. The metabolic pathway of the breakdown of the mentioned substances in the body differs from the breakdown of sucrose, and they are originally plant ingredients or are technologically produced from natural raw materials. Natural sweeteners cause fewer side effects than artificial sweeteners. However, the high caloric content negates their beneficial properties. Sugar substitutes are classified into: artificial sweeteners, sugar alcohols, natural sweeteners, "New" sweeteners (Anderson, 2012; Krtanjek, 2014).

5. ARTIFICIAL SWEETENERS

These non-nutritive sweet substances, which do not harm the human body in prescribed quantities, are used as a substitute for nutritious sweeteners, of which ordinary sugar or sucrose is the most used (Šimundić, 2008). The time of sugar as a means of sweetening is increasingly being forgotten, mostly due to excess calories and the occurrence of caries, and artificial sweeteners are entering the everyday life of consumers in a big way as a highly sought-after and desirable low-calorie substitute. Artificial sweeteners for personal consumption are mixed with appropriate fillers (starch, maltodextrins, lactose, etc.) and pressed (tabletted) into small tablets, the sweetness of which corresponds to a pinch or two of sugar. Consumer products are not sold according to the mass of the unit packaging or the active component, but according to the number of tablets in the package, which is extremely suitable for the industry and retailers. Only tablets of three artificial sweeteners have a practical meaning in the retail trade: Saccharin – up to 500 times sweeter than sucrose, Cyclamate – up to 35 times sweeter than sucrose, Aspartame – up to 200 times sweeter than sucrose (Krtanjek, 2014).

6. SUGAR ALCOHOLS

Sugar alcohols or polyols are non-nutritive sweeteners and have 50% lower energy value than sucrose, so they can be combined with other low-calorie sweeteners, resulting in tasty and significantly lower-calorie products. Due to a number of favorable characteristics, such as stability at high temperatures, mild, fine, pleasant and neutral taste, resistance to the action of bacteria, polyols are, in addition to sweeteners, used as emulsifiers, cryoprotectants and as excellent agents for stabilizing and binding moisture. The most commonly used polyols are; erythrol, xylitol, isomalt, lactitiol, maltitiol, mannitol and sorbitol (Katalenić, 2008).

7. NATURAL SWEETENERS

Natural sweeteners are sources of sugar in their pure state, and the less refined they are, the more vitamins, minerals and antioxidants they contain, and in some cases, fiber. The most important advantage of natural sweeteners is that the human body knows and can process them. Natural sweeteners include; honey (as the most represented on the market), maple syrup, agave syrup, date sugar, molasses and fruit juice concentrate. Natural sweeteners, which have been mentioned, are often promoted as a healthier alternative to white sugar, but some of the ones mentioned, regardless of the category, go through industrial processing processes (Katalenić, 2008).

8. NEW SWEETENERS

The category of new sweeteners was created because the new sweeteners differ from others in terms of their production method and chemical structure, so they could not be added to the existing categories. New sweeteners are of natural origin, and their use is becoming more and more popular every day. New sweeteners include Stevia, Trehalose and Tagatose (Krtanjek, 2014).

CONCLUSIONS

Considering the recommendations that it is necessary to reduce the proportion of simple sugars in food, this has really started to be applied, and there are many reasons for using sweeteners: they help in losing weight, they reduce the risk of tooth decay, they can be used by people suffering from diabetes, relatively are cheap, etc. Artificial sugar substitutes are recommended by doctors for type 2 diabetes because they do not participate in energy metabolism and do not cause an increase in blood sugar. Due to their low calorie content, they are quite common in industrially processed food. It can be noted that the scientific community is divided regarding the harmlessness of long-term use of artificial sweeteners or, for example, Stevia, but there is not enough evidence of their harm, on the contrary, some studies speak in favor of benefits for human health. Artificial sugar substitutes are recommended by doctors for type 2 diabetes because they do not participate in energy metabolism and do not cause an increase in blood sugar, but if the patient consumes a controlled portion of simple sugars, the glycemic index will not rise uncontrollably. It is possible to conclude that as with drugs, dose is a matter of toxicity.

REFERENCES

[1] Anderson G. H, Foreyt J, Sigman-Grant M. & Allison D. B (2012): The Use of Low-Calorie Sweeteners by Adults: Impact on Weight Management. *J Nutr* 142:1163-1169.

[2] Bauer, LJ., Biškupić, I., Brkan, B., Dekanović, I., Dolenec Dravski, M., Domaćinović, V., Kovačić, K., Matijaško, N., Matković Mikulĉić, K., Milković, B., Pavlek - Moćan, M., Olić, R., Sulimanović, Đ. & Zeba, LJ. (1999.): Med, pčelarenje i običaji, (Obad, T.,ured.) Pučko otvoreno učilište, Zagreb, 91-132.

[3] Berg, J. M., Tymoczko, J. L. & Stryer, L. (2013): Biokemija, prevoditelji Ivana Weygand Đurašević, Branimir Jernej, Željko Kućan. - 6. izd. (englesko). - Zagreb : Školska knjiga, Prijevod djela: Biochemistry. - ISBN 9789530309289.

[4] Jašić, M. (2010) : Bioloski aktivni sastojci hrane : uvod u biološki aktivne komponente hrane, modul prvi. Univerzitet u Tuzli, Tehnološki fakultet Tuzla.

[5] Katalenić, M. (2008): Aditivi i hrana. Hrvatski zavod za javno zdravstvo. file:///C:/Users/Korisnik/Downloads/06.pdf, *Accessed:* 30.4.2024.

[6] Krtanjek, J. (2014): Zaslađivači i zdravlje (Diplomski rad). Medicinski fakultet, Zagreb.

[7] Lacković, I. (2014): Sladila u konditorskoj industriji (Završni rad). Sveučilište Josipa Jurja Strossmayera, Osijek.

[8] Montignac, M. (2009): Glikemijski indeks. Zagreb: Naklada Zadro.

[9] Šimundić, B. (2008): Prehrambena roba, prehrana i zdravlje. Rijeka: Fakultet za turistički i hotelski medadžment u Opatiji.

[10] Vinković - Vraček, I. & Lerotić, D. (2010): Aditivi u hrani, vodič kroz E-brojeve. Zagreb: Školska knjiga.

CHEMICAL MANAGEMENT SYSTEM IN RIMAC TECHNOLOGY AND BUGATTI RIMAC

Ivana Žitko[1]

[1] Rimac Technology d.o.o., Ljubljanska 7, 10431 Sveta Nedelja, CROATIA, ivana.zitko@rimac-technology.com

Abstract: *This paper will present Chemical management system when it comes to safe handling of chemicals (substances and mixtures) in Rimac Technology and Bugatti Rimac. Purpose of the system is ensuring a high level of protection of human health and the environment.*

Chemical management system is primarily determined by legal requirements, requirements by ISO 45 001 and ISO 14 001 standards, and various company management requirements.

All mentioned requirements were considered when creating Chemical management procedure, which gives rules that must be followed from the selection of chemicals itself to their disposal. In addition to the way chemicals are managed, the obstacles encountered during the system establishment and the way of resolving them is also mentioned.

Keywords: *chemical management, chemicals, requirements, occupational health and safety, environment*

1 INTRODUCTION

In today's world where we are exposed to chemical hazards on daily basis, new ways of mitigating people and environmental exposure are researched and found every day. Maybe the most significant step is manufacturing electric vehicles instead of internal combustion engine vehicles. Despite that, even in automotive industry where electric vehicles and components are manufactured, we are facing exposure and impact from different chemical hazards – from cleaning agents for whiteboards to cooling liquids used in vehicle cooling system.

With the aim of mitigating the people's exposure to chemicals and impact on the environment, Chemical Management System in the Rimac Technology and Bugatti Rimac was introduced. In the process of implementation, we have found ourselves in the situation where we needed to change or adapt already existing processes so we could manage chemicals in the companies and possibly mitigate the workers and environment exposure from the very beginning.

2 CHEMICAL MANAGEMENT SYSTEM

2.1 REQUIREMENTS

First set of requirements when it comes to Chemical Management in Croatia derive from Croatian legislation, which is majorly implementing European Union regulations together with few added requirements from their side. On the other hand, to ensure compliance with international standards, ISO 45001 and ISO 14001, which are impacting Chemical Management, are also followed. All mentioned requirements, together with specific internal requirements, were considered when creating Chemical Management Procedure in Rimac Technology and Bugatti Rimac. Internal requirements and rules are set up for the purpose of simplifying the process of managing chemicals and other processes that are directly or indirectly related to it, such as the construction of locations and departments where chemicals are used or stored.

2.2 FOUNDATIONS

According to Chemicals Act, company must employ and appoint Person responsible for chemicals under whose direct supervision hazardous chemicals will be produced, used, stored, or placed on the market [1]. Other than mentioned, appointed Person responsible for chemicals has responsibility for implementing mentioned laws and standards, collaborate with departments handling chemicals and with support departments. At the very beginning, questions about employment of person responsible for chemicals and area of coverage have arisen. Ministry of Health was contacted for every question regarding implementation of REACH regulation in both companies. It was confirmed that Person responsible for chemical must be employed in both companies to perform its duties in accordance with legislation, with taking into consideration the number of hours that are needed to cover the responsibilities towards companies. Regarding area Person responsible for chemicals must directly supervise - possibility of coverage, quick arrival and the possibility of continuous supervision is necessary with no matter on city and/or counties.

For understanding the scope legal compliance register, which contains list of all laws and ordinances with an overview of compliance to specific articles, was created. Legal compliance register was a crucial step in understanding strengths and weaknesses of both companies and with it, clear picture on improvements needed was drawn up.

Dividing all items in ERP system into categories, including chemicals, was the next step in setting up Chemical Management System. This step was prerequisite for getting a list of all chemicals in the company, for implementing proper storage of chemicals, Safety Approval and in general overview of chemical path from the procurement to disposal of chemicals. Several chemical categories were used so they can be stored in the warehouse according to them, thus avoiding the possibility of unwanted interactions in case of incidents. Mentioned division in categories was made retroactively for all items, but it is also the first step for every new introduction to the system, before procurement.

Person responsible for chemicals is responsible for giving inputs about categories of chemicals, which are also the signal for activating Safety Approval. This function is activated in ERP system, together with finance and other approvals, but only for the chemicals. Implemented rule is valid for production and testing chemicals, as well as for research and development (R&D) samples and cleaning and maintenance supplies. With Safety Approval, Person responsible for chemicals is making sure all safety information about chemicals are available before coming to the company.

Other than creating legal compliance register and having the overview of chemicals used in the company, workers using the chemicals is as much important information. In order to receive information about new employments and possible organizational changes in time for providing education and/or health examinations, Health and Safety team is receiving information about employees first days from Human Resources. With all mentioned data process of managing chemicals is simplified.

2.2.1 HIERARCHY OF HAZARD CONTROLS

When there is a need to introduce a new chemical to Rimac Technology and Bugatti Rimac processes, hierarchy of hazard controls must be followed. With its five levels of action to remove or mitigate the hazards, ranked from the most effective to the least effective method, the highest level of safety is ensured [6]:

1. Elimination – Removing the hazard.
2. Substitution – Replacing the hazards with a less hazardous one.
3. Engineering controls – Isolating people from hazard: Redesigning a process to place a barrier between person and hazards or removing the hazard from the person.
4. Administrative controls – Changing the way people work: Adopting a standard operating procedure and/or safe work practices, providing appropriate training, ensuring proper instructions for safe handling, etc.
5. Personal protective equipment (PPE) – Protection of the employee with PPE: Last line of defense which can be used with one or more of the other control measures.

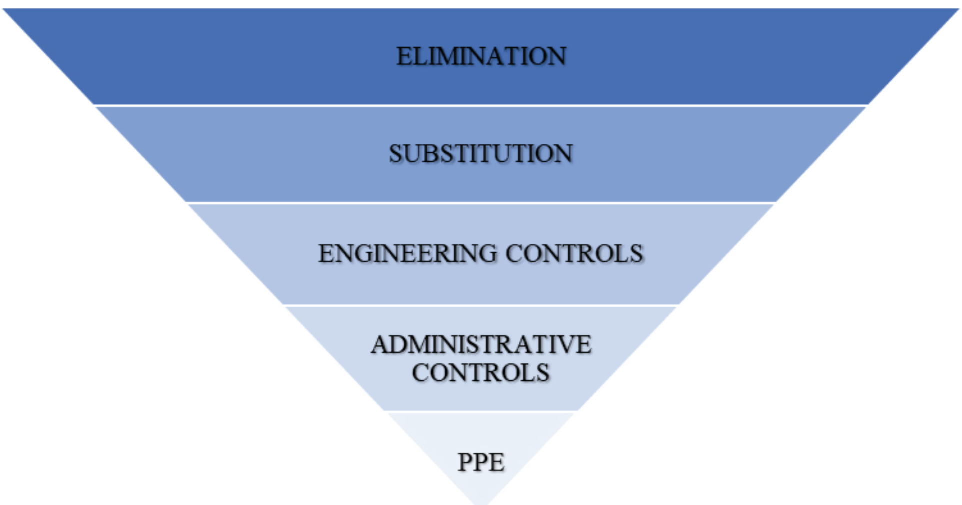


Figure 1: Hierarchy of hazard controls

2.3 DOCUMENTATION MANAGEMENT

Upon receiving information about new chemicals, suppliers are contacted for Safety Data Sheets (SDSs), based on which Instructions for safe handling of chemicals are compiled. Since Rimac Technology and Bugatti Rimac are multinational companies, instructions are written on Croatian and English language to avoid any ambiguity when it comes to workers health and safety. Instructions for safe handling of chemicals contain information about the hazards specific chemical poses, use, protective measures, first aid measures, accidental release measures, firefighting measures, storage, and disposal information, as well as information about supplier and/or manufacturer. Mentioned information are given on one page in short, on the same template so workers are familiar with it in case of need for quick access to safety information.

SDSs are translated and compiled in accordance with Croatian Laws when importing chemicals from other countries. It is important to mentioned exemption given by *Law on implementation of Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (OG 53/08, 18/13, 115/18)*, which states that SDS has to be written according to REACH regulation, on Croatian Language and Latin alphabet except in cases when less than 100 kg of chemical for industrial and laboratory use per year is imported on Croatian Market [3]. Exemption does not eliminate the need for compiling Instruction for safe handling of chemicals, moreover, it is legal obligation to write instructions on Croatian language when SDS on Croatian language is not available.

Law on implementation of Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (OG 50/12, 18/13, 115/18, 127/19) states that if chemical is used for industrial of laboratory purposes chemical labels can be on foreign language if Croatian instructions for safe handling are available to everyone who is using them. With taking this Law into consideration chemical labels are created only for empty packaging [4].

Records of import of chemicals and annual records are kept based on applicable SDSs and chemical procurement reports extracted from ERP system, based on chemical categories implemented at the very beginning of Chemical Management System implementation in the companies.

Safety data sheets of produced products are also under Person responsible for chemicals responsibility. Chemical composition of the products, SDSs of major components, various technical information are needed for proper SDSs of our products which are considered articles[1] by REACH regulation [3]. Collaboration with colleagues within the company with the knowledge of ADR transport, technical information about products, firefighting, disposal information and other is also needed.

2.4 AVAILABILITY OF SAFETY INFORMATION AND EQUIPMENT

With large number of chemicals used for production, testing, R&D purposes or as cleaning and maintenance supplies entering the company, there was a need to create

[1] Article means an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition.)

easy-to-use system for storing safety information. For this purpose, MS application *Document library* was used, since it was a part of already used system, workers using it were familiar with it and it was available to everyone, everywhere and at any time when they might need it. Other that legal and ISO requirements for availability of safety information, it is necessary to have all safety information on hand so new workers can get familiarized with them and in case of need for quick access – in case of incident or similar.

For every chemical safety data sheet, on Croatian and/or English language and instructions for safe handling of chemicals, on both languages, are available in mentioned system. Searching by name of the chemical, ERP code, document type, language of the document, chemical category, chemical hazards, physical state, storage place, supplier and manufacturer, as well as searching by department and company using the chemical were enabled. *Document library* can be pinned in any channel on MS teams, which is the main communication application in both companies, thus making it accessible in any channel needed. Instructions for safe handling of chemicals are also available in paper form on the departments.

Other safety information and equipment needed when it comes to safe handling and/or storage of chemicals are available on, so called, Safety Points. Safety Points are places in the production, testing and storage area where safety equipment and specific safety instructions are available. First aid kit and eyewash station or emergency shower, instructions on how to use eyewash, emergency numbers and explanation of pictograms, hazard and precautionary statements and general instructions for handling or storage of chemicals are part of Safety Point. General instructions for safe handling and proper storage of chemicals are written by Person responsible for chemicals since general instructions which can be bought are not fully applicable for chemicals and equipment used in Rimac Technology and Bugatti Rimac.

2.5 EDUCATIONS

Other than education on protection from hazardous chemicals [2], performed by Croatian Institute of Public Health – Division for Toxicology, which is attended if workers are using hazardous chemicals, workers are attending online Safe Use and Handling of Diisocyanates Trainings if they are using chemicals containing diisocyanates.

None of these educations have specific information about chemicals and Chemical Management System used in the companies, which is why e-learning was created. E-learning is created by Person responsible for chemicals, as interactive presentation with quiz at the end of each section. Every worker that is working with any kind of chemical must attend e-learning before start of work and until passing the quizzes with 100% efficiency, workers are not considered to be fully aware of the hazards and how to work safely with chemicals. Only after passing the quizzes with maximum efficiency, workers can work with chemicals.

2.6 OPRATIONAL ACTIVITIES

For checking compliance with mentioned laws, standards and internal procedures while handling or storing chemicals on the departments, internal control check is performed on quarterly or half-yearly basis depending on the deficiencies found on the previous one. The goal is to be fully compliant with mentioned at any time and if some deficiency has been found, to eliminate it as soon as possible, so there is no impact on workers or the environment, as well as no risk if audit or inspection occur.

Legal obligation of every legal entity using hazardous chemicals is to organize chemical hazards measurement when new process or location where chemicals are used has been implemented or changed [5]. Apart from compliance with legal obligations, chemical hazard measurement is performed also in R&D stage to check if proper engineering and other controls have been implemented. With the positive results we are confirming workers protection from the hazards chemicals are posing, or, if results are not satisfactory, additional measures are implemented at the very beginning of next project stage so there are no bigger financial or time losses.

3 CONCLUSION

In addition to the implementation of minimum conditions from legal obligations, it is important to see whether the implemented measures are satisfactory when it comes to the protection of human health and the environment. By reviewing the legislation, standards and potential requirements from the management, it is necessary to establish the initial state of management system and an action plan for reaching the desired level of protection.

By setting good foundations, it is possible to facilitate the management of any system, which does not reduce the need for professional guidance and improvements when new knowledge is gained or changes in legislation occur.

REFERENCES

[1] Chemicals Act (OG 18/13, 115/18, 37/20), *Accessed*: 2024-05-23

[2] Ordinance of conditions for performing activities of production, placing on the market and use of hazardous chemicals (OG 99/13, 157/13, 122/14, 37/20, 147/21), *Accessed*: 2024-05-23

[3] Law on implementation of Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (OG 53/08, 18/13, 115/18), *Accessed*: 2024-05-23

[4] Law on implementation of Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures (CLP), which amends, supplements and repeals Directive 67/548/EEC and Directive 1999/45/EC and amends and supplements the Regulation (EC) No 1907/2006 (OG 50/12, 18/13, 115/18, 127/19), *Accessed*: 2024-05-23

[5] Occupational Health and Safety Act (OG 71/14, 118/14, 154/14, 94/18, 96/18), *Accessed*: 2024-05-23

[6] ISO 45001 Occupational health and safety management systems — Requirements with guidance for use (ISO 45001:2018), *Accessed*: 2024-05-23

4

TECHNICAL-TECHNOLOGICAL PROTECTION FACTORS

MAINTENANCE OF INDUSTRIAL CUTTING LASERS AND THE INFLUENCE OF POOR MAINTENANCE ON MACHINE OPERATION

Tomislav Božić[1], Zvonimir Ornik[2], Tomislav Šančić[3]

[1] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, tomislav.bozic@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, (student)

zvonimir.ornik@gmail.com

[3] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, tsancic@vuka.hr

Abstract:

Laser cutting is one of the most common technologies in the metal industry today. Due to their cutting speed and processing accuracy, they have almost completely replaced the use of stamping tools. For their continuous and high-quality work, it is necessary to carry out adequate maintenance. This paper describes the process of laser maintenance related to automatic systems for removing dust and harmful particles that affect the working environment, to the mechanical principles of manual laser maintenance directly related to the quality of the work of this technology. Removal of harmful particles created by laser cutting is crucial for the environment and human health.

Key words: laser cutting, laser maintenance, harmful particles, ecology.

1. INTRODUCTION

Laser machine for cutting materials is a device that emits a narrow beam of high-intensity focused coherent light that melts the material [1]. The device itself can cut a wide range of different materials, with different geometries. In relation to machining, where machine parts are made in 3 dimensions of space with often simultaneous movements of all machine axes, the laser is based on cutting sheets of different thicknesses with simultaneous movements of two machine axes, while the third represents the positioning of the height of the laser head. Technologically, there are 2 types of lasers: CO2 lasers and fiber lasers. Cutting materials such as stainless steel, high alloy steel, titanium alloys and aluminum requires an atmosphere filled with inert gas under high pressure. The gases that fill the working space of the laser are nitrogen and argon [2].

Conventional methods of cutting contour shapes mechanically by punching and stamping or thermally by flame or plasma introduce large mechanical and thermal stresses into the material [3]. By using a focused beam of high light intensity, there are no mechanical forces that cause stresses in the material, and thermal stresses are reduced to a minimum. Due to the small diameter of the generated light beam, there is also a significant saving of material. In addition to saving materials, the high speeds at which the laser can work reduce the production time and thus the cost of manufacturing parts with this technology. The shear speed with which the laser head moves is directly related to saving the time of the production itself, however, if the laser cut is not of high quality, waste products are created, which increase production costs.

The quality of the cut is described by the appearance of slag and excessive roughness of the cut, and is controlled by parameters such as the design of the beam focusing lens, nozzle diameter, laser power, gas pressure and shear rate [4]. Improper maintenance of the laser also affects the quality of its cut, and delays in production.

In order to avoid this, this paper describes the proper maintenance of laser devices.

2. MATERIALS, METHODS AND EQUIPMENT

Different performances depending on the applied technology and construction performance of the laser depend on the complexity of its maintenance. Despite this, the principle of maintenance of such machines is very similar, so this paper lists the key segments of the machine that need to be properly maintained in order to ensure a quality cut and smooth operation of the machine. An example on which the laser maintenance procedure is described is the BySprint Fiber 3015 laser device. The entire processing area is enclosed by a casing and a protective door so that the space is secured during the process, but it is still possible to monitor through the protective door. The windows are made of polycarbonate, which blocks laser radiation and achieves safe monitoring of the machine without the risk of direct or reflected radiation, and injury to workers on moving parts of the machine. The protective doors have safety switches on them that lock them so that the machine cannot start working if they are not closed. This is why it is necessary to clean the windows, guides and contact on the door on a daily basis.

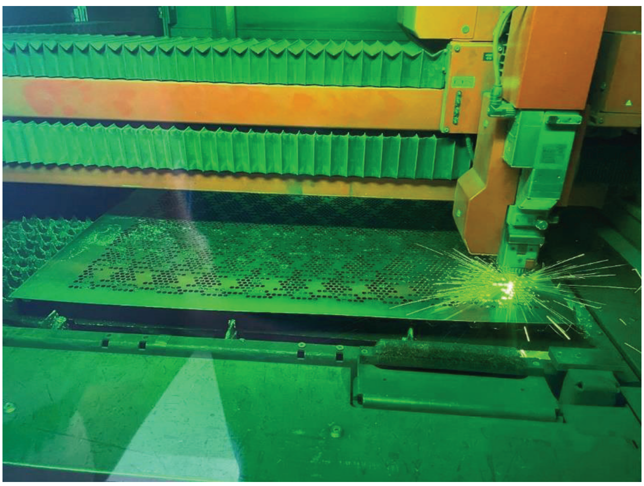


Figure 1: View through the protective glass of the machine

The working space of the laser is not closed only for safety reasons, but also for optimal extraction of cutting emissions. An extraction system is placed on the base of the machine, and it is divided into several sectors shown in Figure 2. Depending on the sector in which the cutting head is located, the corresponding suction module is turned on, and the sucked air is drained through the dust collector, where the dust is separated. It is very important to clean the tray with collected cutting dust on a daily basis in order for the suction system to function properly.

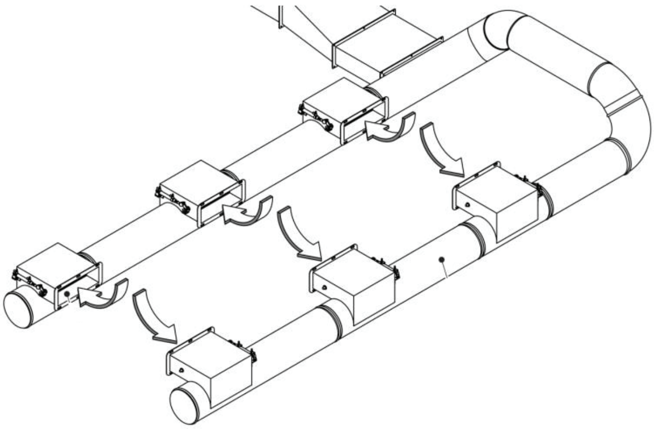


Figure 2: Dust extraction system

The process of cutting material with a laser, which generates harmful particles that are sucked into the system, begins with the placement of sheets on the table of the laser composed of grids that serve as a base for the workpiece to be cut, and it depends on the thickness of the cut material. When maintaining tables, the most common action is the removal of molten material from the table grid. If the melted material was not removed, the laser beam would weld the position during cutting. This happens because the gas has no space to blow away the molten material and it remains welded to the lower surface of the workpiece. The gratings are cleaned mechanically, manually or by machine, depending on the amount of cut material.

Figure 3: a) Table grids with accumulations of molten material after cutting aluminum alloy, b) Representation of good part, c) representation of scrap position due to accumulation of molten material

Under the table, there are containers for collecting material remains after cutting. The containers must be emptied every day in order to avoid overfilling, which could result in cut segments falling into the moving part of the table.

On the pedestal, right next to the table, there is a brass brush for cleaning the nozzle. During cutting, the laser automatically cleans and calibrates the nozzle after every approx. 100 punches to ensure a good cut. If the brass brush is too worn, the stuck-on material will not be removed during cutting, and this will result in a low-quality cut.

The cutting bridge is a moving part of the machine during processing, and it is of great importance that there is no dust or any foreign body on the guides that would cause vibrations. The complete set of X-axis and Y-axis guides must be disassembled, washed in oil and lubricated with the agent prescribed by the manufacturer every 1000 working hours of the machine. Bad cuts due to vibrations especially occur when cutting complicated geometries with sharp edges. As the laser head suddenly changes direction at high speed, an uneven cut or burnout of the position occurs. The technological solution for this is to make a loop on the detail with a sharp edge along which the laser cuts. In this way, there are no sudden changes of direction.

The cutting head shown in Figure 4. a) is the most important part of the laser cutting machine and requires special attention during maintenance. When the operator notices a bad cut on the material, in addition to the cutting parameters in the program, he also checks the laser cutting head. More precisely, it controls the nozzle, the capacity meter and the protective glass of the lens. In newer generations of lasers, the optics are made in such a way that the lens is constantly protected by a protective glass, thus preventing the lens from steaming or the sticking of splinters, making the lens longer lasting. The replacement of the protective glass shown in Figure 4. b) must be done very quickly so that dust does not get on the lens.

Figure 4: a) Laser cutting head, b) Replacement of protective glass

4. CONCLUSION

This paper describes the maintenance of laser devices for their smooth and high-quality operation. The goal is to prevent unnecessary breakdowns that cause work stoppages, resulting in loss of time and additional costs for troubleshooting. For this reason, it is necessary to properly and preventively maintain the device so that it does not stop working.

In addition to mechanical stoppages, due to the generation of harmful particles created by the melting of materials, it is especially necessary to control and pay attention to their proper disposal in order to avoid dangerous situations for human health and the environment.

This elaboration of the basic maintenance of laser devices is the basis for more detailed research on the impact of maintenance and the possibility of predicting preventive maintenance with the aim of reducing failures.

REFERENCES

[1] Badoniya, P.: *CO2 Laser Cutting of Different Materials-A Review*, International Research Journal of Engineering and Technology (IRJET), 2395-0056, July 2018

[2] Mahrle, A.: *Theoretical aspects of fibre laser cutting*, Journal of Physics D: Applied Physics, DOI:10.1088/0022-3727/42/17/175507, August 2009

[3] Schuocker, D.: *LASER CUTTING,* Materials and Manufacturing Processes, DOI: 10.1080/10426918908956297, Wien 2007.

[4] Thombansen U., Hermanns T., Stoyanov S.: *Setup and Maintenance of Manufacturing Quality in CO2 Laser Cutting,* Procedia CIRP, Volume 20, Pages 98-102, 2014.

BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

Katarina Čavlović[1], Slaven Lulić[2], Mario Fanjak,

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, katarina.cavlovic@zelenilo.hr

[2] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, slulic@vuka.

[3] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, mario.fanjak@vuka.hr

Abstract: *The laws of physics dictate that we are all exposed to electric, magnetic and electromagnetic fields produced by the simple fact of using electricity. Electromagnetic fields can act directly on an exposed body, causing direct biological effects. These effects may be thermal at high frequencies, due to the absorption of the fields, or non-thermal at low frequencies, due to the presence of induced electric fields and currents inside the body. The paper will discuss these effects..*

Keywords): *electric fields, magnetic fields , electromagnetic fields, biological effects*

1. INTRODUCTION

1.1 Natural fields

Terrestrial electric fields have existed since the atmosphere was created. There is a potential difference of 300 kV between the ground and the ionosphere – part of the atmosphere that lies above 50 km in altitude and is an electrical conductor due to the presence of free electrons.This voltage produces a permanent electric field that can reach over 200 $V \cdot m^{-1}$ in a flat and clear area. The strength of this field depends on solar activity, the season, air humidity and weather conditions.

The field can exceed 20 $kV \cdot m^{-1}$ between an electrically charged cloud and the ground. It is strengthened by the presence of pointed items, such as lightning rods. When it reaches several hundred $kV \cdot m^{-1}$, lightning strikes occur. A huge magnetic field encircles the Earth, from the North Pole to the South Pole. The shape of its lines is identical to that of a single bar magnet.This field is locally distorted by the geology of the land and by man-made structures on a smaller scale. The Earth's magnetic induction is static on our time scale. It varies according to latitude, from 30 μT near the equator to 70 μT near both poles. It is around 47 μT in France. This field protects life on Earth from cosmic rays and helps migratory species find their bearings. The Earth is also subject to natural electromagnetic fields:

- infrared rays radiated by all heat sources;
- light;
- ultraviolet rays;
- ionizing cosmic rays that are not intercepted by the Earth's magnetic belt;

– lightning: the electrical discharge produces an electromagnetic field pulse

The area of human exposure to electromagnetic fields encompasses all radiations whose frequency is lower than 300 GHz, i.e. the area where signals have a wavelength greater than 1 mm. Radiofrequencies cover a large extent of it.

The electromagnetic fields with the lowest frequencies usually encountered are those produced by the power network and by all the electrical appliances using it (electrical household devices, tooling, machines, etc.). Radiations are generally at 50 Hz in Europe (60 Hz in North America and Japan) and may be added to by multiple frequencies .

Fields with frequencies between 20 and 100 kHz have appeared more recently, with induction heating systems (cooking hobs, ovens, etc.) and switched-mode power supplies.

Frequencies located between a hundred kilohertz and a megahertz have been used in radio broadcasting (AM) for more than a century, but these services are coming to an end. Other uses will be proposed. At higher frequencies, between 80 MHz and 6 GHz, applications are numerous: FM radio, digital terrestrial television, telephony, Wi-Fi, microwave ovens, etc. They have become vital for many of us. Electromagnetic fields are also encountered in the industrial environment, such as in the power production sector and the metallurgy sectors (induction heating, welding, etc.).

2. BIOPHYSICAL MECHANISMS

Describing these mechanisms and their effects is complex, because it involves several scientific disciplines, such as physics, biology and medicine. Electric, magnetic and electromagnetic fields differ, since they act according to different physical phenomena on exposed biological tissues and organisms.

Looking at this, we can see that we have both the interaction of fields and matter in general, as well as the specific interaction of fields with biological tissues. When electromagnetic fields penetrate tissues and when their energy is transformed into heat, the significant biological effects which may occur are called "thermal effects". Effects produced through other mechanisms are called "non-thermal effects". These effects can have consequences for health well-being, depending on the frequency.

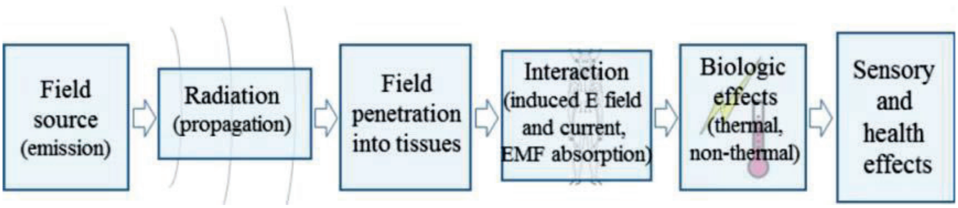


Figure 1. Complete process of the mechanisms
that may lead to effects on the health and well-being

2.1. Interactions with matter

Matter consists entirely of electrically charged particles. The electron is the smallest charged particle, which is negative. The atomic nucleus, made up of protons and neutrons, is a positively charged element. In its natural state, matter is generally neutral and at rest, because the charges are balanced. In reality, this is true in appearance only,

as on a microscopic level particles move randomly in all directions across very small distances, under the effect of thermal agitation. The sum of these movements is zero.
Materials with many free charges are called "conductors". Those that do not have enough of these charges are called "dielectrics" or, more commonly,"insulators". They cannot conduct electricity. Biological tissues have both properties, making them different from the materials usually used in electrical engineering. When an electromagnetic field is applied, matter is subjected to three phenomena:

– interactions due to low-frequency electric fields;
– interactions due to low-frequency magnetic fields;
– energy absorption from high-frequency electromagnetic fields.

The electrical properties of matter, as well as the concepts of conduction currents, displacement currents and dielectric losses, are discussed here, with reference to conductive and dielectric materials. These concepts are necessary for understanding the complexity of the properties of tissues and their interaction with fields, as explained further.

2.2. Coupling with the human body

Coupling is involved in interaction mechanisms between electromagnetic fields and the body of an exposed person. Three fundamental coupling mechanisms are well established:

– low-frequency electric field coupling;
– low-frequency magnetic fields coupling;
– high-frequency electromagnetic fields coupling.

These coupling mechanisms depend, on the one hand, on the characteristics of the field (frequency, spatial uniformity, propagation and polarization direction, etc.) and, on the other hand, on the bodily characteristics of the person, such as posture, size and morphology.

2.3. Low-frequency electric field coupling

At low frequencies, living organisms, including plants, distort the spatial distribution of an electric field. Figure 2 illustrates this phenomenon around a human body.

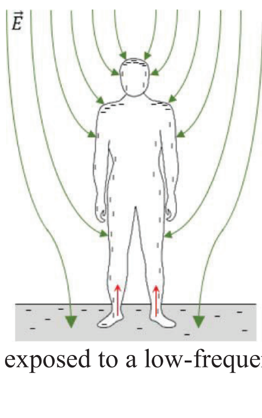


Figure 2: Body exposed to a low-frequency electric field

It will be noted that the electric field lines are almost perpendicular to the surface of the skin, due to the good electric conductivity of biological tissues in comparison to the air: only the normal component (perpendicular) at the surface of the field remains, since the tangential component is zero for the conductors.
The electric charges present in an organism will be attracted to its surface or pushed as the external field alternates. This phenomenon causes an internal electric current in a direction parallel to the field lines. It instantaneously follows variations in the field and ceases when the new distribution of charges balances the external field (electrostatic equilibrium). This new distribution of charges counterbalances the external field and the internal electric field becomes zero.
When a human body is connected to the Earth or to a mass with enough available free charges, it becomes electrically charged (Figure 2). When the body is insulated, it becomes polarized through capacitive coupling (Figure 3). The induced currents are less significant.

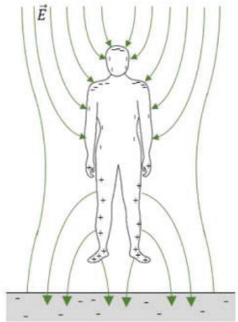


Figure 3: Insulated body exposed to an electric field

The size and posture of the body have a great influence on the fields and currents induced. The current densities present in a body touching the ground and located in a uniform vertical field of 10 kV·m^{-1} at 60 Hz are shown in Figure 4.
The accumulation of electric charges on the surface can locally accentuate the external electric field. It is at its maximum above the head. If the person moves his hand toward the source of the field, the field can reach very high values (fields must be measured in the absence of any person, including the measuring operator).

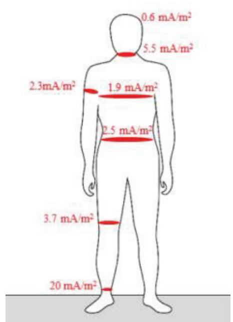


Figure 4: Body exposed to a uniform vertical electric field of 10 kV/m at 60 Hz. The current density is more significant when the cross-section is reduced

The alternation of electric charges and their distribution on the surface of the body determine the level of the currents. These are distributed depending on the conductivity of the biological tissues. Their densities depend on the surface being crossed. Hence, they are also more significant in the neck and ankles, especially when the body is touching the ground.

2.4. Low-frequency magnetic field coupling

The presence of a body in a magnetic field does not disturb it, unlike for electric fields. As the magnetic permeability (μr) of the tissues is very closeto 1, like the air, the internal magnetic field in the body is practically identical to the external magnetic field, and this field is not distorted. Magnetic fields induce electric fields according to Faraday's law .
Electric currents occur in a loop perpendicular to the direction of the magnetic field, since the human body is considered a conductor at low frequencies. These are eddy currents.
In the presence of a uniform magnetic field, the internal electric field and current density are zero at the center of the exposed area. They take on an increasingly significant value as they near the edges, and the highest values are encountered in the cutaneous tissues. They are distributed nonhomogeneously, depending on the electric conductivity of the tissues. These quantities are not relevant at frequencies above 10 MHz, because absorption phenomena take over. Figure 5 is a simplified representation of eddy currents in the case of a time-varying magnetic field whose flux lines are directed frontally toward a body.

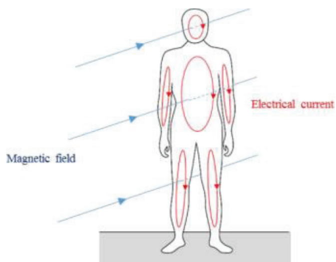


Figure 5: Currents caused by a time-varying low-frequency magnetic field in a human body (the magnetic flux is perpendicular to the frontal plane)

3. CONCLUSION

The impact of electromagnetic fields on the human body varies depending on their frequency, strength, and type. The diagrams illustrate how the human body can absorb or scatter electromagnetic waves, leading to various biophysical effects. Under normal circumstances, the body functions within a natural electromagnetic environment, but exposure to more intense or artificially induced electromagnetic fields can cause changes at the cellular level, as well as potential health risks. Therefore, understanding the interaction between electromagnetic fields and the human body is crucial for developing safety standards and guidelines in everyday life and technology.

REFERENCES

[1] Staebler, P. (2018). *Human Exposure to Electromagnetic Fields: From Extremely Low Frequency (ELF) to Radiofrequency*. John Wiley & Sons (2018)
[2] Bernhardt J.H., "The establishment of frequency dependent limits for electric and magnetic fields and evaluation of indirect effects", Radiation and Environmental Biophys.,(1988)
[3] Bolomey J.C., Gardiol F.E., Engineering Applications of the Modulated Scatterer Technique, Artech House, London, (2001)

THE RELEASE OF FIBRE FRAGMENTS FROM ARTIFICIALLY AGED POLYESTER/COTTON FABRIC DURING WASHING PROCESS

Tihana Dekanić[1], Tanja Pušić[1], Ana Šaravanja[1]

[1] University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, 10000 Zagreb, Croatia

tihana.dekanic@ttf.unizg.hr, tanja.pusic@ttf.unizg.hr, ana.saravanja@ttf.unizg.hr,

Abstract: *Fibre fragments released during the washing of synthetic textiles pose a serious threat to the environment and aquatic organisms, leading to undesirable consequences over the years. To mitigate these problems, their release must be prevented or reduced. To determine the release of fibre fragments during washing and their impact on wastewater, a standard polyester/cotton fabric was used. The tested fabric was exposed to UV radiation under controlled conditions in a weathering device and washed using a standard and an innovative washing process. Artificial ageing simulates the processes that occur naturally over time, but with the aim of achieving the desired goal more quickly. A standard polyester/cotton fabric was artificially aged for 85 hours in accordance with the ISO 105-B02+A1:2013 standard and washed 10 times at 60 °C, before and after ageing. The wastewater from each wash was collected and analysed. The laser diffraction method was used to determine the size and differences in particle distribution. The physico-chemical indicators of the collected wastewater were determined by measuring pH, conductivity, chemical oxygen demand (COD) and by microscopic analysis of the released and isolated fragments. The results show detached fibre fragments and differences in the quality parameters of the wastewater. The distribution of the particles after ageing and washing with the innovative and the standard process support the innovative washing process.*

Keywords*: polyester/cotton, artificial ageing, washing process, fibre fragment release*

1. INTRODUCTION

The mass production, excessive use and exploitation of plastic items have led to a significant accumulation of plastic in environment. The sharp increase in the world's population, particularly in the last thirty years, has also contributed to this. Plastic has found its way into all areas and pores of our society. Consumerism and irrational behaviour, insufficient care, lack of education and disinterest of the population have contributed to the acceleration of systematic environmental pollution.

Textile products are considered one of the largest potential sources of microplastic pollution in the aquatic environment. Microplastics (MP) originating from textiles are in the form of debris, fragments and fibres referred as microfibres (MF) [1,2]. One of the main sources for the release of MFs is the manufacture of textile products themselves, followed by industrial and domestic washing and drying [3-7]. Most fibre fragments are released during the first wash cycle and the release decreases with increasing number of washes. Washing process factors such as chemistry, mechanical agitation, temperature and time have a certain influence on fibre release [8], while the size and quantity of fibre fragments released from textiles such as polyester/cotton textiles during domestic washing depend on the properties of the material itself and the washing conditions. The type and composition of the detergent also influence the total mass of fibre fragments released during washing. The results show that a single garment can release over 1900 fibres per wash, while all garments release up to 100 fibres per litre of wastewater, with nonwovens releasing up to 180% more than others [9].

The properties and characteristics of textile materials change over time and under the influence of different environmental conditions [10]. Due to the long duration of the natural ageing process, more and more researchers are turning to the artificial ageing process to obtain estimates under real conditions [11]. In laboratory test devices, a xenon lamp replaces sunlight, which can lead to deformation and ageing of the polymer under the environmental conditions caused by UV radiation [12,13].

The aim of this study was to monitor the release of fibre fragments from artificially aged polyester/cotton fabric during standard and an innovative washing process. The purpose of the innovative compared to the standard process is to mitigate the release of fibre fragments into wastewater, as the main hypothesis of a study.

2. MATERIALS AND METHODS

The effects of standard and innovative washing processes on standard and aged polyester/cotton (PES/CO) (65/35) fabric, the mass per unit area 180.0 g/m^2 and a warp/weft density of 28.3/19.0 threads/cm in plain weave, provided by the Centre for Testmaterials BV Employees, CFT, Netherlands, were investigated.

To avoid the influence of threads protruding from the edges of the tested samples, an ultrasonic cutter TTS400, Sonowave, Italy, was used to prepare and cut the samples.

The fabrics are artificially aged for 85 hours (85H) in the Xenotest device, SDL Atlas, USA, according to the ISO 105-B02+A1:2013 standard. The PES/CO fabric is exposed to direct UV radiation with a relative humidity of 40% and an irradiation of 42±2 W/m^2 in the wavelength range from 300 to 400 nm.

Standard and artificially aged PES/CO fabrics were subjected to the washing process in the Rotawash, SDL Atlas, USA, according to HRN EN ISO 6330 using the standard ECE A detergent with a bath ratio of 1:7 at a temperature of 60 °C for 30 minutes in 10 washing cycles, Tab. 1.

Table 1: Sample labels with description

Samples	Description
PES/CO_N_st	Standard polyester/cotton fabric, unaged, washed 10 times according to the standard procedure
PES/CO_N_in	Standard polyester/cotton fabric, unaged, washed 10 times using an innovative procedure
PES/CO_85H_st	Artificially aged polyester/cotton fabric for 85 hours, washed 10 times according to the standard procedure
PES/CO_85H_in	Artificially aged polyester/cotton fabric for 85 hours, washed 10 times using an innovative procedure

The innovative process refers to the gradual reduction of the washing bath temperature before rinsing. After each individual wash cycle, the wastewater is collected to obtain a composite sample of the wastewater for further physico-chemical and microscopic analysis.

The degree of contamination of the wastewater is analysed after 10 washing cycles. The fibre fragments are quantified based on the composition of the wastewater using standard methods. The pH value was determined in accordance with HRN EN ISO 10523:2012 and the conductivity in accordance with HRN EN 27888:2008 using a Mettler Toledo multimeter. The chemical oxygen demand, COD, is determined with a PhotoLab photometer, WTW, in accordance with HRN ISO 15705:2003 and the turbidity with a Hach Lange turbidimeter in accordance with HRN EN ISO 7027-1:2016. The particle size distribution is determined with the laser diffraction method using a PSA analyser (Particle Size Analyzer), Anton Paar, in accordance with HRN ISO 13320:2020. A Kern OBE 134 transmitted light microscope was used to examine the collected wastewater samples to detect MF fragments.

3. RESULTS

In this study, the standard PES/CO fabrics were subjected to simulated artificial ageing for 85 hours. Both samples were subjected to a standard and an innovative washing process through 10 cycles. The physico-chemical parameters of a standard and innovative wastewater samples are shown in Table 2.

Table 2: Physico-chemical parameters of the wastewater samples after standard and innovative processes

Samples	pH	κ (μS/cm^2)	T (NTU)	COD (mg O_2/L)
PES/CO_N_st	8.28	740.7	31.4	83
PES/CO_N_in	8.11	551.7	29.4	77
PES/CO_85H_st	7.79	741.1	31.7	87
PES/CO_85H_in	7.97	584.9	25.9	72

According to the values of pH, the alkalinity of all wastewaters is proved. The conductivity of the analysed wastewater samples is different, where PES/CO_N_st and PES/CO_85H_st are very similar and higher to PES/CO_N_in and PES/CO_85H_in by almost 150-200 units. Turbidity (T) is an optical parameter for determining clarity, so can be related to the dispersed particles in the washing wastewaters. Turbidity values of PES/CO_N_st (31.4 NTU) and PES/CO_85H_st (31.7 NTU) wastewater samples are higher than the value of a wastewater sample PES/CO-85H_in (25.9 NTU). The conductivity and turbidity values are in good correlation, showing a lower level of wastewater load in the innovative washing process than in the standard process. The chemical load (COD) of wastewater PES/CO_N_in and PES/CO_85H_in is also less than PES/CO_85H_st and PES/CO_N_st..

According to the obtained results in turbidity, conductivity and COD, the artificial ageing process (85H) did not significantly affected the weakening of the PES/CO fabric. The difference in these values indicates on impact of washing parameters. The gradual cooling in innovative washing process showed a potential to stabilise the structure and thus prevent certain defragmentation.

The influence of the standard and the innovative washing process was additionally monitored by characterising the wastewater by determining the particle size distribution curve using the laser diffraction method according to the Fraunhofer theory. Laser diffraction is based on the fact that particles passing through a light source scatter the light at an angle that decreases logarithmically with increasing particle size. The scattering of the light depends on the size of the particles and the wavelength of the scattered light. The results are displayed as a volume distribution of particles of a certain size in a certain size interval.

The results of the volume distribution of the wastewater particle sizes are shown in Figure 1, while the characteristic parameters of the curves are listed in Table 3.

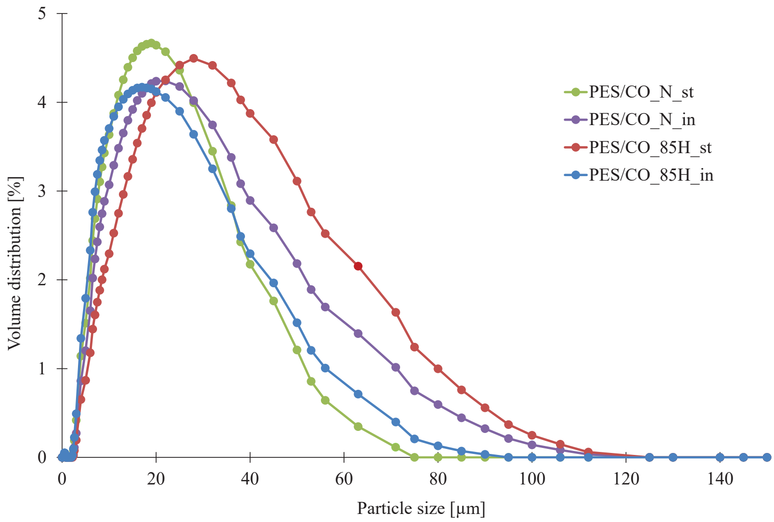


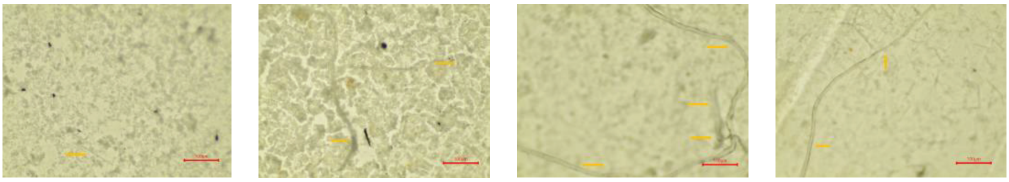
Figure 1: Particle size distribution in the wastewater after 10 washing cycles of standard and artificially aged PES/CO fabric using standard and innovative processes

Table 3: Characteristic parameters of the particle size distribution

Samples	Parameters		
	k	Span value	Mean size volume (µm)
PES/CO_N_st	1.65	1.95	18.44
PES/CO_N_in	1.48	2.23	23.23
PES/CO_85H_st	1.53	2.07	27.74
PES/CO_85H_in	1.49	2.24	18.85

The washing process of the aged fabrics has an influence on the particle size distribution, Figure 1. The impact of standard washing procedures depend on the samples; The shape of a PSD curves for PES/CO_N st and PES/CO_N_in is similar for the particle size (0-40 µm), but the k value of a curve PES/CO_N_in (1.48) indicate a shift to large particle sizes (till 110 µm). The same trend is obtained with a PES/CO_85H_st (1.53) and PES/CO_85_in (1.49). In the standard washing process of non-aged PES/CO fabric, the distribution shifts towards smaller particles (mean size 18.84 µm), whereas it is increased in the innovative process (mean size 23.23 µm). The shape of PSD curves (PES/CO_N_st and PES/CO_85H_in) as well as particle distribution are similar in shape but different in a span. Characteristic parameters and PSD curves proved that the impact of standard and innovative washing procedures are different on non-aged and aged polyester/cotton fabric samples. The most expressive impact is recorded by PSD curve of PES/Co_85H_st fabric sample.

The microscopic observation of the wastewater samples were performed and micrographs are shown in Figure 2. Fibrilar fragments from the PES/CO fabrics deposited on polyethersulfone filters.



a.) b.) c.) d.)

Figure 2: Micrographs of wastewater drop: a.) PES/CO_N_st, b.) PES/CO_N_in, c.) PES/CO_85H_st, and d.) PES/CO_85H_in

Micrographs prove a difference in presence and distribution of fibre fragments released from the polyester/cotton fabric during the standard and innovative washing process. These results also confirmed application of this method for evaluation of MF fragmentation in a washing process.

4. CONCLUSION

The aim of this study was to observe the release of fibre fragments from non-aged and artificially aged standard polyester/cotton fabric during a standard and an innovative washing process. The results confirmed that the ageing process had no significant effect on physico-chemical parameters of conductivity, turbidity and chemical oxygen demand of analysed wastewaters.

It was proved that impact of standard and innovative washing processes of aged polyester/cotton fabric is different. Microscopic view of wastewater drops showed the fibre fragments. The volume distribution of particles is in favour of the innovative washing process.

The results proved a convenient impact of innovative process compared to standard process, so the main hypothesis is confirmed. All parameters indicate that the innovative washing process is a good mitigation option to reduce the release of fibre fragments.

REFERENCES

[1] Roos, S.; Levenstam Arturin, O.; Hanning, A.-C. Microplastics Shedding from Polyester Fabrics, Mistra Future Fashion Report No 2017:1, SEREA. 2017. Available online: http://mistrafuturefashion.com/wp-content/uploads/2017/06/MFF-Report-Microplastics.pdf (accessed on 26 November 2021).

[2] Manshoven, S.; Smeets, A.; Malarciuc, C.; Tenhunen, A.; Mortensen, L.F. Microplastic Pollution from Textile Consumption in Europe, Eionet Report—ETC/CE 2022/1. Available online: https://www.eionet.europa.eu/etcs/etc-ce/products/etc-ceproducts/etc-ce-

report-1-2022-microplastic-pollution-from-textile-consumption-in-europe (accessed on 26 November 2021).

[3] De Falco, F.; Gullo, M. P.; Gentile, G.; Di Pace, E.; Cocca, M.; Gelabert, L.; Brouta-Agnés, M.; Rovira, A.; Escudero, R.; Villalba, R.; Mossotti, R.; Montarsolo, A.; Gavignano, S.; Tonin, C.; Avella, M.: Evaluation of microplastic release caused by textile washing processes of synthetic fabrics, *Environmental Pollution,* **236** (2018), 916-925., https://doi.org/10.1016/j.envpol.2017.10.057, ISSN 0269-7491

[4] De Falco, F.; Cocc, M.C.; Avella, M.; Thompson, R.C.: Microfiber Release to Water, Via Laundering, and to Air, via E-veryday Use: A Comparison between Polyester Clothing with Differing Textile Parameters, *Environmental Science Technology*, **54** (2020) 6, 3288-3296, 10.1021/acs.est.9b06892, ISSN 1520-5851

[5] Napper, I. E.; Thompson, R. C.: Release of synthetic microplastic plastic fibres from domestic washing machines: Effects of Fabric type and washing conditions, *Marine Pollution Bulletin* **112** (2016) 1-2, 39-45, https://doi.org/10.1016/j.marpolbul.2016.09.025, ISSN 0025-326X

[6] Pirc, U.; Vidmar, M.; Mozer, A.; Kržan, A.: Emissions of microplastic fibers from microfiber fleece during domestic washing, *Environmental Science and Pollution Research* **23** (2016), 2206-2211, DOI 10.1007/s11356-016-7703-0, ISSN 0944-1344

[7] Choi, S.; Kwon, M.; Park, M.-J.; Kim, J.: Characterization of Microplastics Released Based on Polyester Fabric Construction during Washing and Drying, *Polymers* **13** (2021) 24, 4277., https://doi.org/10.3390/polym13244277, ISSN 2073-4360

[8] Choi, S.; Kwon, M.; Park, M.-J.; Kim, J. Characterization of Microplastics Released Based on Polyester Fabric Construction during Washing and Drying, *Polymers* **13** (2021), 24, 4277, ISSN 2073-4360

[9] Browne, M. A.; Crump, P.; Niven, S. J.; Teuten, E.; Tonkin, A.; Galloway, T.; Thompson, R.: Accumulation of microplastic on shorelines woldwide: sources and sinks, *Environmental science & technology*, **45** (2011) 21, 9175-9179, https://doi.org/10.1021/es201811s, ISSN 0013-936X

[10] Šaravanja A.; Pušić, T.; Dekanić, T.: Microplastics in wastewater by washing polyester fabrics, *Materials*, **15** (2020) 7, 2683.,https://doi.org/10.3390/ma15072683, ISSN 1996-1944

[11] Miraftab, M.; Horrocks, A. R.: Ecotextiles - The way forward for sustainable development in textiles, Woodhead Publishing in association with the Textile Institute, ISBN-10:978-1-4200-444-7, Cambridge, 2007

[12] Jiangyan, M.; Yunying, W.: A review on artificial aging behaviors of fiber reinforced polymer-matrix composites. In: MATEC Web of Conferences. EDP Sciences, 67 (2016), 06041., DOI: 10.1051/06041

[13] Lemmi T. S., Barburski, M.; Kabziński, A.; Frukacz K.: Effect of thermal aging on the mechanical properties of high tenacity polyester yarn, *Materials*, **14** (2021) 7, 1666, https://doi.org/10.3390/ma14071666, ISSN 1996-1944

Acknowledgments: This research was funded in a part by the Croatian Science Foundation, grant number HrZZ-IP-2020-02-7575 and in a part by the HrZZ-DOK-2021-02-6750.

SAFETY ASPECTS OF STRAIGHTNESS DEVIATION OF COLUMNS ACCORDING TO EN 10034:1993

Josip Hoster[1], Andrija Berislavić[2]

[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, jhoster@vuka.hr

[2] Karlovac University of Applied Sciences, Student at the Mechanical Engineering Study, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, berislavic.andrija@gmail.com

***Abstract**: Frame structures with columns designed from a hot rolled sections are very common, wide in use. The connecting, mostly horizontal, beam is often a truss structure. Columns are mainly considered straight in design procedure, from which load on the column's any given cross section is simplified in comparison to the straightness deviation taken into consideration in this paper. EN 10034:1993 depicts the acceptable boundaries for straightness deviation for "I" an "H" hot rolled sections, which will be incorporated into design here. Maximum difference in stress due to difference in bending moment will be shown.*

***Keywords:** Column, Straightness, EN 10034, bending, frame structure*

1. INTRODUCTION

The frame structures are the vertical part of various metal structures, such as warehouses, farm facilities, and so on. The "backbone" of such structures are frame structures, supporting the wall panels, roof beams, roof covers and so on. The frame structure consists of columns, mainly vertical 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 and in some cases accidental impacts with internal trasportation vechicles. All the vertical loads act bending the beam, causing its end parts to rotate. Those ends are rigidly joined (connected) to the column's tips, and so acting on the columns by the bending moment. The columns 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 limited in maximum value relative to the section span in the EN 10034:1993. Here, for the sake of simplicity, this unstraightness 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 EUROCODE [3] offers solutions for critical load for various constraint cases. Simplified calculation of buckling critical load by Euler method [1] does not incorporate any initial unstraightness. Calculation proceedure in those roolbooks cover wide range of load and support combinations. However, they do not offer details in introducing stiffeners or reinforcements. Some details in eccentric force acting on a streaight column is depicted in [2], however, not incorporated all possible loads on a colun in a frame structur. A user cannot view in detail how the bending moment, hence the stress, is distributed. So, the aim of this approach is to offer a numerical solution procedure to have an insight into details of deformation and load of columns. Taking into consideration initial deviation from straightness, and deflection of the column's tip with respect to the base cross section, the calculation, or behavior of columns is nonlinear.

2. PROBLEM FORMULATION

Following the detailed derivation of the differential equation for the initially imperfect (non strainght) column, shown in [4], a frame structure, simbolically shown in 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 adopted here has the form

$$w_0\left(x\right)=0,5e\left(1-\cos\left(2\pi x/L\right)\right). \qquad (1)$$

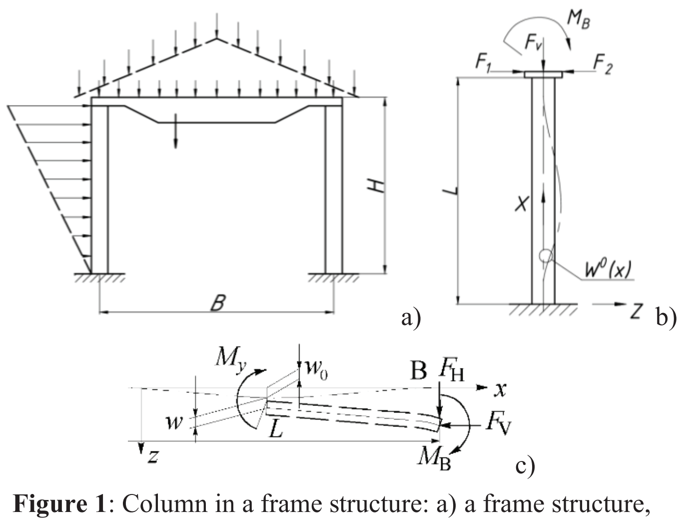


Figure 1: Column in a frame structure: a) a frame structure, b) physical model of a column, c) a free body diagram

For the numerical solution for deformed shape of column's elastic line a vertical force F_V, a horizontal force F_H and a bending moment M_B at beam and column joint is incorporated into mathematical model further on.

2.1. Numerical solution for deformation of columns

The influence of initial deflection on maximum bending moment under some combination of before mentioned loads on column is here derived from the numerical solution for the deformed elastic line through a presumed solution method. Presumed solution of deflection part caused by the loads is in form of polynomial of order n. Equilibrium equations have been satisfied in n - 2 chosen points. This is in detail depicted in [3].

The solution of the structure's deformed state (i.e, the columns) has been obtained by adopting numerical procedure based on a assumed solution [5] and imposing a condition of exact satisfying the differential equation at chosen set of points, described in detail in [2, 4, 5]. The solution for part of deflection caused by loads, not initial deflection, w^a, is in polynomial form, without detailing for the sake of brevity, depicted by

$$w^{a}\left(x\right)=\sum_{2}^{4}a_{i}x^{i}+a_{5}\cos\left(2\pi x/L\right) \tag{2}$$

$$\begin{aligned} &M_{y}\left(x\right)=-EI_{y}\left(x\right)\left(\mathrm{d}^{2}w^{a}/\mathrm{d}x^{2}\right);\\ &-F_{V}\left(w_{B}-w^{a}\left(x_{i}\right)-w_{0}\left(x_{i}\right)\right)-F_{H}\left(L-x_{i}\right)-M_{B}=-EI_{y}\left(x_{i}\right)\left(\mathrm{d}^{2}w^{a}/\mathrm{d}x^{2}\right).\end{aligned} \tag{3}$$

The solution function (2) has been chosen such that it satisfies the constraint conditions for the fixed lower end, $w^a(0) = 0$, $\mathrm{d}w^a/\mathrm{d}x(0) = 0$. Further on, the remaining 4 unknown parameters will be calculated from the system of equations by setting the exact equilibrium at points $x_i = \{L/4, L/2, 3L/4, L\}$, according to equilibrium equations (3).

2.2. Allowable initial deviation from straightness

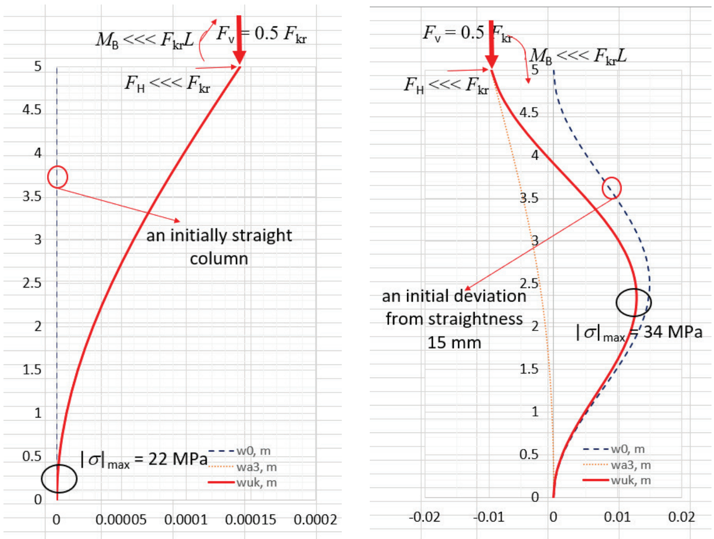
The standard EN 10034:1993 depicts the allowable value of straightness relative to section length, in relation to the section height. In short, those relative values are shown in table 1.

Table 1: Straightness tolerance according to EN 10034:1993

Section height, h, mm	Straightness tolerance, q, %
$80 < h < 160$	0,3 L
$160 < h < 360$	0,15 L
$h > 360$	0,1 L

2.3. Results for the column deformed shape

Based on the before mentioned equations, a case study of a column chosen as hot rolled HE120AA section, length 5 m, with no initial deviation from straightness, and the same column with allowable deviation from straightness according to table 1, have been calculated loaded at the tip with vertical force equal to half the critical Euler buckling force [1], a horizontal force of 1 N, so that numerically it can be incorporated, and a bending moment 1 Nm. On the following figure the deformed shape and maximum absolute normal stress are shown.



a) b)

Figure 2: Deformed shape of column's elastic line:
a) initially straight column, b) initially non straight column

In comparison, the allowable deviation from straightness in amount of 15 mm for the same load, same calculation procedure, gives difference in tip displacement in direction (towards left – non-straight column, towards right – straight column), amount around 10 mm non-straight, 1,5 mm straight, and maximum absolute stress, about 50% more stress in non-straight column. This alone will not be the criteria to conclude how much can the deviation from straightness affect deformation of columns. Their deformation in a structure will further on show how much can deviation from straightness affect safety of such structures.

2.4. Numerical solution for deformation of the beam

Beam in the case study is presumed as a truss carrier comprising of upper and lower rafter closed hollow rectangular sections joined by strut hollow sections welded together. The beam height is allowed to be longitudinally variable for optimization purpose. Deformed shape, here omitted for the sake of brevity, has been obtained through the analog beam method [1]. The beam has been assumed axially rigid, and linear deformation behavior.

3. NUMERICAL EXAMPLE OF A FRAME STRUCTURE

For the purpose of emphasizing the influence of deviation from straightness on buckling behavior of a column, a numerical example of a frame structure shall be employed. The columns are 5 meters in length, the structure has a 10-meter span, loaded with a concentrated load of 14 kN at the midspan, snow on the roof, its own weight, and a side wind of 25 m/s. The length of 5 meters and an initial iteration of calculation for the column section yields a 120 mm section height, so the limit value for sections between 80 and 160 mm of height, according to table 1, gives 0,3%*L* limit value, which for 5 meters of length gives 15 mm of deviation. The chosen value is then 15 mm at the column mid span, in shape of a shifted cosine, as shown in figures 1 b) and 3. Deflection is not in scale with the structure geometry with the goal to emphasize the deformed shape. The highest stress is around 115 MPa at the joint of beam and the right-hand side column. Same calculation performed for initially straight columns gives similar maximum stress at the beam and right-hand side column joint. The highest stress in the beam in both cases is within 1% difference to the initially non-straight column. The joint flexural rigidity is of highest importance for reducing highest stress, as it was presented in [4]. Increasing columns flexural rigidity at the top of the column, i.e., at its joint with the beam, reduces the stress most significantly.

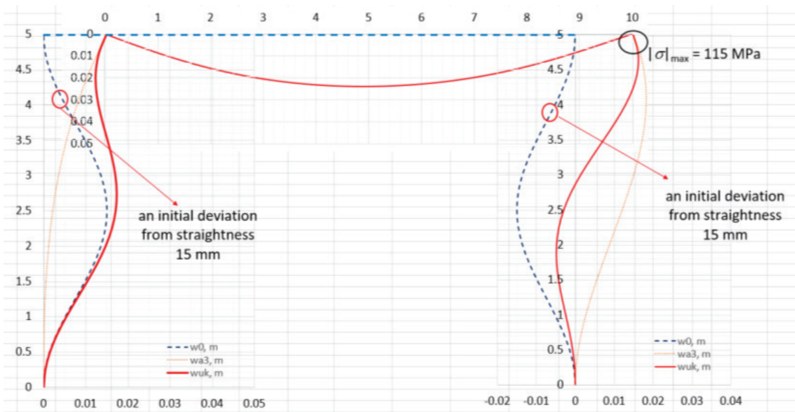


Figure 3: Frame structure in deformed configuration with initial deviation from straightness

The results shown through figures 3 and 4 lead to a conclusion that initial deviation from straightness within the values limited by the EN 10034:1993 standard in some cases of deviation "orientation", which would be if the columns are both deviated to the same side, the direction of the outer horizontal force, and so on, it is not that straightforward to conclude the maximum influence of deviation form straightness.

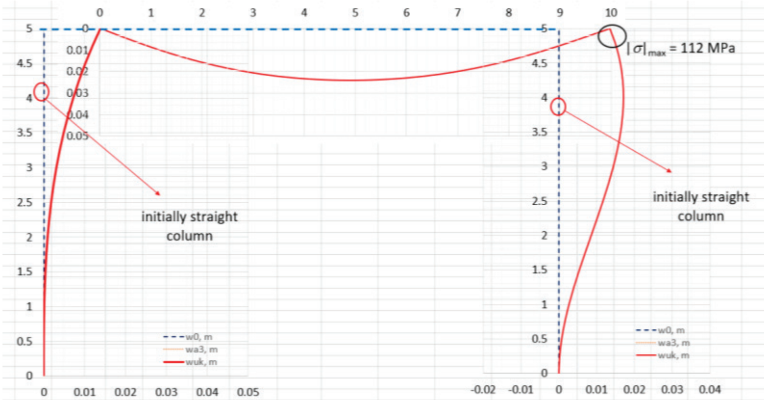


Figure 4: Frame structure in deformed configuration without initial deviation from straightness

4. CONCLUSION

Throughout this presented numerical cases, the influence of deviation from straightness is very clear, but in case of such columns in a frame structure, it does not show at the same magnitude, or, the better way of saying the results, it would take more combinations of horizontal wind direction combined with shape of initial deviation from straightness to conclude the maximum influence of deviation from straightness. The analysis of a single column with deviation from straightness shows around 60% higher maximum stress in case of a non-straight column.

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] Hoster, J.; Stavljenić, D. & Katić, M.: Improvement of safety of columns with geometrical imperfections in frame structures, *Proceedings of VIII. International Professional and Scientific Conference: Occupational Safety and Health*, Kirin, S. (Ed.), pp. 335-341, ISSN 2975-3139, Zadar, Croatia, September 2022, Karlovac University of Applied Sciences, Karlovac, (2022).

[5] Liu, G. R.: *Mesh Free Methods; Moving beyond the Finite Element Method*, CRC Press, ISBN 0-8493-1238-8, Boca Raton, 2003.

INCREASING STABILITY AND SAFETY OF THIN-WALLED HOLLOW SECTIONS BY PRESTRESSED INSERTS

Josip Hoster[1], Andrija Berislavić[2], Antun Radečić[2]

[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, jhoster@vuka.hr

[2] Karlovac University of Applied Sciences, Student at the Mechanical Engineering Study, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, berislavic.andrija@gmail.com; antunradecic49@gmail.com

***Abstract**: Thin-walled hollow sections are very favorable in many structures for their excellent stiffness to weight ratio. They are excellent building components in truss structures, such as beams. In case of compression of a part with hollow section the first level of stability design criteria is global buckling, such as Euler buckling, critical force, and further on the second level of stability criteria is case of local compression, or bending, not whole of the section is necessarily in danger of buckling, local loss of stability, i.e., cross section buckling. For the purpose of increasing stability of hollow sections, a prestressed inserted element is considered as a stiffening aid to avoid danger of cross section buckling. In this paper the main idea is to show the influence of inserted element elasticity modulus on increase of stability, hence the safety of use of such a hollow section. Round sections made from structural steel S235 have been used in the measurement.*

***Keywords:** Thin walled, hollow section, bending, cross section stability, local buckling.*

1. INTRODUCTION

The thin-walled sections are an essential building elements of truss structures. The truss structures are the most widely used form of high span structures, due to their favorable load capacity to weight ratio. The closed hollow sections as the building elements of truss structures are favorable for their buckling stability to weight ratio, and smaller surface area to cross section area as compared to open hot rolled sections in the context of surface protection, and the quantity of varnish.

In general, the thinner the section wall, the better its buckling stability as a "global" truss member, i.e. beam buckling, [2, 3] however, this leads to decreasing local cross section stability, with increasing diameter to wall thickness ratio. Therefor the goal of this paper is to show influence of inserted elements, inserts, of more elastic material, namely wood, with prestress, within the most compression stressed part of such circular thin-walled beam. Truss members are mostly loaded with tension and compression axial forces, with not much bending stress. The choice of circular cross section is for the reason of diameter overlap control. The overlap will cause prestress in the section wall, which by itself isn't the aim, but rather giving more support radial to the wall at the beginning of deformation, i.e., the loss of circular shape towards elliptical or some other. The amount of overlap combined with the inserted material's elasticity modulus is considered to be parameters which influence the most to cross section stability.

The results of this approach will give some detail in possibility of improving local stability of thin-walled tubes, and the technique for achieving the prestress in a cylindrical tube. In case of a long tube being used as a beam, with bending moment changing along it, inserting the element for reinforcement for a half of the length would be a poor choice. Hence, sort of an "assembly" insertion element will be used. It will comprise of a cylinder with its outer diameter equal to the inner tube diameter, with a cone hole in its center. In this hole a cone with its largest diameter 2% to 5% larger than the largest diameter of the hole, making the radial pressure achievable through axial pressing of cone element. Largest cone diameter depends on its material elasticity modulus. With such an element it becomes relatively easy to reach middle of the tube that have constant inner diameter.

2. PROBLEM FORMULATION AND METHODOLOGY

The tubes to be used in testing will have supports on their ends, according to figure 1 a), as pines, allowing free rotation, and a ring or cylindrical "sleave" in the midrange, to act as a load distribution element. The geometrical characteristics of tubes planned for testing is ratio of thickness s to mid radius r_m, as shown in figure 1 b), is between 1,5/20,5 for the thickest, to 0,75/12,5 for the thinnest [4]. The material for the load distribution element will be soft wood, pine. Pines will be constructed with ball bearings, for the smallest possible influence of rotational resistance.

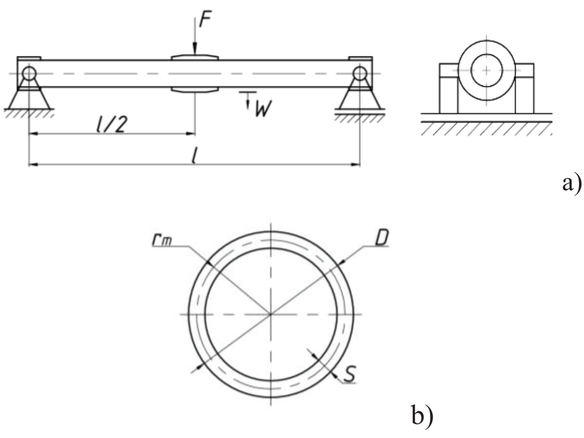


Figure 1: Cylindrical tube in a test rig: a) Tube with supports and load ring, b) Geometrical characteristics of tube

Bearings will have a soft wood sleave for load distribution. Values for the range of vertical force have been determined based on the strength (yield) limit based on thin beam bending theory [1]. Those data shall be plotted in a diagram for the purpose of determining the start of change in linear behavior, i.e., linear dependence of deflection to force. Curves for different set of parameters, i.e., insert material elasticity modulus, length, and initial pressure (overlap), will be compared in diagram with the curve for tube with no reinforcement.

2.1. Force application and measurement

The vertical force, denoted *F* in figure 1 a) will be applied in form of a free weight suspended by a flat cargo securing strap, 20 mm wide. It will be in form of a loop around the tube, with strap passing over the outer element over the tube. The measurement will be carried out as a combination of setting the load, a free weight, measured by digital scale to a 2-gram precision, and measuring deflection *w*. Deflection will be measured in precision 0,2 mm using a caliper and measuring relative to a fixed point.

2.3. Prestress in insert elements

The influence of inserted element is mostly dependent on its elasticity modulus, pressure and its length. Value of prestress is calculated with assumption of no change of inner tube diameter, i.e. rigid tube, and rigid cone which expands the inserted element [1]. The length of inserted element, in figure 2, is denoted further on as l_2. The prediction of prestress is based on control of length of steel cone inserted in the wooden insert element, hence, change of radial measure of wood and axisymmetric strain and stress state.

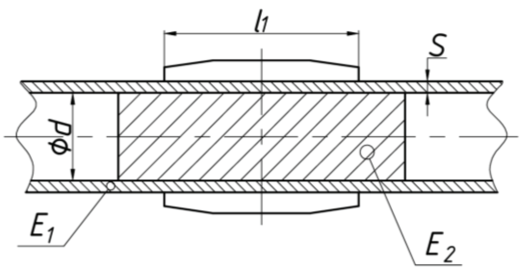


Figure 2: Inserted element

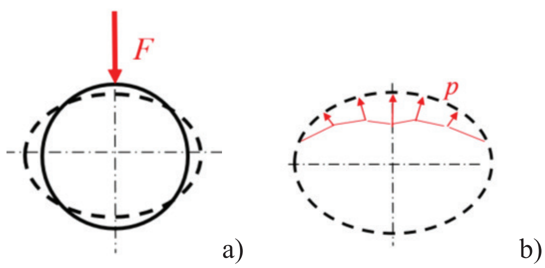


Figure 3: Tube under load: a) change in cross section, b) expected pressure distribution

3. RESULTS OF MEASUREMENT

Three different tube geometries have been measured. The thinnest one has the geometry ratio $s/r_m = 0.75 / 13.25 = 0,05666$, $s/r_m = 1 / 15 = 0,0666$ and $s/r_m = 1.5 / 20.5 = 0,0732$, with different free bending lengths, i.e., spans. Basic geometry parameters are written in a box in each diagram showing results. The results of measurements are shown for a basic tube stability curve, and three insert element prestresses. For the first tube with $s/r_m = 0.75 / 13.25$ the results are shown in diagram in figure 4.

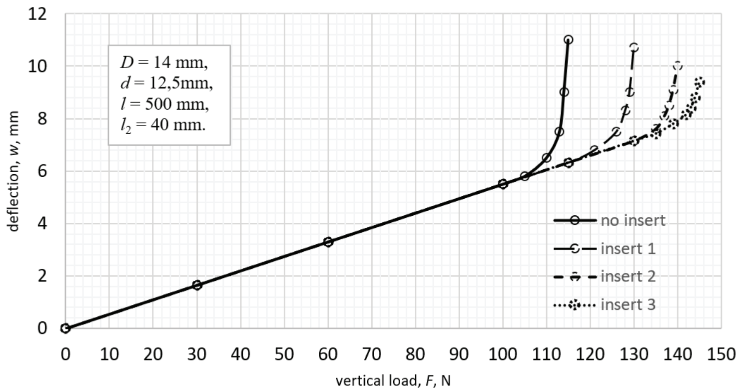


Figure 4: Results of 3 point bending for $s/r_m = 0,05666$ tube

For the second tube with $s/r_m = 1 / 15$ the results are shown in diagram in figure 5.

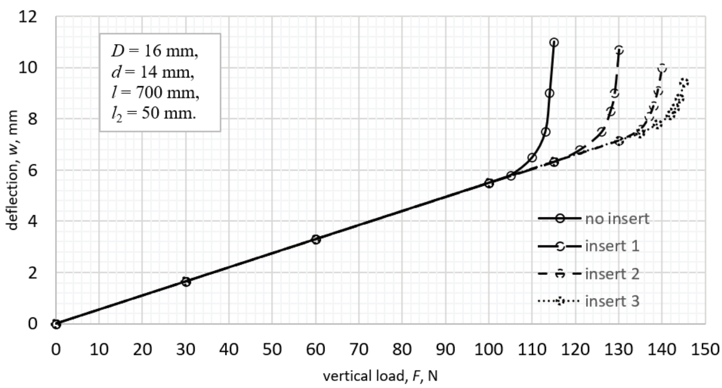


Figure 5: Results of 3 point bending for $s/r_m = 0,0666$ tube

For the third tube with $s/r_m = 1,5 / 20,5$ the results are shown in diagram in figure 6.

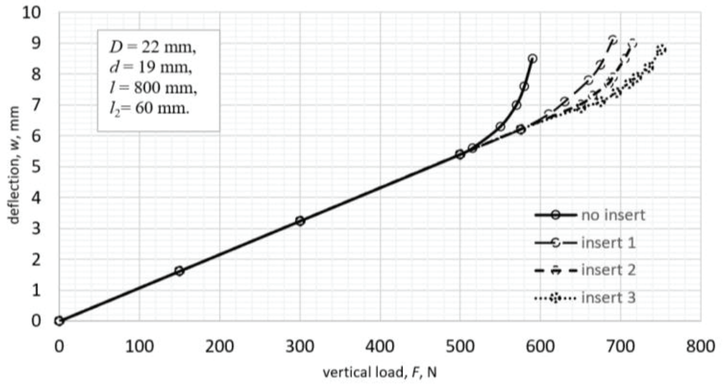


Figure 6: Results of 3 point bending for s/r_m = 0,0732 tube

From the figures 4, 5 and 6 show that increase in tube thickness contributes to cross-section stability [3, 4], or in other words, post buckling local behavior. The overall conclusion on the measurements results is measurement uncertainty caused by influence of force distribution conditions, deflection measurement uncertainty, prestress variability and insert element mechanical properties determination. This all leads to need of improvement in each segment in order to have higher certainty in predicting in safety of using thin-walled sections locally stiffened.

3. CONCLUSION

Intention here was to show a measured and validated technique for reinforcing a thin-walled circular tubes under simple 3 point bending conditions. In the first order the local cross section stability has been measured as a function of inserted elastic element with initial pressure (overlap) at the point of highest bending moment. Those results have been compared to the load carrying capability (stability) of tube with no reinforcement. The material used for insert is soft wood for its easy machinability and accessibility. The measurement has been carried out outside of laboratory conditions, so the results should be taken with a larger margin that usual measurements under standardized conditions.

The results show reasonable increase in load carrying capacity with increase in prestress of inserted element, up to a point of, reasonably to conclude, plastic collapse or inelastic changes in the inserts. With the relative elasticity modulus of 6/200 of insert material to steel tube, the most increase of load carrying capacity relative to the tube with no insert is 15%. Conclusion of this approach and measurement is that for more precise prediction of possibility of increase of section carrying capacity is to machine the edges of inserts more precisely to make feasible increase of insert's material elasticity modulus and its compression strength and yield limit, so to have more "support" to the section. Increasing insert's material strength will allow for increased initial pressure (overlap).

The broader picture here could be the idea of using the most thin-walled sections possible, using inserted elements for increasing local safety, i.e., the cross-section stability, hence reducing CO_2 footprint of a steel or other material structure.

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/lecture29.pdf *Accessed:* 2016-02-13.

[3] Assakkaf, Ibrahim A.: Advanced Topics in Mechanics-I, *Available from* http://www.assakkaf.com/courses/enes220/lectures/lecture30.pdf *Accessed:* 2016-02-13.

[4] Liu, G. R.: *Mesh Free Methods; Moving beyond the Finite Element Method*, CRC Press, ISBN 0-8493-1238-8, Boca Raton, 2003.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

SAFETY MEASURES AT WORK WHEN TRANSPORTING AND UNLOADING STEEL SCRAP IN THE TECHNOLOGICAL PROCESS THE OF STEEL PRODUCTION

Aida Imamović[1], Omer Kablar[2], Mirsada Oruč[1], Dragana Agić[3]

[1] Faculty of Engineering and Natural Sciences, University of Zenica, BiH
[2]ArcelorMittal Zenica, Zenica, BiH
[3]Institute IPI Engineering, Zenica, BiH

Abstract: *It is known that the technological process of steel production also uses a large amount of steel scrap, which must be delivered by means of transport, properly transported, unloaded, properly stored and handled. Steel scrap is a bulky, heavy and demanding material to handle. From the aspect of safety at work and avoiding injuries when handling it, it is necessary to comply with regulations and standards that can be supplemented with the internal standards of each company, especially the steelworks. This paper presents the internal, so-called operational standard for the unloading of steel scrap in the steelwork Zenica, and it can be an important document for companies engaged in similar work. Also all the protective measures that are taken to prevent injury or loss of life to personnel involved in the performance of these jobs, starting with truck drivers and ending with personnel in the storage etc, are described.*

Keywords: *steel scrap, protection during unloading and storage, standard*

1. INTRODUCTION

About 40% of the world's steel production is obtained in electric arc furnaces, using steel scrap as the basic raw material for production. So the basic raw material for the production of steel in electric arc furnaces is steel scrap (steel waste), and products of direct reduction of iron ores. Basic oxygen converter steelmaking is the main step in ore-based steel production using blast furnace hot metal and steel scrap as basic raw materials [1].

So, in both methods of steel production, steel scrap is used. Steel scrap is delivered to steelworks by truck or rail and these are large quantities that must be accompanied by proper unloading and storage.

Such a charge for steel mills must be controlled and properly disposed of until use. Handling scrap metal requires appropriate equipment (cranes, excavators and loaders, etc.) and, most importantly, trained personnel. The possibility of contamination of the surrounding area with dust particles, possible explosive or radioactive parts must also be checked, which is not the subject of this work.

This paper presents the regulation of the unloading of ferrous waste from trucks and the protection measures that are implemented with the aim of protection at work. Many companies and steelworks regulate this with their internal or operational standards. Thus, the internal standard in the only steelworks in Bosnia and Herzegovina applies to all shops with steel scrap within the steelwork Zenica.

2. SCRAP AS WASTE

The production of a wide range of steel, according to modern experiences, requires a careful selection of steel scrap, with a clear separation and control program. The term separation refers to the selection of the weight of mixed scrap metal into groups according to chemical composition. A very precise steel scrap separation program is of essential importance for preserving the alloying elements and achieving the desired steel composition [2].

Separating "own" steel scrap is relatively simple, but bought and imported scrap metal presents a problem. There are several methods for controlling scrap metal, in terms of whether a particular delivery meets the requirements of the specification. Special attention should be paid to the removal of all flammable and explosive objects, as well as the removal of other types of dirt, which significantly affects the pollution of the environment and the work space. Prior sorting of steel waste is necessary, and waste selection is facilitated. By sorting and classifying waste, the content of supporting elements can be influenced, but on the other hand, it is related to the change in the costs of ferrous waste (which has the highest percentage related to steel) as an input material [3].

The size of the pieces and the volumetric weight of steel scrap have a great influence on the technical and economic aspects of its melting in electric arc furnaces. Light steel scrap (wires, sheets, cans) have a significantly lower volume weight compared to heavy steel scrap (ingots, continuous castings, scrap semi-finished products). In the process of selecting of steel scrap is important the elimination of water, grease, and dirt as undesirable for both the technological process and the environment [2].

Most modern electrical steel plants require a smaller warehouse located either in the part of the factory where the furnace is located or in an adjacent hall, parallel to the furnace hall.

3. INTERNAL STANDARD FOR DISCHARGE OF SCRAP

Since the steel scrap is transported to the warehouse, it must be properly transported and then unloaded. Many companies, in accordance with the needs but also in accordance with the regulations, have created an internal standard from the aspect of safety at work in order to avoid incident situations. Safety at work is regulated by laws, regulations, standards and other regulations and instructions. Thus, the internal standard (operational standard) in the Zenica steel plant consists of the following, i.e. points that regulate [4]:

- truck movement around the scrapyard,
- dangers in and around the scrapyard,
- minimum safety requirements at work.

So the standard regulates the movement of trucks as the main means of transporting steel scrap, both at the entrance to the factory and through the factory. A clearly marked flow (traffic plan, including the height of a special electrical network, pipes...) of incoming and outgoing trucks that must be organized to keep traffic under control and

ensure safe operation. The plan must be known by everyone involved in the process. This plan also includes the installation of appropriate signage with the aim of regulating traffic in general, and especially when focused on the aforementioned heavy-duty trucks.
It is also necessary to include the waiting area for trucks in the traffic plan. In the event that the area around the scrapyard is not spacious enough, a safe parking area must be organized, in such a way that unloading must proceed in the order of arrival of heavy trucks. Truck passageways must be maintained to avoid problems with tire damage and dust that greatly pollutes the environment with very harmful metal and non-metal particles. It is also prescribed to put protection or covers if the trucks have trailers.
Trailer covers are used when:
- there is a risk of material loss (light and thin scrap metal),
- when avoiding the presence of water due to weather conditions,
- legal requirements that prescribe the same.

3.1. Hazards in and around scrapyard

During the transportation of steel scrap and its unloading and storage, there are many dangers such as the following [4]:
- collisions and collisions with moving equipment, cranes and vehicles, electrical cables,
- falling from a height: into pits, stairs, etc,
- crushes: an overturned truck, steel scrap fell when the truck door was opened and the accumulated scrap metal fell,
- bruises and contusions of personnel caused by metal parts of scrap metal projected during the manipulation of steel scrap at the site,
- staff cuts when manually handling steel scrap,
- metal parts that average the server's boots or gloves,
- risk of tripping and falling while walking (uneven floor, weather conditions...),
- dusty atmosphere,
- hearing damage due to noise,
- overturning the truck,
- truck falling into a pit,
- contact with radioactive material,
- server run over by a truck or other equipment,
- risk from other equipment at the scrapyard.

For each specific local risk that is detected on the basis of HIRA (Hazard Identification and Risk Assessment), appropriate measures should be taken immediately to correct the risky situation.

4. SAFETY REQUIREMENTS AT WORK AT THE UNLOADING OF STEEL SCRAP

Safety in technological processes aims to reduce the number of accidents, injuries at work, occupational diseases and material losses caused by work stoppages, with the basic aim of improving the safety of workers during work, and affects the awareness of workers/employees about the importance of personal protection and obligations to comply with all regulations on occupational safety [5].

Thus, as part of the above and in accordance with the internal standard, the following is prescribed [4]:

- It is strictly forbidden to drive and turn the truck with a raised trailer, crane loader (in case the truck is equipped with the same).
- The drive must not start before the unloader is lowered. However, an exception may be made for forward movements with truck and trailer in line to facilitate the unloading of scrap metal. During such movement, the driver must make sure that there are no barriers in the zone. As soon as the trailer is empty, the truck must stop and place the trailer (and crane) in the lowest possible position before moving.

-To open the rear door of the unloader safely, all trucks must be equipped with:

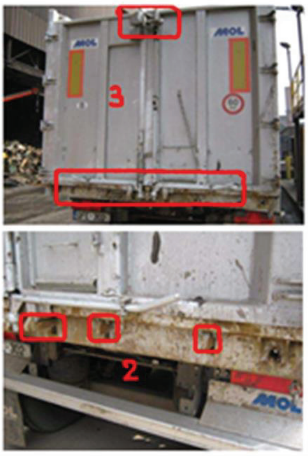
a) automatic system or have a system that allows opening the back door of the truck while standing next to it, instead of in front of the unloading door. (figure 1 and 2)

b) any truck that does not meet one of the two conditions described (a movable piston or a temporary solution in the form of a long lever for manual opening from the side of the truck) will not be unloaded and will be sent back to the supplier at his expense.

- These truck requirements as well as the consequences of non-compliance must be immediately included in all scrap procurement contracts.
- Trucks with an aluminum dumper and/one hydraulic moving piston show an additional rollover risk. They are only accepted at the entrance to the factory if they are transporting scrap metal that cannot be jammed during unloading.
- Zones for the storage of steel scrap must have buffers in order to ensure the position of the truck without risk, especially when it comes to pits.
- It must be ensured that the truck stops on stable ground before starting each unloading operation to avoid the truck falling sideways during the unloading operation.

Figure 1. Incorrect solution because a person is standing behind the opening door [4]

Solution 2 **GOOD**



This is a door closing system with safety hooks. The driver unlocks the simple hook (3) and then commands the control lever (1) on the trailer stand to remove the hooks (2) and open the door.

Figure 2. The correct solution for opening the door of a truck with steel scrap [4]

4.1. Requirements for ferrous scrap truck drivers

In the system of eliminating hazards and assessing the risk of incident situations, truck drivers with steel scrap have one of the most important roles. For the above, it is necessary to adhere to the following:

-Hazard identification and risk assessment must be performed to make a decision whether the driver should stay in or leave the truck during the unloading of steel scrap; if the driver has to stay the distance must be safe. The so-called three-point contact should be used when truck cabs are being assembled and disassembled.

- The seat belts supplied by the equipment manufacturer are always fastened when the driver is in the cab, including the situation when the truck is not unloaded.
- The following must be worn when entering the scrapyard office located near the scrapyard: ankle boots, helmet, ear protection, dust mask (if required), goggles, clothing with sleeves (rolled down), gloves and fluorescent jacket with reflective tape).

-When opening the door for unloading (picture 1), the driver must not pass behind the truck but walk in front of the truck to open the other door (if any).

- When steel scrap is unloaded into containers, the truck must come to a complete stop and the hydraulic side supports of the truck must be extended, when available, to a stable part for good support.
- The driver must be aware of the risks involved in the mentioned operations.

4.2. Scrap bulldozer driver, magnets or scrap metal handling star at the scrapyard

In addition to the truck driver, the bulldozer driver has a very important role in this

technological chain, who must also comply with the following:
- stop the manipulation if the truck or person is less than 20 m away,
- the scrap metal official must inform the drivers via radio about any movement (truck or person) at the scrapyard,
- wear the following PPE (personal protective equipment): helmet, ankle boots, ear protection, dust mask (if needed), goggles, clothing with sleeves down, gloves and fluorescent jacket with reflective tape,
- be familiar with the risks mentioned,
- the scrap metal officer should follow the entire process of unloading scrap metal, truck by truck.

5. INSPECTION OF SCRAP BEFORE AND AFTER UNLOADING

Inspection supervision is achieved by direct inspection of natural persons who perform a certain activity and undertaking administrative and other measures for which they are authorized by law or other regulation (laws, standards and other regulations). In this case it is necessary:
- ensure that the truck passes through radioactivity detection before unloading (an exception may be internal old iron if it is safely transported to the origin),
- specific protection zones are determined with a prior inspection,
- if ladders are required for all truck inspections, they should be placed next to the truck, check if they are stable (i.e. in accordance with the factory's rules on the use of ladders),
- make sure that the truck has stopped, that the engine is turned off and the brakes are applied and the driver must stand next to the inspector.

6. CONCLUSIONS

Steel scrap is a bulky, heavy and demanding material to handle. From the aspect of safety at work and avoiding injuries when handling it, it is necessary to comply with regulations and standards that can be supplemented with the internal standards of each company, especially the steelworks.
Since the scrap metal is transported to the warehouse, it must be properly transported and then unloaded. Many companies, in accordance with the needs but also in accordance with the regulations, have made internal standards from the aspect of occupational safety and in order to avoid incident situations.
So the standard (operational standard for unloading steel scrap) regulates the movement of trucks as the main means of transporting steel scrap, both at the entrance to the factory and through the factory. A clearly marked flow (traffic plan, including the height of a special electrical network, pipes...) of incoming and outgoing trucks that must be organized to keep traffic under control and ensure safe operation.
Failure to comply with prescribed rules and endangering oneself or others is classified as a serious violation of work obligations and discipline, which entails appropriate consequences.

REFERENCES

[1] Oruč M., Muhamedagić S., Vitez I.: *Metode kontrole procesa proizvodnje i proizvoda*, Fakultet za metalurgiju i materijale, Univerzitet u Zenici, Zenica, (2011)

[2] Pašalić Z.: *Metalurgija čelika*, Fakultet za metalurgiju i materijale, Univerzitet u Sarajevu, Zenica, (2002)

[3] Imamović (Mahmutović) Aida: „*Einfluß von Begleitelementen auf die Heißrissanfälligkeit des Stahls S355 bei unterschiedlichen Erstarrungs- und Abkühlungsbedingungen*“, Disertacija IEHK Institut RWTH Univerzitet Aachen, SR Njemačka (2004).

[4] Interni standard AM Zenica: AM Zaštita ST 006 – A1, (2010)

[5] Kunica Z.: *Projektiranje proizvodnih sustava*, Fakultet strojarstva i brodogradnje, Sveučilište u Zagrebu, Zagreb, (2016).

https://dokumen.tips › documents *Accessed 2024-04-26*

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

RISKS IN ELECTRICAL POWER SYSTEMS

Anđela Jevtić[1]; Vladimir Stanković[2]; Evica Jovanović[3]

[1] Faculty of Occupational Safety, University of Niš, Čarnojevića 10a, Niš, REPUBLIC OF SERBIA, andjela.jevtic@znrfak.ni.ac.rs

[2] Faculty of Occupational Safety, University of Niš, Čarnojevića 10a, Niš, REPUBLIC OF SERBIA, vladimir.stankovic@znrfak.ni.ac.rs

[3] Faculty of Occupational Safety, University of Niš, Čarnojevića 10a, Niš, REPUBLIC OF SERBIA, evica.jovanovic@znrfak.ni.ac.rs

Abstract: *Electrical power systems, as complex technical systems, present a number of risks that can endanger both the machinery and the operators. Environmental risks such as adverse weather conditions, technical risks (system failures), and human errors are just some of the causes of accidents in electrical power systems. Many risks are often beyond the employees' control, so monitoring and understanding them are crucial for system's reliability and safety.*

In order to lower these risks to a manageable level, this paper provides an overview of the potential risks in electrical power systems, the education of employees about the risks associated with handling electrical equipment improperly, and demonstrates how to use tools and resources for personal protection at work.

Keywords: *electrical power system, risks, accident, human error, risk reduction.*

1. INTRODUCTION

The electrical power system (EPS) is a complex system whose task is to ensure the production of electricity, its transformation, transmission to distribution systems, and distribution to end consumers [1]. Each of these subsystems is exposed to different risks that can affect the stability and reliability of the entire system. Anything that can damage or disrupt the functioning of equipment and devices in the power system and endanger human life is considered a risk. The occurrence of these accidents is often beyond the control of the employees.

Understanding potential threats and risks is essential for the reliable functioning of the EPS. Risk identification involves finding all possible factors that can threaten the operation of the system. These risks can be grouped into three categories: environmental risks (bad weather conditions, floods, earthquakes, hurricanes, or the interaction of animals with parts of the EPS), technical risks (equipment and system failures), and anthropogenic risks (human error, cyberattacks, or terrorist attacks) [2].

System risk assessment is required for the safe operation of complex systems, such as the power system. To achieve this, it is essential to comprehensively evaluate the dangers the system faces. This paper provides an overview of some of the technical, environmental, and anthropogenic risks that can most often endanger the operation of the system and human lives.

2. TECHNICAL RISKS

The inability of electric power equipment and devices to perform their functions arises from unforeseen conditions, most often malfunctions and dangerous operating conditions. Failure can be defined as any deformation, interruption, damage, wear and tear, etc. The causes of failures are diverse, starting from the age of the equipment and atmospheric discharges to weather conditions and human errors.

Certain working conditions, such as working outdoors, in environments with a risk of fire and explosion, or moving equipment from one location to another, can lead to damage to electrical equipment or reduce its expected lifespan [3].

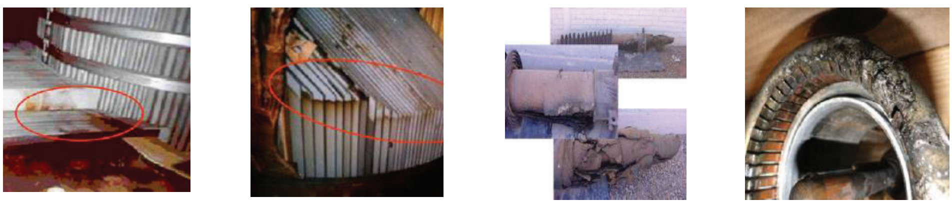
Failures can be classified in the following ways [4]:

- According to the place of occurrence: the object, device, or equipment where the failure occurred;
- According to the cause: equipment age, ambient conditions, poor maintenance, overvoltage, birds, animals, etc.;
- According to the interruption of power supply or electricity production: with or without interruption of power supply or production;
- According to duration: transitory/short-term and permanent.

Transient failures occur for only a short period of time, after which the system continues to operate normally. Such faults most often occur on overhead lines and are usually eliminated by disconnection and automatic reconnection. Permanent failures are more serious and most often occur due to network overload, ambient conditions and natural disasters, aging and worn-out equipment, and improper handling and maintenance [4,5].

It is also important to know the approximate service life of the most critical elements in the power system. For example, power transformers have a service life of 35 to 45 years, measuring devices 30 to 40 years, switchgear 25 to 35 years, surge arresters 20 to 30 years, and insulators about 40 years [4].

Figure 1 shows various types of damage to equipment in the power system.



a) b) c) d)

Figure 1: Damages: a) transformer core, b) winding, c) conductive insulator, d) active part of the high-voltage switch contact

In addition to malfunctions, the function of power system elements can also be threatened by so-called dangerous operating conditions, which include [6]:

- abnormally high voltages that stress and endanger the insulation of the device,
- too low voltages, which make it difficult for consumers to work,
- overload,
- external short circuits,
- excessive heating,
- asymmetric load,

- excessive number of revolutions in rotating machines, etc.

If dangerous operating conditions occur, necessary measures should be taken to address the root cause of the issue and remove the danger. Otherwise, the system can quickly go into a state of permanent failure.

3. ENVIRONAMENTAL RISKS

Natural disasters have also posed a huge challenge for the EPS in recent years. The different characteristics of EPS elements make them sensitive to extreme weather conditions and natural disasters, such as floods, heat waves, stormy winds, thunderstorms, forest fires, snowfall, and extreme cold [7]. In addition to posing a significant threat to the stability and reliability of the energy supply, these risks can also cause substantial damage to various parts of the EPS.

Environmental risks can be classified into two categories: disasters and extreme weather conditions. Disasters include earthquakes, volcanic eruptions, landslides, snow avalanches, tsunamis, geomagnetic storms, and floods. Extreme weather conditions include tropical cyclones, which are short-lived, and heat waves, winter storms, and droughts, which last for a longer period of time [8]. Figure 2 shows a transmission line covered with snow.

Figure 2. Snow-covered transmission line [9]

All these phenomena can impact various components of the EPS differently. For example, storms, hurricanes, lightning strikes, snow, and ice can cause severe damage to transmission lines and result in power outages. Floods negatively affect the production subsystem, with hydroelectric power plants and facilities near watercourses being particularly at risk. Earthquakes can damage power equipment, resulting in extended interruptions in transmission and distribution lasting several days. Forest fires can also cause significant damage to EPS elements, particularly by burning transmission and distribution lines and potentially damaging transmission poles. In addition, ash and smoke from fires can ionize the surrounding air, creating an electrical path away from the lines and potentially causing power outages. Temperature extremes also greatly influence electricity demand, leading to heavy loads on the system [7,8].

4. ANTROPOGENIC RISKS

Anthropogenic risks in power systems include risks that are directly or indirectly caused by human actions. These risks can have negative consequences for the system, threatening its reliability, safety, and efficiency; additionally, they can endanger human lives. Human errors in power systems can occur at various levels, including generation, transmission, and distribution of electricity. Common causes of human errors include making wrong decisions, inadequate responses to unforeseen situations, failure to recognize dangers, and making seemingly correct decisions at the wrong time, among others [10].

Human behavior and decision-making in power systems are influenced by performance shaping factors, which are considered causes of error. These factors can either increase or decrease the likelihood of human error. Performance shaping factors can be external, such as organizational and technical prerequisites, or internal, related to individual factors and psychological readiness [11].

The consequences of human errors can range from minor disruptions in equipment operation and short-term interruptions in electricity supply to severe damage to expensive system components and the endangerment of human lives [10]. An analysis of causes and injury severity at electric utility power company Elektroprivreda Srbije concluded that the risk of serious injuries is higher during work at high voltage. Conversely, the highest number of accidents (90%) occurred during work on low voltage devices and installations. Accidents most often occurred due to insufficient concentration and carelessness of the operator, incomplete implementation of workplace safety measures, non-use of prescribed means and equipment for personal protection at work, inadequate cooperation among participants in the work, and similar factors [11]. Figure 3 shows work being carried out without the use of personal protective equipment.

Figure 3. Performing work without personal protective equipment [12]

The energy sector has recently become more vulnerable to cyberattacks, which threaten data privacy and the infrastructure of the power system, impacting its stability and reliability. Cyber security deficiencies can result in unauthorized access to control systems, misuse of data, and potentially remote control of essential EPS functions. For example, a cyberattack could significantly disable protective relays, causing equipment failure and power outages. Consequently, cyber security is a crucial requirement in the EPS risk assessment [13].

Responding to a cyberattack involves identifying the attack, investigating it, putting an end to it, recovering from it, and eliminating any consequences such as business interruption, loss of information and income, and damage to equipment. All these activities can result in substantial material losses. To protect the system from cyberattacks, it is crucial to adapt to new technologies as well as new risks and threats. While complete prevention of cyberattacks is not possible, it is feasible to make the system more resistant to them. Protection against cyberattacks should be based on previous experiences, as past events highlight which parts of the system need to be adapted and strengthened [14].

5. CONCLUSION

Identification, assessment, and management of risks are crucial for maintaining EPS functionality and ensuring a continuous supply of electricity to consumers. This paper identifies several risks that have a significant impact on EPS, such as equipment failures, hazardous operating conditions, natural disasters, cyberattacks, and human error. Damage and malfunction of electrical equipment, workplace hazards, insufficient worker qualifications, operator negligence, and improper use of personal protective equipment represent daily risks for the power system. Each of these risks can have significant consequences, impacting the system's stability, electricity supply, and the safety and health of EPS employees.

Strategies for risk management include the implementation of preventive measures such as regular testing and maintenance of equipment, professional training of employees, legal compliance. Additionally, applying protective measures and providing both basic and supplementary personal protective equipment are essential. Establishing effective mechanisms for continuous monitoring and responding to potential crises is crucial to minimizing the negative impact of risks on the system. Continuous monitoring and event analysis are also vital to identifying errors and preventing their recurrence.

ACKNOWLEDGMENTS

The authors are grateful to the Ministry of Science, Technological Development and Innovations of the Republic of Serbia for the financial support of this work (contract number 451-03-66/2024-03/ 200148).

REFERENCES

[1] Škuletić, S.; Sekulić, Z.: *Proizvodnja električne energije*, Zavod za udžbenike i nastavna sredstva, ISBN 987-86-303-2200-6, Podgorica, 2019.
[2] Cox, S.: Understanding Power System Threats and Impacts. Resilient Energy Platform. *Available from* https://www.nrel.gov/docs/fy19osti/74346.pdf *Accessed:* 2024-06-10.
[3] Managing Electrical Risks In The Workplace. Code of Practice. Available from https://www.safeworkaustralia.gov.au/system/files/documents/1705/mcop-managing-electrical-risks_in_the_workplace-v1.pdf *Accessed:*2024-05-25.
[4] Radetić, R.: *Priručnik za održavanje visokonaponske opreme*, Bor, 2017.
[5] Types of Faults in Electrical Power System. Available from https://www.electricaltechnology.org/2022/09/faults-in-electrical-power-system.html *Accessed:* 2024-05-28
[6] Škuletić, S.; Kaljević, N.: *Visokonaponska razvodna postrojenja*, Zavod za udžbenike i nastavna sredstva, ISBN 978-86-303-2298-3, Podgorica, 2019.
[7] Wang, C.; Ju, P.; Wu, F.; Pan, X.; Wang, Z.: A systematic review on power system resilience from the perspective of generation, network, and load, *Renewable and Sustainable Energy Reviews*, Vol. 167 (2022), No. 112567
[8] Huang, T.; Pi, R.; Bompard, E.; Profumo, F.; Cuccia, P.; Fulli, G.; Masera, M.: Analysis and Visualization of Natural Threats Against the Security of Electricity Transmission System, *The scientific bulletin of electrical engineering Faculty*, (2017), ISSN 1843-6188. Available from https://core.ac.uk/download/pdf/76535273.pdf *Accessed:* 2024-06-03.
[9] Impact & Mitigation of Icing On Power Network Equipment. Available from https://www.powerandcables.com/impact-mitigation-of-icing-on-power-network-equipment/ *Accessed:* 2024-06-04.
[10] Dhillon, B. S.: *Human Reliability, Error, and Human Factors in Power Generation*, Springer Series in Reliability Engineering, ISBN 978-3-319-04018-9, Ottawa, 2014.
[11] Stojiljković, E.: *Procena ljudske pouzdanosti*, Fakultet zaštite na radu u Nišu, ISBN 978-86-6093-090-5, Niš, 2020.
[12] Rubino, A.: Energy transmission and distribution: Power theft in India, *Nature Energy*, Vol. 1 (2016), No. 16044, ISSN 2058-7546. Available from https://www.nature.com/articles/nenergy201644
[13] Xiao, P.; Jiang, Y.; Liang, Z.; Wang, H.; Zhang, Y.: Power system risk assessment strategy based on weighted comprehensive allocation and improved BP neural network, *The Journal of Engineering*, 2023. Available from *Accessed:* 2024-06-07. https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/tje2.12323

[14] Power Systems in Transition, Challenges and opportunities ahead for electricity security, International Energy Agency, 2020. Available from https://www.iea.org/reports/power-systems-in-transition/cyber-resilience#abstract *Accessed:* 2024-06-09.

RISKS FACED BY WORKERS DURING THERMAL POWER PLANT MAINTENANCE

Lidija Lj. Joleska Bureska, Suzana Zikovska, Cvetanka T. Mitrevska,

International Slavic University St. Nikola, Marsal Tito 77, Sveti Nikole, MACEDONIA, lidija.joleskabureska@msu.edu.mk

Abstract: *The maintenance process in Thermal Power Plants involves a series of activities aimed at defining, identifying, and reducing factors of equipment depreciation and degradation. It is also vital for every worker in the Thermal Power Plant (TPP) to be able to recognize the dangers they may be exposed to during work. This would enhance prevention efforts to avoid workplace accidents. The various objects and materials used in the work processes at TPP expose workers to significant hazards. Several studies have identified the hazards faced by workers involved in the maintenance process, the level of risk, the impact of hazard recognition as a significant indicator of the risk level of accidents for workers, and their need for training. Unfortunately, there are no empirical findings on hazard recognition for workers involved in the maintenance process in TPP. The aim of this paper is to focus on workers involved in maintenance in TPP in terms of their exposure to hazards, main risks, health issues, and accidents, while also providing guidelines for appropriate improvement measures.*

Keywords: *Thermal Power Plants, maintenance, non-fatal accidents, fatal accidents*

1. INTRODUCTION

According to the European standard EN 13306 [1], maintenance is a combination of all technical, administrative and management activities during the whole life time of plants and machines, with the goal of preserving or restoring their function. Maintenance is important for plants and production due to:

- ensuring continuous productivity;
- producing high-quality products;
- maintaining the company's competitiveness.

Additionally, maintenance significantly contributes to safety and health at work [2]. Maintenance impacts the safety and health of workers in two ways. The first way is through properly planned and executed maintenance of machines and plants, which is essential for equipment, enabling a safe working environment and reliability of the plants. The second way is that maintenance must be carried out safely, using appropriate protective equipment for workers involved in maintenance and others present at the workplace.

As with other technical systems, the maintenance of Thermal Power Plants (TPP) can be performed as corrective, preventive, and large scale maintenance during extended plant downtime.

Corrective maintenance, or maintenance carried out after a fault has been identified, aims to bring the facility to a condition where it can perform its required function [2]. In this case, the maintenance activities aim to return the system from a faulty state to a working state or to restore the functional capabilities of the faulty systems. This includes, for example, the repair or replacement of defective components [3]. This type of maintenance is also known as "reactive maintenance" because the action is triggered when an unplanned equipment failure occurs [4].

Preventive maintenance, i.e., maintenance carried out at predetermined intervals or according to prescribed criteria, aims to reduce the probability of breakdowns or disturbances in the operation of the facility. In this case, the activities are scheduled in advance, elements that can lead to system failure are proactively monitored, and the deterioration process is monitored. This maintenance is applied to reduce the probability of failure or extend the life of parts and facilities, including replacement, lubrication, cleaning, inspection, etc.

Large-scale maintenance is another type of maintenance that is often applied to TPPs during long downtimes. In particular, this type of maintenance allows facilities to be upgraded with new or additional functions or to improve existing functions. It is usually carried out during the shutdown of the TPP, and the downtime is pre-planned. The activities performed are aimed at the modification, reconstruction, modernization, or renovation of equipment, parts of systems, or entire systems. This includes work on boilers and their auxiliary equipment, including fuel and air supply systems and gas exhaust systems, integral pipe lines and feed water piping, turbine equipment and its auxiliary equipment, condenser and surrounding equipment, chemical water treatment plants, flue gas treatment filters, desulfurization systems, chimneys and so on.

The specifics of maintenance in TPPs dictate the specifics of the equipment.

2. SAFETY AND HEALTH RISKS FACED BY WORKERS DURING MAINTENANCE IN TPPs

The maintenance process in TPPs involves workers from different professions who perform a series of activities, which makes it difficult to determine the exact number of individuals involved. Maintenance encompasses multiple professions, including mechanical engineers, technicians, electricians, electronics engineers, construction workers, maintenance supervisors, and other personnel who may perform equipment maintenance as part of their responsibilities. In addition, it is common for maintenance tasks to be outsourced to external contractors who are engaged to perform maintenance activities either independently or in support of the factory's workforce.

In addition to the essential role of maintenance in companies, the risks related to maintenance have not yet been given full attention, and a small part of research is devoted to the impact of maintenance on the safety of those who work on maintenance and their associates. Maintenance can be carried out in work halls or workshops with appropriate machines and tools (depending on the type of repair being carried out), but also at the place where the failure occurred. Incidents and accidents are more common when performing work at the site of failure, because in such conditions there is a possibility of using inappropriate or improvised equipment during work, then working under time pressure, etc. In addition, during the design of equipment, maintenance tasks are rarely taken into account. Maintenance workers are exposed to a large number of different risks during their work. The variety of risks is due to different activities that include maintenance, the environment, various equipment, etc.

Maintenance in the TPPs is carried out in different conditions: outdoor work exposed to changing climatic conditions (rehabilitation of gas or air fans, transport systems for ash and slag, outside the boiler room, or vibrations, noise) and chemical substances (e.g., maintenance of equipment in the laboratories for the analysis of coal, water, etc.); work in closed rooms exposed to a high level of noise (renovation in the engine room or boiler room, auxiliary facilities, circulation pumps, etc.). In these cases, the risks mainly relate to: the environment where the work is performed; different types of used machines and tools; type of energy used (e.g., electrical, pneumatic, or hydraulic); working conditions; and chemical and/or biological agents handled by workers during work. In most cases there is a combination of several risks.

Common hazards faced by workers involved in the maintenance of TPPs include:

Construction hazards

- the risk of workers and objects falling,
- electrical contact and adherence to guidelines for working near and around overhead voltage transmission lines,
- work on/near equipment under voltage. Work on/near energized equipment (irrespective of the energy source) must adhere to the relevant protocols and guidelines in TPPs. All work in such instances should be implemented when the systems are de-energized (power off, no pressure, empty, no fluids) and secured using appropriate switches, assemblies, valves, etc.
- hazards associated with lifting and lowering cargo and equipment,
- other specific hazards identified by TPP.

Chemical hazards

Before commencing work, workers should receive information and training on the hazardous substances present in the work environment and to which they may be exposed. The protective equipment utilized should be suitable for the specific hazard. A variety of hazardous substances can be encountered in the working environment of the TPP, including:

- asbestos and lead, which are embedded materials, can cause cancer and damage the kidneys and brain.
- in TPPs that burn coal dust, the fly ash from the coal contains oxides of silica, aluminum, and iron, with traces of manganese, lime, sodium, and unburnt fuel (carbon). Trace elements such as arsenic and selenium have been identified in it.
- fly ash from oil and fuel oil may contain pentoxide, vanadium oxides, and other soluble compounds of nickel, etc., which can cause irritation of the respiratory tract, dermatitis, and possible eczema upon contact with the skin.
- if the boiler is covered with fire-resistant bricks, during planned shutdowns, it may contain silica, which can cause damage to the eyes and, when inhaled, can lead to silicosis.
- carbon monoxide (CO) is a colorless, odorless, and tasteless gas that can be present in a working environment where combustion is incomplete. It is a toxic gas that can cause drowsiness and even death.

- the sulfur content in oil, fuel oil, coal, etc. can lead to the presence of sulfur dioxide (SO2). This gas is highly irritating and corrosive, has a sulfur-like odor, and can form acid when in contact with moisture.
- coal dust is predominantly found in areas of coal preparation and transport.
- fumes generated during welding are also hazardous. The risks associated with these fumes vary depending on the material being welded, the welding process used, and the surface being welded.

Operators and maintenance workers of TPP boilers may be at risk of developing upper respiratory tract diseases, such as bronchitis and conjunctivitis, due to exposure to vanadium compounds (produced from the combustion of light and heavy oils) and sulfur dioxide (SO2) emissions [5].

The methods used to purify exhaust gases and remove soot, over time, can lead to chronic bronchitis, rhinopharyngitis, and pneumosclerosis caused by soot dust, sulfur dioxide, and trioxide [5].

Residues from burning oil pose greater harm compared to dust emitted from the combustion of other fuels. Contact with ash on wet skin can lead to dermatitis, while the combination of nickel, vanadium, and sulfuric acid compounds in the residue can cause eczema.

3. STATISTICAL DATA ON WORKERS INVOLVED IN THE MAINTENANCE OF TPPs

Within TPPs, there exist numerous hazardous areas, primarily due to the intricate nature of the plants, the complexity of processes, and the characteristics of materials and equipment utilized during routine operations. Employees in TPPs handle highly flammable substances, toxic chemicals, operate in environments with high electric voltage, work with steam and water under high pressure and temperature, superheated steam, heavy machinery with high rotational speeds, and are exposed to extreme noise levels and harmful gases, all of which pose significant health risks. Approximately 76% of the hazards in TPPs are classified as medium-high to high-risk hazards [6].

The literature regarding actual accident statistics in TPPs is limited. According to the Electric Power Research Institute (EPRI) Occupational Safety and Health Database, there were a total of 63,193 injuries and 63 fatalities reported in 18 thermal power plants in the United States (US) between 1995 and 2013 [7].

In TPPs, ensuring the safety of employees involved in equipment maintenance is a complex issue. This complexity arises from the fact that the production of thermal energy is less automated and relies heavily on human involvement, thereby exposing workers to increased risks during their tasks. Operators and maintenance workers in TPPs are exposed to various forms of energy and numerous hazards that can endanger their health. Consequently, their workplaces carry a high risk of accidents [8].

Key components within the TPP that are potential hazards to the safety and health of workers engaged in preventive or corrective maintenance include:

- the water demineralization plant: potential chemical burns from spills, high noise levels, and ammonia leakage from storage tanks or pipelines;

- the boiler plant: risk of explosion, burns from contact with hot water, steam, or high-temperature surfaces, slips, and falls from different levels during routine operational work, maintenance, or inspection;
- the generator and turbine: risk of turbine explosion due to cooling system failure, fire in cooling oil, high noise levels from turbines and pumps, exposure to high temperatures and steam pressure, and exposure to hazardous mineral oil;
- the electricity transmission system: potential risks of electric shock and burns from unprotected high-voltage equipment, maintenance or inspection of electrical components, switches, and transformer fires;
- liquid fuel storage tanks and coal dump: risks include fuel storage tank fires due to leaks during transfer and self-ignition of coal at the dump, etc.

In TPPs, all hazards are not ranked the same because each of them represents a different weight of risk, both for the safety of the workers and for the electricity production facility itself [6]. Hazards are prioritized based on their level of risk, and their management follows suit. High-risk threats necessitate immediate attention and the allocation of additional resources. A study conducted in 2014 on two TPPs in India identified and classified hazards, revealing that out of 33 significant hazards, 3% were categorized as low risk, 21% as moderate, 40% as moderate to high risk, and 36% as high risk [6]. These findings underscore the fact that TPPs fall within the category of significantly hazardous industries [9].

The best way to minimize accidents in TPP is through the skill of hazard recognition. Accident prevention is the primary goal of implementing safety management systems in industry.

4. RESULTS AND DISCUSSIONS

In Macedonia, there is a lack of specific data on workers directly involved in maintenance within TPPs. All employees in TPPs, regardless of their roles, are categorized under the sector of electricity, gas, steam, and air conditioning supply. The structure and number of workers in the sector of Supply of electricity, gas, steam, and air conditioning by gender from 2017 to 2022 are presented in Table 1.

Table 1: Number of employees in the sector Supply of electricity, gas, steam, and air conditioning in the Republic of Macedonia, 2017-2022 [11]

Supply of electricity, gas, steam, and air conditioning (D)	2017	2018	2019	2020	2021	2022
Men	8900	8599	8818	7893	6856	5957
Woman	1507	1725	1793	1502	1394	2009
Total	10407	10324	10610	9395	8250	7967

Source: State statistical office of Macedonia

Out of the total workforce in Macedonia, approximately 1.2% is employed in the sector of electricity, gas, steam, and air conditioning supply. As indicated in Table 1, women make up 15% to 16% of the workforce in this sector, except in 2022, when the representation of women increases to 25%. Among employed men in Macedonia, 1.5% works in this sector, while women account for 0.7% [11]. However, these statistics encompass all employees and do not provide specific data for those working in the maintenance sector, particularly within TPPs.

Findings from the French survey "Sumer 2003" reveal that the maintenance workforce in industry is predominantly male. Specifically, 95% of all maintenance employees, including 91% of maintenance and organization technicians and supervisors, and up to 99% of car repair workers, are men. Women account for only 5% of the workforce in these three activities [12]. In Spain, the proportion of female maintenance workers is higher than in France, with 63% being men and 37% women in 2006. However, specific data on workers engaged in the maintenance of TPPs is not available. In Spain, the maintenance sector employs a substantial percentage (around 65%) of workers aged between 25 and 49. Despite this, the maintenance sector constitutes a smaller segment of the total workforce. It is worth noting that there is a distinct age distribution within this sector, characterized by a lower presence of younger employees and a higher concentration of older workers [12].

In the Republic of Macedonia, there are several organizations and institutions that collect statistical data on accidents at work. These include the State Statistical Office, the Labour Inspectorate, the Institute for Public Health, the Macedonian Occupational Safety and Health Association, the Organization of the Employers of the Republic of Macedonia and the Trade Unions. The information regarding work-related accidents in the Republic of Macedonia is not confidential, as various relevant institutions have published diverse statistical data on this matter. Specifically, the Macedonian Association for Safety at Work includes the accidents of employees in the energy sector under the category of Supply of electricity, gas, steam, and air conditioning (as per the national classification of activities) in its annual reports. However, the Institute of Public Health, another institution where workplace accidents are documented by activity, does not have this specific activity listed, potentially resulting in accidents being recorded under a different category. The inconsistent data collection methods (in different categories) lead to incomplete and non-comparable data, which complicates the analysis process. The inadequacy of the data is evident from the findings presented in Table 2. As someone directly involved in the maintenance sector within TPPs, I can attest that the results in Table 2 do not accurately reflect the real situation.

This paper presents statistical data on non-fatal and fatal work-related accidents in the sector of electricity, gas, steam, and air conditioning supply in the Republic of Macedonia from 2017 to 2022. The data utilized in this analysis is sourced from the Macedonian Occupational Safety and Health Association. [13,14,15,16,17,18]. There is a lack of statistical data on the number of accidents involving maintenance employees in TPPs in Macedonia within the institutions mentioned above.

Table 2: Number of accidents at the workplace of employees in the sector Supply of electricity, gas, steam, and air conditioning in the Republic of Macedonia, 2017-2022

Number of accidents	2017		2018		2019		2020		2021		2022	
	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	Fatal
Supply of elec. gas,steam and air condit.(D)	1	0	0	0	0	0	3	0	1	0	2	0
Total in all sectors (category)	134	24	124	33	153	25	127	25	135	30	147	22

Source: Macedonian Occupational Safety and Health Association

5. CONCLUSION

This paper outlines the various forms of energy exposure faced by operators and maintenance employees in TPPs, along with the potential health hazards they may encounter. Consequently, TPPs are categorized as a significantly hazardous industry, with workplaces carrying a high risk of accidents. Despite being classified as a high-risk industry, there is a lack of specific data regarding the gender, age, and other demographics of workers engaged in the maintenance of TPPs. This absence of information hinders the ability to analyze the gender and age distribution among maintenance workers in TPPs. Given the global decline in the number of maintenance workers, particularly younger individuals, these data are crucial for effective planning within the TPP maintenance sector.

In order to comprehensively address workplace safety and health concerns, collaboration among various entities such as the State Statistics Office, the Labour Inspectorate, the Institute for Public Health, the Macedonian Occupational Safety and Health Association, the Organization of the Employers of the Republic of Macedonia, and the Trade Unions is essential. It is imperative to standardize and align data on workplace accidents with European standards. Enhancing hazard recognition capabilities and implementing robust safety and health management systems are crucial steps towards reducing accidents in TPPs. These measures are fundamental prerequisites for mitigating the occurrence of accidents among employees in TPPs.

REFERENCES

[1] Comité Européen de Normalisation, EN 13306: 2001 Maintenance terminology, Geneva, CEN, 2001.
[2] Swanson, L., ‘An information-processing model of maintenance management’, International Journal of Production Economics, Vol. 83, No. 1, 2003, pp. 45-64.
[3] Kim, C.S., Djamaludin, I., Murthy, D.N.P., ‘Warranty and discrete preventive maintenance’, Reliability Engineering & System Safety, Vol. 84, No. 3, 2004, pp. 301-309.

[4] Sachdeva, A., Kumar, D., Kumar, P., 'Planning and optimising the maintenance of paper production systems in a paper plant', Computers and Industrial Engineering, Vol. 55, No. 4, 2008, pp. 817-829.
[5] https://www.ihsa.ca/rtf/health_safety_manual/pdfs/locations/Power_Plants.pdf
[6] Shrivastava, R., & Patel, P. (2014). Hazards identification and risk Assessment in. International Journal of Engineering Research & Technology (IJERT), 3(4), 463–466.
[7] Volberg, V., Fordyce, T., Leonhard, M., Mezei, G., Vergara, X., & Krishen, L. (2017). Injuries among electric power industry workers, 1995–2013. Journal of Safety Research 60, 9–16. https://doi.org/10.1016/j. jsr.2016.11.001.
[8] Fleming, M., & Fischer, B. (2017). Hazard recognition: Bridging knowledge\& competency for process\& occupational safety. Professional Safety, 62(6), 52.
[9] FLPFI. (2018, November). Loss prevention in thermal power plants. Fire Loss Prevention Forum of India, [Preprint].
[10] European Statistics on Accidents at Work (ESAW), Summary methodology, (2013).
[11] https://makstat.stat.gov.mk/PXWeb/pxweb/mk/MakStat/MakStat__PazarNaTrud__AktivnoNaselenie__Vraboteni/022_PazTrud_Mk_ Sektori2 _ml.px/?rxid=46ee0f64-2992-4b45-a2d9-cb4e5f7ec5ef
[12] Maintenance and Occupational Safety and Health – a statistical picture Malgorzata Milczarek, Joanna Kosk-Bienko, European Agency for Safety and Health at Work (EU-OSHA).
[13] Annual Report for fatalities, injuries and accidents at work 2016, Macedonian Occupational Safety and Health Association, (2017).
[14] Annual Report for fatalities, injuries and accidents at work 2017, Macedonian Occupational Safety and Health Association, (2018).
[15] Annual Report for fatalities, injuries and accidents at work 2018, Macedonian Occupational Safety and Health Association, (2019).
[16] Annual Report for fatalities, injuries and accidents at work 2019, Macedonian Occupational Safety and Health Association, (2020).
[17] Annual Report for fatalities, injuries and accidents at work 2020, Macedonian Occupational Safety and Health Association, (2021).
[18] Annual Report for fatalities, injuries and accidents at work 2021, Macedonian Occupational Safety and Health Association, (2022).

ULTRAVIOLET RADIATION: PROTECTION AND APPLICATIONS

Anamarija Kirin[1]; Vanesa Sarvaš[2]; Katarina Čavlović[3]; Filip Žugčić[4]; Slaven Lulić[5];

[1] Karlovac University of Applied Sciences, Trg J. J, Strossmayera 9, Karlovac, CROATIA, akirin@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J. J, Strossmayera 9, Karlovac, CROATIA, sarvasvanesa@gmail.com

[3] Karlovac University of Applied Sciences, Trg J. J, Strossmayera 9, Karlovac, CROATIA, katarina.cavlovic@zelenilo.hr

[4] Karlovac University of Applied Sciences, Trg J. J, Strossmayera 9, Karlovac, CROATIA, fzugcic@vuka.hr

[5] Karlovac University of Applied Sciences, Trg J. J, Strossmayera 9, Karlovac, CROATIA, slulic@vuka.hr

Abstract: *Ultraviolet (UV) radiation is a part of the electromagnetic spectrum of radiation with wavelength longer than that of X-rays and shorter than visible light. The main natural source of UV radiation is the Sun which is very important for the process of photosynthesis and the production of vitamin D in the body. Excessive exposure to UV radiation can cause damage to the skin and eyes, or it can damage DNA, which can lead to health risks such as skin cancer. We first describe the properties, types and sources of UV radiation, then we explain the application, benefits and consequences of UV radiation with a special emphasis on protection against UV radiation.*

Keywords: *UV radiation, types of UV radiation, skin cancer, protection against UV radiation*

1. INTRODUCTION

Ultraviolet (UV) radiation is a part of the electromagnetic spectrum (shown in Fig 1). of radiation with wavelength longer than that of X-rays and shorter than visible light [1]. The main natural source of UV radiation is the Sun which is very important for the process of photosynthesis and the production of vitamin D in the body. However, excessive exposure to UV radiation can cause damage to the skin and eyes, or it can damage DNA, which can lead to health risks such as skin cancer [2]. Therefore, it is recommended to use protective measures, such as applying a cream with a protective factor, wearing protective clothing and sunglasses with UV protection.

UV radiation also has numerous applications in industry, scientific research and medicine. It is used for disinfection and sterilization in the food industry, medicine, pharmaceutical industry, as well as for the detection of DNA traces in forensic research and in the study of space.

In this paper we first describe the types of UV radiation based on its wavelength, frequency and impact on the human body, then we explain some of the applications of UV radiation and finally describe the protective measures against it.

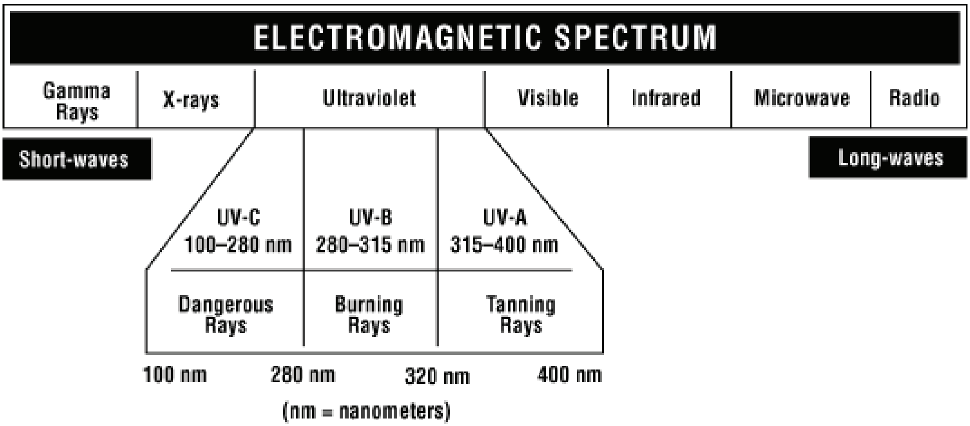


Figure 1. Ultraviolet radiation in the electromagnetic radiation spectrum [2]

2. TYPES OF UV RADIATION

UV radiation is divided into three categories based on its wavelength, frequency and impact on the human body. Figure 2 shows the passage of UV radiation through the ozone layer of the atmosphere to the Earth's surface.

Short-wave UV radiation (UVC) poses the greatest risk. The Sun emits UVC, but the ozone layer of the atmosphere absorbs it before it reaches the Earth. Therefore, the UVC of the sun's rays does not affect humans. Since it is the most energetic and has the potential to directly ionize atoms or molecules it can kill bacteria, viruses and other microorganisms and is therefore used as a disinfectant and sterilization agent in medicine, the pharmaceutical industry, and the food industry for the disinfection of air, water and surfaces. It can be found in artificial sources such as germicidal lamps and some lasers. When used for industrial purposes, UVC radiation is used under strict rules and is recommended to be used only by trained professionals [2].

Medium wave UV radiation (UVB) does not penetrate deep into the skin, but it can penetrate the upper layers of the skin, making it responsible for causing skin burns, skin redness and skin darkening. UVB radiation also plays an important role in the synthesis of vitamin D in the skin. Long-term exposure increases the risk of skin cancer. UVB radiation represents a smaller share (about 5%) of the total UV radiation that reaches the Earth's surface [2].

Long-wave UV radiation (UVA) accounts for up to 95% of UV radiation that reaches the Earth's surface. Although UVA is less intense than UVB, it is more widespread and can penetrate deeper into the layers of the skin, affecting connective tissue and blood vessels. Long-term exposure to UVA radiation can contribute to skin aging, decreased skin elasticity, increased pigmentation, and increased risk of certain types of skin cancer [24]. It may increase the risk of eye damage, including cataracts and retinal damage. It can pass through glass, which means that we can be exposed to UVA radiation even when we are indoors or in a vehicle. UVA radiation also has some positive effects. It can activate melanin synthesis in the skin, which can help protect against shorter wavelength UV radiation (UVB). Also, UVA radiation plays an important role in some medical treatments, such as phototherapy and photodynamic therapy [2].

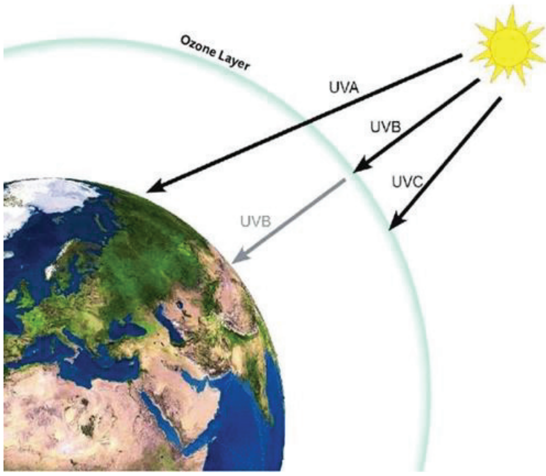


Figure 2. The passage of UV radiation through the atmosphere to the Earth's surface [3]

3. APPLICATIONS OF UV RADIATION

UV radiation is an important part of the electromagnetic spectrum and plays a crucial role in many natural processes on Earth. Below we state some significant applications of UV radiation in health, industry and science [5, 6].

- **Sterilization:** Ultraviolet radiation is useful for disinfecting water and sterilizing surfaces, equipment, and instruments in a variety of industries, including food processing, medicine, and electronics manufacturing. UV radiation kills bacteria, viruses and other microorganisms by disrupting their DNA and preventing their reproduction.
- **Water treatment:** UV radiation is used in water treatment plants to disinfect drinking water. UV light kills microorganisms such as bacteria, viruses and parasites, without the use of chemicals. This is especially useful in areas where access to clean water is limited.

- **Aquaculture:** UV radiation is used in aquaculture to control bacterial and viral diseases in fish farms. UV light can kill pathogens in the water, preventing disease outbreaks among fish populations.
- **Insect Control:** UV radiation is used in insect control, such as insect trap devices and insect traps. Many insects are attracted to UV light, and the use of UV radiation can lure them into a trap, where they are either killed or trapped.
- **Food preservation:** UV radiation is used in food preservation to kill bacteria and extend the shelf life of certain foods, such as dairy products and fruits. UV radiation can also help prevent mold and mildew growth.
- **Air purification:** UV radiation is used in air purification systems to destroy bacteria, viruses and molds in the air. UV light can also help reduce airborne odors.
- **Medical treatments** UV radiation is used in some medical treatments, for example phototherapy for skin conditions such as psoriasis and eczema. In phototherapy, UV radiation is used to slow the overgrowth of skin cells and reduce inflammation.
- **Manufacturing**: UV radiation is used in a variety of manufacturing processes to rapidly cure or solidify materials such as inks, coatings, and adhesives. UV radiation can initiate polymerization, which helps set and harden these materials.
- **Forensics:** UV radiation is used in forensic investigations to detect body fluids and other evidence, as they can fluoresce under UV light.
- **Aesthetic dentistry:** UV radiation is used in cosmetic dentistry to whiten teeth. A special UV light activates the whitening agent in the gel, which removes stains from the teeth.
- **Photolithography:** UV radiation is used in photolithography to make microchips and other electronic components. UV light is used to transfer the desired pattern to a silicon wafer, which is then etched to create the desired component.

3. PROTECTION AGAINST UV RADIATION

The effects of UV radiation on living organisms depend on the dose, wavelength and duration of exposure. UV radiation can have a beneficial effect on humans, however excessive exposure to UV radiation has a harmful effect.

UV radiation can have various effects on materials and the environment, and can cause degradation and discoloration of plastics, fabrics and other materials, leading to reduced durability and aesthetic value. UV radiation can also affect ecosystems by altering plant growth and reproduction and by damaging the DNA of marine organisms. Exposure to UV radiation, whether natural or artificial, can have adverse effects on human health. Protection from UV radiation is important to reduce the risk of harmful effects of UV radiation on the skin, eyes and other biological materials. Therefore, it is important to apply appropriate protection measures against UV radiation [7, 8]. Below we state some of the protection measures against UV radiation.

- **Wearing protective clothing:** Clothing that covers our skin can provide a barrier against UV radiation. Clothing made of tightly woven fabric, such as long-sleeved shirts and pants, may provide better protection than loosely woven clothing. In addition, some clothing is specifically designed with UV protection in mind and is marked with a UPF (Ultraviolet Protection Factor) rating.

- **Using sunscreen:** Sunscreen with a high UVA and UVB protection factor can help prevent skin damage from the sun's rays. Applying a broad-spectrum sunscreen with an SPF (Sun Protection Factor) of 30 or higher can help protect your skin from UV radiation. Sunscreens that protect against both UVA and UVB radiation are often called "broad spectrum" or "UVA/UVB protection." Sunscreens should be applied evenly to the skin 20-30 minutes before sun exposure and reapplied every 2 hours or after swimming or sweating.

- **Using sunglasses with UV protection:** Sunglasses with UV protection can help protect your eyes from harmful UV radiation, which can contribute to the development of cataracts and other eye problems.

- **Limiting exposure:** We can limit our exposure to UV radiation by staying indoors during peak UV hours or by reducing the amount of time we spend outside.

- **Be aware of reflective surfaces:** UV radiation can bounce off reflective surfaces, such as sand, water and snow, and increase our exposure. It is especially important to wear protective clothing and sunscreen in such environments.

- **Use of protective work equipment:** In case of occupational exposure to UV radiation, the use of protective equipment such as special glasses, UV protective clothing, masks, suits and gloves may be necessary to reduce the risk of UV exposure.

Legislative radiation protection is prescribed by laws and regulations for radiation protection. Some of the acts that prescribe radiation protection are: Law on radiation protection and safety of radiation sources (Official Gazette 64/2006), Ordinance on basic requirements for devices that produce optical radiation and conditions and measures for protection against optical radiation (OG 3/2020), Laws on protection against non-ionizing radiation (OG 105/1999, NN 91/2010).

4. CONCLUSION

Although invisible to the human eye, UV radiation plays an important role in many aspects of our lives. The sun's rays as the main source of UV radiation can have positive effects, such as the synthesis of vitamin D, but at the same time they can damage the skin, causing burns and increasing the risk of skin cancer. Awareness of sun protection is key to maintaining skin health.

It is important to be aware of the effects of ultraviolet radiation and to apply appropriate protective measures to protect ourselves from its harmful effects. Regular use of sunscreen, wearing protective clothing and sunglasses, and avoiding mid-day sun exposure can go a long way in reducing the risk of skin damage caused by UV radiation. Understanding and proper use of UV radiation is key to reaping its benefits and protecting against its potential risks.

REFERENCES

[1] The Editors of Encyclopaedia: ultraviolet radiation. Encyclopedia Britannica *Available from* https://www.britannica.com/science/ultraviolet-radiation *Accessed:* 2024-07-10.
[2] Canadian Center for Occupational Health and Safety: UV Radiation, *Available from* https://www.ccohs.ca/oshanswers/phys_agents/ultravioletradiation.html *Accessed:* 2024-07-10.
[3] Raos, N.Život na Zemlji – dar ultraljubičastog zračenja (?), *Available from* *https://www.bug.hr/znanost/zivot-na-zemlji--dar-ultraljubicastog-zracenja--10560* *Accessed:* 2024-07-10.
[4] UPMC Health Beat: The Difference Between UVA, UVB, and UVC Rays, *Available from* https://share.upmc.com/2014/07/difference-between-uva-uvb-uvc/ *Accessed:* 2024-07-10.
[5] Sandri, A.; Tessari, A.; Giannetti, D.; Cetti, A.; Lleo, M. M.; Boschi, F.: UV-A Radiation: Safe Human Exposure and Antibacterial Activity, *Int J Mol Sci.* **24** (2023) 9., 8331.
[6] Neale, P: UV Effects on Ecosystems, *Available from* https://serc.si.edu/research/laboratories/photobiology-and-solar-radiation/uv-effects-ecosystems, *Accessed* 2024-07-11
[7] Vulevic, B.: Izvori ultraljubičastog zračenja i zaštita, *Proceedings of ENVIRONMENT TO EUROPE - EnE15 - The eleventh Regional Conference*, 978-86-89961-02-7, Belgrade, June 2015
[8] American Cancer Society: How to Protect Your Skin from UV Rays, *Available from* *https://www.cancer.org/cancer/risk-prevention/sun-and-uv/uv-protection.html* *Accessed:* 2024-07-10.

PROPERTIES AND RECYCLING OF POLYMER MATERIALS

Kostadin, Tihana[1]; Tomašić, Ana[2]

[1]Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, tihana.kostadin@vuka.hr

[2] Karlovac Technical School, Ljudevita Jonkea 2a, 47000 Karlovac, Croatia, ana.tomasic1@skole.hr

Abstract: *Polymer materials are one the most important technical materials today. The basic division of polymers is usually according to the type of macromolecules, that is, according to their behavior when heated, so they are distinguished: plastomers, elastomers and duromers. In this paper, the mechanical properties of three types of plastomers will be discussed. Plastomers have linear macromolecules; when heated, they soften, and they become solid again on cooling. For this reason, it is possible to recycling plastomers, that means, to return them to the production cycle, which is very important from an ecological point of view, which is also discussed in this paper. The most common is mechanical recycling, which uses usual processing procedures, such as extrusion or injection molding. In conclusion, it can be said that polymer materials today offer wide application possibilities, due to their properties and also the possibility of recycling.*

Keywords: *polymer materials, plastomers, mechanical properties, recycling, ecology.*

1. INTRODUCTION

According to the type of macromolecules they are made of, polymers are divided into: plastomers (linear macromolecules), elastomers (slightly cross-linked macromolecules) and duromers (completely cross-linked macromolecules). There is also a group of polymers called elastoplastomers, which can be processed as plastomers, and have an elasticity like elastomers. According to consumption, plastomers are the most widespread group of polymer materials. When heated, they soften and can be processed. Plastomers can be amorphous and crystalline, with different proportions of the crystalline phase, which is called the degree of crystallinity. [3] [4]

Mechanical properties are the most important properties of the material in technical application. The following are included here: strength, toughness, hardness, strain (elongation), and the values of these properties are determined by tests on the appropriate equipment. To determine the basic mechanical properties, such as tensile strength and elongation, equipment is used in laboratory conditions. Tests are performed on test samples and the results are recorded during testing.

2. MATERIALS, METHODS AND EQUIPMENT

In this work, the properties of three types of plastomers were examined: lauramide (from the polyamide group), polypropylene and polyoxymethylene. Lauramid from the polyamide group has an optimal combination of mechanical, chemical and physical properties, which enables a wide range of technical applications. Polypropylene belongs to the group of crystalline plastomers with well-balanced properties and is also easy to process. Polypropylene has the lowest density of all polymers. Polyoxymethylene has a degree of crystallinity of 75 to 80%, and thus excellent mechanical properties: high strength, stiffness and toughness, and a low friction factor. Its application is common in mechanical engineering. [1]

Tests of mechanical properties were performed in the Laboratory for material testing in the Karlovac University of Applied Sciences, on a Shimadzu, AG-X plus, measuring range up to 100 kN. This testing machine is connected to a computer, and the data is processed by TrapeziumX software. The tensile strength test method was used, with a test speed of 80 N/s.

Figure 1 shows the test specimen before and after the testing in the laboratory.

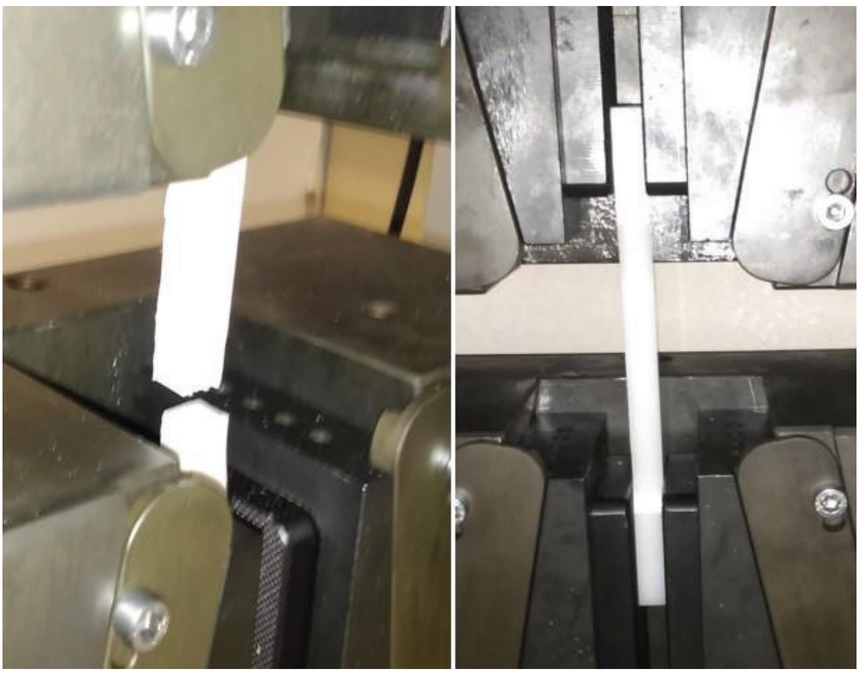


Figure 1: Test specimen before and after the testing [1]

Figure 2 shows the testing machine in the laboratory.

Figure 2: Testing machine [1]

3. RESULTS AND ANALYSIS

Here are the tables with the results of mechanical properties (tensile strength and elongation) for three types of tested materials. Test results for lauramide are on the Table 1, test results for polypropylene are on the Table 2, and test results for polyoxymethylene are on the Table 3. [1]

Table 1: Test results for lauramide

RESULTS	Tensile strength R_m [N/mm^2]	Elongation A [%]
Required values	51-58	15-20
1-1	58,0858	15,7536
1-2	54,6970	13,3597
1-3	57,1639	14,7710
1-4	54,6187	14,4782
1-5	58,2805	13,7686
Average	56,5692	14,4263
Standard deviation	1,7953	0,9292

Table 2: Test results for polypropylene

RESULTS	Tensile strength R_m [N/mm^2]	Elongation A [%]
Required values	31-41	12-16
2-1	40,9801	13,0529
2-2	38,9007	12,5836
2-3	39,3113	12,4157
2-4	39,3496	12,5291
2-5	39,6180	13,7665
Average	39,6319	12,8696
Standard deviation	0,7961	0,5572

Table 3: Test results for polyoxymethylene

RESULTS	Tensile strength R_m [N/mm^2]	Elongation A [%]
Required values	62-70	10 min.
3-1	70,2836	11,4690
3-2	69,1793	12,5915
3-3	66,8136	15,5130
3-4	68,8028	13,5080
3-5	68,3045	17,4799
Average	68,6768	14,1123
Standard deviation	1,2709	2,3962

At the end of the measurement, after recording all the results and comparing the required tensile strength and elongation with the obtained results, the following can be analyzed.

When testing lauramide, the required tensile strength is between 51 and 58 N/mm^2, and the elongation is between 15 and 20%. After comparing the obtained results, it can be concluded that test specimen 1-1 passed the test, while test specimens 1-2, 1-3, 1-4 and 1-5 have adequate tensile strength, but the elongation values do not correspond to the required value. In testing of polypropylene, test specimens 2-1, 2-2, 2-3, 2-4 and 2-5 met the required values of tensile strength and elongation. Test specimens of polyoxymethylene 3-1, 3-2, 3-3, 3-4 and 3-5 met the required values of tensile strength and elongation. [1]

The average and standard deviation are also calculated and can be seen in tables for all three tested materials.

4. RECYCLING OF POLYMER MATERIALS

Recycling of polymer waste can be: mechanical (it is the most common), then chemical (decomposition), energy recycling and composting. It is returning of polymer materials to the production cycle. Mechanical recycling (material recovery) aims to obtain new polymer materials, i.e. products, and these procedures are completely the same as the procedures in the industry of primary production of pure polymer materials, such as extrusion or injection molding. Most plastomers can be recycled in this way. [2]

The quality of the recycled product is evaluated according to the properties of the product obtained from pure polymer. Mechanical recycling contributes to reducing the use of natural resources and reducing the generation of waste, as well as environmental protection, and therefore it is necessary to highlight the ecological component in the processing and application of polymer materials.

5. CONCLUSION

By comparing the measurement results of individual materials regarding to their application it can be concluded that lauramide requires high strength and is therefore used in automotive industry, construction, shipbuilding, food and chemical industry. Polypropylene is used to produce technical parts, due to its good mechanical properties, hollow bodies, containers, pipes, toys and household containers are made. Polyoxymethylene has excellent strength and is characterized by retaining its properties mechanical properties even at high temperatures. It is used for making bearings and gears.

After analyzing the obtained results and comparing them with the required values, it can be concluded that the tensile strength values are satisfactory for all three materials, only the elongation is slightly lower for lauramide, when compared to the required value. For a more detailed analysis, it would be necessary to carry out additional tests.

Polymer materials today offer wide application possibilities, due to their properties and the possibility of recycling. Recycling of polymer materials contributes to reducing waste, and also to environmental protection and protection of human health.

REFERENCES

[1] Fudurić, A.: *Svojstva i primjena polimernih materijala, te njihova oporaba u Hrvatsko*j, završni rad, Veleučilište u Karlovcu, Karlovac, 2016.
[2] Hrnjak – Murgić, Z.: *Gospodarenje polimernim otpadom*, Udžbenici Sveučilišta u Zagrebu, Zagreb, 2016.
[3] Kostadin, T.: *Materijali II*, interni nastavni materijal, Veleučilište u Karlovcu (dostupno online), Karlovac, 2023.
[4] Rogić, A. i dr.: *Polimeri i polimerne tvorevine*, DPG Zagreb, 2008.

ECOLOGICALLY ACCEPTABLE MACHINING OF POLYMER MATERIALS

Kostadin, Tihana[1]; Šančić, Tomislav[2]; Šimunić, Nikola[3]; Rendulić, Matija[4]

[1] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, tihana.kostadin@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, tsancic@vuka.hr

[3] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, nikola.simunic@vuka.hr

[4]Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, matija.rendulic112@gmail.com (student)

Abstract: *Machining of polymer materials by turning or milling is used in the processing of plastomers and duromers. Special tools are used, with proper selection of cutting parameters and appropriate cooling technique. In this work, samples from three different types of plastomers were made by the milling, and the surface roughness was measured, in order to be able to analyze which parameters give a lower surface roughness, also taking into account the economic profitability of the processing. Special attention should be paid to the environmentally friendly machining of polymer materials, with the proper choice of cooling technique. Cooling with compressed air is recommended in milling because it is an efficient and natural way of cooling, without harmful effects for the environment and human health.*

Keywords: *polymer materials, machining, surface roughness, cooling techniques, ecology.*

1. INTRODUCTION

The main problem in the machining of polymer materials is the increase in temperature due to friction, which reduces workability. Due to the heating of the tool, as well as the polymer, the quality of the polymer may decrease and their melting may occur. That is why the correct choice of specially made tools is important, as well as the choice of cooling technique. During the machining, it is important to match the material and geometry of the cutting tool with the type of polymer material. The tool should be made of hard metal, or with inserts of diamond. Tools must always be sharp, to ensure cutting instead of deforming the material. Cutting parameters should be optimized and constantly controlled during operation. In machining of polymer materials, the first choice for cooling is compressed air, due to the improved chip removal and preventing environmental pollution. [1] [2]

In this work, samples from three different types of plastomers were made by the milling, and the surface roughness was measured and analyzed.

2. MATERIALS, METHODS AND EQUIPMENT

In this work, three types of polymer materials from the plastomer group were selected: polyethylene (PE), polyamide (PA) and polyacetal (POM-C). After choosing the material, CAD/CAM preparation of the samples is done in the Fusion 360 software. Next is the selection of tools; a carbide (hard metal) milling cutter was used for milling the polymers. After that, the setting of appropriate cutting parameters was made. After the samples have been made, the surface roughness is measured. Tool for cutting examples was 3 flute endmill, 12 mm diameter from Hoffmann group with catalog number 20 2273. Cutting speed v_c is determent by catalog and it is: 200 m/min for PA, 160 m/min for PE and 160 m/min for POM-C. Finish pass has depth of cut a_p = 9 mm for every test and width of cut a_e is 10% of tool diameter equal 1.2 mm. The experimental part was carried out in the Laboratory of the Karlovac University of Applied Sciences.

Figure 1 shows the test equipment, and figure 2 shows test samples. [3]

Figure 1: 5-axis CNC milling machine DMG MORI DMU 50 Ecoline

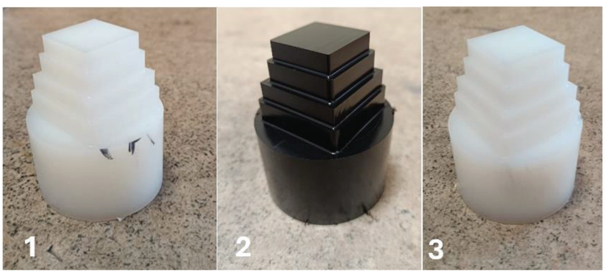


Figure 2: Test samples 1) polyamide PA, 2) Polyethylene PE, 3) Polyacetal POM-C

3. RESULTS AND ANALYSIS

Here are the test results for all three materials.

Table 1 shows the values of the surface roughness and table 2 shows the average values. Standard deviation values are on the table 3. [3]

Table 1: Results for surface roughness

Feed per tooth [mm]	Roughness, R_a [µm]	Roughness, R_z [µm]
Polyethylene (PE)		
0.05	0.554	3.160
	0.428	2.619
	0.518	2.805
0.07	0.365	2.396
	0,326	2.107
	0,380	2.116
0.14	0.332	2.048
	0.483	2.745
	0.348	1.809
0.14 (a_e=10mm)	0.401	2.304
	0.394	2.869
	0.415	2.656
Polyamide (PA)		
0.05	0.306	2.474
	0.291	2.542
	0.334	2.487
0.07	0.295	3.021
	0.340	2.788
	0.314	2.882
0.14	0.389	3.093
	0.338	2.701
	0.465	3.638
0.14 (a_e=10mm)	0.336	2.776
	0.315	2.276
	0.386	2.797

Polyacetal (POM-C)		
0.05	0.237	1.721
	0.196	1.739
	0.224	1.892
0.07	0.259	2.154
	0.260	2.183
	0.249	1.885
0.14	0.322	2.192
	0.381	2.577
	0.285	2.267
0.14 (a_e=10mm)	0.250	1.892
	0.231	1.777
	0.230	1.730

Table 2: Average values

Material	Feed per tooth [*mm*]	Surface roughness, R_a [μm]	Surface roughness, R_z [μm]
Polyethylene (PE)			
	0.05	0.500	2.861
	0.07	0.357	2.206
	0.14	0.388	2.021
	0.14 (a_e=10mm)	0.403	2.610
Polyamide (PA)			
	0.05	0.310	2.501
	0.07	0.316	2.897
	0.14	0.397	3.144
	0.14 (a_e=10mm)	0.346	2.616
Polyacetal (POM-C)			
	0.05	0.219	1.784
	0.07	0.256	2.704
	0.14	0.329	2.345
	0.14 (a_e=10mm)	0.237	1.800

Table 3: Standard deviation

Material	Surface roughness, R_a [µm]	Surface roughness, R_z [µm]
Polyethylene (PE)	0.05344	0.32996
Polyamide (PA)	0.03443	0.25028
Polyacetal (POM-C)	0.04179	0.38766

At the end of the measurement, analysis show that the first material, polyethylene with the smallest feed per tooth, has the highest surface roughness, R_a value. The assumption is that less roughness will be achieved with less feed per tooth. This deviation of the results can occur when the material is clamped, due to cooling or unknown samples vibration during processing. By increasing the feed rate, the R_a decreases, which is optimal compared to other results.

Polyamide is the second material and shows a mean value with the smallest feed compared to the other two tested materials. It increases linearly to the highest roughness R_a on the third step. It slowly drops by a not so big difference of 0.05 µm to the last step.

The last tested material, POM – C has the lowest R_a value with the lowest feed per tooth. It rises with increasing feed per tooth to the highest point in the third stage, and then falls with roughness processing for 0.09 µm. [3]

Polyethylene has the smallest value of roughness parameter R_z for processing recommended from the catalog with a feed per tooth of 0.14 mm.

Proportional to it with the highest value is another material, polyamide. The materials end at the same point with a small difference of 0.006 µm.

POM – C is the material with the lowest R_z value compared to other tested materials. It starts with the smallest feed per tooth, and then moves linearly to the largest test value with feed per tooth of 0.07 mm and ends with the smallest R_z value for roughing of other materials with 1.8 µm. [3]

4. CONCLUSION

After the analysis of the results from the economic aspect, it can be concluded that rough machining can achieve approximately the same surface roughness as with finer machining. By passing with a smaller one with a feed per tooth, a longer processing time is achieved, thus increasing the price of the product.

The goal is to achieve the best possible roughness with as little processing time as possible, because today almost everything is related to the price of the product and the final cost of the product.

Machining of polymer materials uses adequate cutting parameters, proper selection of tools, as well as cooling techniques. When machining polymers, the first choice is cooling with compressed air, which is the most efficient, natural and environmentally friendly way of cooling.

Therefore, for further work and research, cooling with compressed air in the machining of polymer materials can be recommended.

REFERENCES

[1] Čatić, I.: *Proizvodnja polimernih tvorevina*, Zagreb, 2006.
[2] Kostadin, T.: *Prerada polimera*, interni nastavni materijal, Veleučilište u Karlovcu (dostupno online), Karlovac, 2023.
[3] Rendulić, M.: *Obrada odvajanjem čestica polimernih materijala,* završni rad, Veleučilište u Karlovcu, Karlovac, 2023.

PROPERTIES OF BIOCOMPATIBLE MATERIALS

Kostadin, Tihana[1]; Šimunić, Nikola[2]; Medić, Srđan[3]; Jurčić, Domagoj[4]

[1] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, tihana.kostadin@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, nikola.simunic@vuka.hr

[3] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, smedic@vuka.hr

[4] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, Croatia, domi.jurcic@gmail.com (student)

Abstract: *The term biocompatible materials is used as a name for those materials that do no harm to living tissue. The human body recognizes this type of material as its own, not a foreign material. Because of this, allergic reactions and the body's tendency to reject such materials do not occur. The use of this type of material in dental medicine is very common, and one such example is covered in this paper. The transparent biocompatible polymer MED610 was used in the experimental part. The mechanical properties of this material were tested, and the obtained results were analyzed. MED610 is a quite rigid material and is often used for manufacturing ergonomically designed patient specific surgical guides (PSSG) using additive technology.*

Keywords: *biocompatible materials, polymers, mechanical properties, use in dental medicine, ergonomics.*

1. INTRODUCTION

Biocompatible materials are used as key components in the manufacture of artificial parts of injured and/or destroyed tissues such as bone, muscle, or blood vessel tissue. They are also the main material for making implants in dental medicine and aesthetic surgery. The most important property of biocompatible materials must be longevity, i.e. immutability of properties over a very long period, because unlike living tissue, synthetic tissue cannot be renewed on its own. Since the development of medicine is not possible without the development of technique and technology, and their development runs parallel and dependent on each other, biocompatible materials have found application in technology for the purpose of making reliable and durable elements, with precisely defined properties. [1] [2]

In the experimental part of this work, specimens of the biocompatible polymer MED610 were tested and it was determined whether the material meets the requirements of modern dental medicine.

2. MATERIALS, METHODS AND EQUIPMENT

Mechanical properties of the transparent biocompatible polymer MED610 were tested. The material has high dimensional stability and is ideal for applications that require long-term contact with the skin.

Tests of mechanical properties were performed in the Laboratory for material testing in the Karlovac University of Applied Sciences, on a Shimadzu, AG-X plus, measuring range up to 100 kN. This testing machine is connected to a computer, and the data is processed by TrapeziumX software. The tensile strength test method was used.

For the purpose of testing, a standard test specimens with a rectangular section are used. The test specimens were made according to the ISO 527-2 standard using additive technologies (3D printing process).

Figure 1 shows the test specimens after the testing.

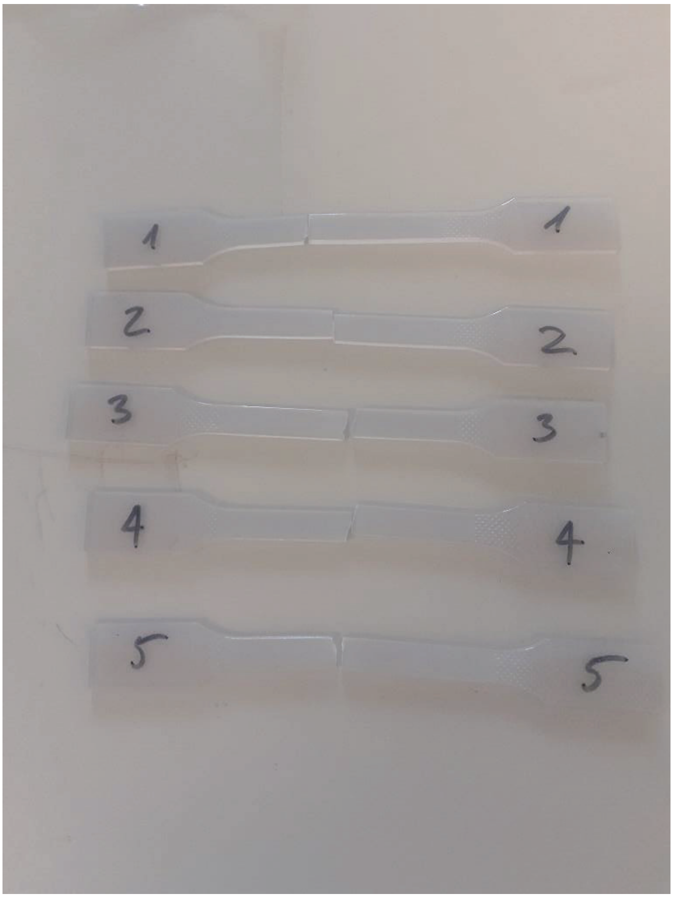


Figure 1: Test specimens after the testing [1]

3. RESULTS AND ANALYSIS

Here are the test results of mechanical properties of material MED610, on the Table 1.

Table 1: Test results of mechanical properties of MED610 [1] [3]

VALUES	Max force (F_m) [N]	Break force (F_k) [N]	Tensile strength (R_m) [N/mm^2]	Break stress (R_k) [N/mm^2]	Strain (ΔL) [mm]	Elongation (A) [%]
REQ. VALUES			**50-65**			
Sp. 1	2011,90	1799,44	62,87	56,23	6,09998	8,37564
Sp. 2	1978,21	1672,25	61,82	52,26	6,21517	7,61756
Sp. 3	2010,03	1925,25	62,81	60,16	6,05083	7,63994
Sp. 4	1964,57	1827,43	61,39	57,11	6,13094	7,25555
Sp. 5	1933,40	1709,24	60,42	53,41	6,15063	7,23773

Average and standard deviation are on the Table 2.

Table 2: Average and standard deviation for tensile strength

Specimen	Tensile strength (R_m) [N/mm^2]
1	62,87
2	61,82
3	62,81
4	61,39
5	60,42
AVERAGE	**61,86**
ST. DEV.	**0,92**

At the end of the measurement, after recording all the results and comparing with the required values, analysis of the test results found that the measured values of maximum force and elongation of all five test specimens are in a very small range of values.

The measured value of the maximum force is in the range from 1933,4 N to 2011,9 N, and the average of the measured maximum force is 1979,62 N.

The tensile strength values are between 60,42 N/mm^2 and 62,87 N/mm^2, with an average tensile strength of 61,86 N/mm^2, and standard deviation 0,92. [1]

Values of tensile strength are meet the required values (50 – 65 N/mm^2).

According to EN ISO 10993-1:2017, as far as biocompatibility is concerned, permanent contact with the skin (more than 30 days) and temporary contact with the mucous membrane (up to 24 hours) are prescribed for the material MED610.

MED610 is an ideal material for manufacturing patient-specific surgical guides due to its biocompatibility and suitability for prolonged contact with the skin. Its compatibility with the body ensures minimal risk of adverse reactions, making it a reliable choice for surgical applications requiring precision and safety. With MED610, surgeons can confidently rely on customized guides tailored to individual patient needs, facilitating accurate and efficient procedures while prioritizing patient well-being. [4]

4. CONCLUSION

After conducting a static tensile test and analyzing the results, it was determined that the tensile strength corresponds to the required values for this material.

Tensile strength and modulus of elasticity of biocompatible materials meet the requirements in dental medicine, and they are the first choice when choosing materials for making dental prostheses. By adopting modern production methods (additive technologies), the quality of products made from biocompatible materials (biopolymers) is further improved, and the time and cost of production are reduced.

The main feature of biocompatible materials is their inertness towards living tissue and high workability with most processing procedures. Despite the high cost of materials and equipment, biocompatible materials are the most used type of material in dental medicine because that there are still no cheaper alternative solutions today. With further testing of similar materials and investment in new processing procedures, this could change in the future.

MED610 is a quite rigid material and is often used for manufacturing ergonomically designed patient specific surgical guides (PSSG) using additive technology.

REFERENCES

[1] Jurčić, D.: *Svojstva i primjena biokompatibilnih materijala,* završni rad, Veleučilište u Karlovcu, Karlovac, 2016.

[2] Kostadin, T.: *Materijali II*, interni nastavni materijal, Veleučilište u Karlovcu (dostupno online), Karlovac, 2023.

[3] https://www.stratasys.com/siteassets/materials/materials-catalog/biocompatible/mds_pj_med610_0720a.pdf?v=48e364

[4] Šimunić, N.: *Numeričko i eksperimentalno modeliranje vodilica u dentalnoj implantologiji*, Doktorski rad, Fakultet strojarstva i brodogradnje, Zagreb, 2023.

HAZARDS AND SAFETY MEASURES WHEN WORKING WITH PLANT PROTECTION MACHINES

Vlado Kušec[1], Martina Kušec Ruganec[2], Igor Kovačev[3], Tomislav Kos[4]

[1] Veleučilište u Križevcima M. Demerca 1. Križevci
CROATIA, vkusec@vguk.hr
[2] Dom zdravlja Karlovac. Ul. Dr. Vladka Mačeka 48, Karlovac,
CROATIA
[3] Sveučilište u Zagrebu, Agronomski fakultet. Svetošimunska cesta 25. Zagreb,
CROATIA, ikovacev@agr.hr
[4] Sveučilište u Zadru, Odjel za ekologiju, agronomiju i akvakulturu. Trg kneza Višeslava 9. Zadar, CROATIA, tkos@unizd.hr

Abstract

The use of machinery and equipment in the pesticide application process has the purpose of improving yields, but at the same time negatively affects the health of employees as well as environmental pollution. The aim of the work is to determine the hazards and safety measures that should be taken when operating machinery for the application of pesticides in order to reduce the threat to the health of workers and the environment to a minimum. Knowledge of safety at work, both in industry and in agriculture, is not only a requirement for successful production, but also for the protection of the health of farmers as well as for the protection of the environment. In addition to the hazards that arise when working with machines for the application of pesticides, the laws and regulations that regulate working with them should also be taken into account. Directive 1107/2009. and the Law on the Sustainable Use of Pesticides (Official Gazette 46/2022) establishes the guidelines for the sustainable use of pesticides, and in Chapter 6, the guidelines refer to protection machines. Tractor drivers who perform protection tasks are most exposed to the harmful effects of pesticides and should be instructed for a safe work with machines, proper use of PPE (personal protective equipment) as well as the harmful impact of PPP (plant protection products) on the environment.

Keywords: *plant protection, pesticides, occupational safety, sprayers*

Introduction

Pesticide use and risks

Chemical agents, with their efficient action and relatively low price, have become an indispensable method in the protection of agricultural crops. However, with increasingly intensive use, there are also negative consequences for the health of humans, animals, and the environment. Directive 1107/2009 EZ establishes guidelines for the sustainable use of pesticides for all members of the European Union. Machines, devices and equipment used in the process of plant protection are quite complex in terms of sources of danger, but also legal regulations and regulations that should be applied in practice (Kušec et al. 2017). He also states that the frequency of injuries that affect human health, environmental protection, but also material goods in the use of machines and devices in the process of plant protection indicate the justification of dealing with this issue. Lambert et al. (2012) research possible hazards to the health of workers in the process of plant protection based on the compromise between safety and quality of task performance. They also state that the main factors affecting safety are physical and time constraints as well as the type of atomizer. Mohamed et al. (2024) state that the excessive use of pesticides in agriculture has caused negative effects on human health and the environment. The results of their research indicate that age, experience and size of the farm are the most influential factors on pesticide use decisions. They conclude that, in addition to the above, the responsible use of pesticides is also influenced by soil fertility, the use of fertilizers and the education of farmers. Fragnoli et al. (2019) state that even a preliminary analysis of the relationship between the use of pesticides and the consequent risk of worker exposure is a complex task. Their work illustrates the procedure for risk assessment of activities related to the application of pesticides with reference to the needs of farmers in compliance with recent legal regulations. Using the AHS (Agricultural Health Study) algorithm, they evaluate all parameters that can affect exposure to pesticides, giving a qualitative result through an assessment of the real situation. Tudi et al. (2021) investigate the impact of pesticide application on the environment. They state that it is necessary to control pesticide contamination, environmental impact and other non-target organisms. They also state that new scientific methodology and technology should be implemented, as well as useful measures such as integrated plant protection, laws banning high-risk pesticides and the creation of a national implementation plan to reduce the negative effects of pesticides.

PPE and pesticides

Moreira et al. (2023) based on certain literature investigate the behavior of farmers, identifying the main risks for diseases in the unsafe handling of pesticides. The main risk factors identified were age, education, training and breeding experience. The most common risky behavior was the application of pesticides without personal protective equipment (PPE), improper disposal of packaging and underestimating the instructions on the label. They also state that the safer use of pesticides requires multidisciplinary and effective education. Bagheri et al. (2018) note irritating (burning) eyes and blurred vision which were symptoms when handling pesticides in the surveyed farmers. They also state that age and experience negatively influenced the use of PPE, while education and information about pesticides promoted safer behavior. Portela de Assis et al. (2020) based their research on the question of what health problems agricultural workers experience as a result of occupational exposure to pesticides. Encouraging the control of pests and weeds without pesticides would have a significant impact on the health of farmers. Likewise, awareness campaigns as well as subsidies for the acquisition of PPE are key to improving safety at work. It is considered that the application of PPE is one of the basic measures for reducing risks when working with pesticide application machines, which enables workers to work safely and is regulated by the ordinance on placing personal protective equipment on the market (Official Gazette 89/2010). Trupčević (2010) states that this regulation will contribute to regulating the PPE market and preventing the import of equipment that does not meet the prescribed quality criteria. Gavanski and Petrović (2023) investigate the

behavior of farmers towards PPE when working with PPP (plant protection products). Based on the conducted surveys, they conclude that there
is ignorance or insufficient information about proper protection and that it is necessary to carry out periodic education of all PPE users about the dangers they pose to people as well as about the correct selection of PPE. Cavalier et al. (2023) state that knowing the role of exposure to pesticides in the development of cancer is a prerequisite for primary prevention. They also consider that, although the existing literature provides sufficient evidence to justify regulatory measures to reduce exposure to pesticides, further research should be conducted to better understand the contribution of the environment to the development of cancer. According to Martinić (2015), in accordance with health regulations, persons working with pesticides must use personal protective equipment (protective suits, protective footwear, gloves, respirators, protective caps and protective glasses).

Maschinery for pesticide application and drift

Jones et al. (2021) consider that agricultural vehicles and machines represent the main source of deaths at work in agriculture. As a recommendation for measures to protect health at work, they suggest adapting the risk assessment technique and training in the field of health and safety with new technologies such as robots, artificial intelligence, etc. The effects of displacement, also known as drift, refer to the unintentional movement or dispersion of pesticides beyond the predicted target area. Understanding the effects of drift is essential for its control, as it allows identifying causes, consequences and preventive measures (FasterCapital, 2024). DRT (drift reduction technology) is also recommended by the EPA (U.S. Environmental Protection Agency, 2021). The EPA applies a rating system for the level of potential drift reduction of the tested technology and based on the submitted results, assigns a DRT rating using 1-4 stars to the technology that meets the minimum drift reduction standard. Tadić (2012) considers that the precise application of pesticides is very important both for ecological reasons and for the efficiency of inputs in production. He states that in order to achieve greater precision of pesticide application and maximum effectiveness, technical systems in plant protection (sprayers and atomizers) must be structurally and technically flawlessly correct, and must have the appropriate potential. Jones (2021) considers that agricultural vehicles and machinery are the main source of occupational fatalities in agriculture. It recommends that measures for protection and health at work should be adapted to risk assessment techniques and training in the field of protection and health with new technologies such as robots, artificial intelligence, etc. Li et al. (2023) consider that although a large amount of research results are available from the application of pesticide application equipment, there is a large gap between current technology, orchard spraying equipment and the requirements for precision spraying. He also states that in order to reduce the amount of pesticide drift, researchers should investigate anti-drift nozzles, optimize droplet size distribution, reduce the proportion of small droplets and prioritize the development of nozzles that are suitable for different operating environments. In 2016, the EPA publishes a generic Pesticide Dispersal Reduction Technology (DRT) verification protocol by which pesticide applicators can select verified products and equipment with the assurance that they will reduce the risk of hazards, while Palardy (2017) states that there are no adequate incentives for its application. He also considers that it is necessary to analyze the provisions on liability that regulate damage from the drift of pesticides and points out that it may be necessary to update the judicial practice that regulates liability in order to achieve technological progress. Soo et al. (2011) investigate the occurrence of acute diseases associated with non-targeted drift of pesticides. They consider that the extent of pesticide drift is influenced by many factors such as the nature of the pesticide (stability), equipment, spraying techniques (e.g. nozzle size and height), and the amount of pesticide applied.

Mehanical hazards

Mechanical hazards include all types of hazards that arise due to the mechanical action of machines, devices or equipment. Falat (2017) also states that serious injuries that occur when working with agricultural machinery are most often the result of a part of the machine and the PTO shaft being caught. Kušec et al. (2013) state that the danger is also represented by the distribution pipes in which there is a medium under high pressure during operation, and that due to the rupture of the pipe, an injury may occur to the worker who is near the sprayer or atomizer.
Given that workers from third countries come to the EU, and to Croatia, and due to language barriers, they do not understand textual warnings about the dangers when working with machines, it is necessary to supplement them with pictorial ones. Bagagiolo et al. (2019) investigate the application of pictorial signs that are attached to agricultural machinery and state that this is essential to warn users of residual risks that cannot be eliminated by the design of the machinery. They conclude that safety pictures attached to agricultural machines have great potential as a means of communication because they should convey messages about the remaining risks in interaction with machines, regardless of the worker's characteristics. Caffaro and Cavallo (2015) investigate the application of pictograms on agricultural machinery and consider them to be important tools for reducing the occurrence of accidents and injuries if correctly applied, understood and followed. Ahmad et al. (2020) investigate factors influencing the implementation of occupational health and safety management in the agricultural machinery industry. The results of their study provide an overview of the factors influencing the implementation of occupational health and safety management with operational agricultural machinery. They also state that interdisciplinary and multidisciplinary approaches are needed that could be a useful tool to provide a good health framework for health and safe work with agricultural machinery. Lincoln and Elliot (2023) study safety and health protection from the aspect of risk mitigation and safety of agricultural workers who encounter new technologies. They consider that occupational safety experts must cooperate with developers of new technologies and that they should be familiar with the process of standards development in order to mitigate the harmful effects on health of workers. Most working agricultural machines and plant protection machines are powered by a PTO (cardan shaft). The safety of PTO and hydraulic transmission applications is investigated by Tomas and Buckmaster (2003). They say that while PTO has been around for decades, it still poses a danger to agricultural workers. If the PTO transmission were replaced by a hydraulic one, the danger of clothing entanglement and pulling in the victim would be eliminated. Given that hydraulic transmission also poses a danger, which is a jet under high pressure, this alternative represents a lower risk in terms of frequency of occurrence and severity of injury.

Dangers and safety measures when working with plant protection machines

Based on the studied literature on the use of pesticides in plant protection, it can be concluded that a significant source of danger is represented by the machines used for the protection procedure. Dangers and risks when using pesticide application machines can be chemical, biological, mechanical and psychological. Sprayers are mainly used in the protection of field crops, and atomizers are used in fruit and viticulture production.
The function of pesticide application machines is:

- to ensure that the optimal amount of PPP reaches the plant and is evenly distributed
- that PPP reaches all parts of the plant
- that PPP losses (drift) are as small as possible

Hazards and safety measures from pesticides

In the process of plant protection, different types of pesticides are used. Some means pose a lesser and some greater danger to human health, which depends on the safety measures that must be followed. With the correct application of pesticides, there should be no excessive exposure or danger to human health, and the risk depends on the properties and amount of pesticides, the method and duration of exposure (Brokulić and Žalac 2018). The most important protection measures in the application of pesticides are:

- general protection measures against hazards when working with PPP
- application of PPE
- following the instructions for safe handling of pesticides and pesticide application machines
- drift protection

General protection measures against hazards when working with PPP

The most important general protection measures are IPM (integrated pest management), i.e. the production of food that is minimally loaded with pesticides, the ultimate goal of which is the protection of human health and minimal environmental pollution (Barić, 2014), as well as the education of pesticide users. Ordinance on training for the safe handling and correct application of pesticides NN 80/2023 (Article 1) regulates the field of training for professional users for the professional use of distributors and consultants for acquiring and renewing appropriate knowledge on the safe handling and correct application of pesticides in order to achieve the goals of sustainable use of pesticides by reducing risks and effects on human health and the environment and the application of general principles of IPM.

Application of PPE

In the process of plant protection, the use of PPE (personal protective equipment) plays an important role, which depends on the method of application and the type of pesticide in terms of harmful effects. PPE must not be used if it is damaged, and the Law on Sustainable Use of Pesticides NN 46/2022 Article 73 must be adhered to. Users, when applying and handling pesticides, must use appropriate means and procedures for personal protection and special protective means as well as devices and equipment in accordance with the instructions on the label and devices and equipment in accordance with the instructions on the label or the decision on the registration and permit of an individual pesticide and treatment methods they apply. According to Martinić (2015), the use of personal protective equipment is one of the basic measures to reduce risks when working with plant protection products, which allows applicators and agricultural workers to work safely.

Following the instructions for the safe handing of pesticides and pesticide application machine

In order for the operators of pesticide application machines to be warned and constantly informed about the dangers, different marking methods are used in practice, and the most common are the so-called pictograms. Pictograms as pictorial signs with symbolic meaning are widely used in practice. They are used in cases where quick perception and understanding of information is required, regardless of the cultural or linguistic differences of the participants in the communication (Brozović et al. 2019). According to ECHA, a hazard pictogram is an image on a label that includes a warning symbol and a specific color to provide information on health or environmental hazards arising from a specific substance or preparation. The CLP (classification labeling packaging) regulation introduced a new way of labeling hazardous substances for the EU ((EC) No 1272/2008), whereby the pictograms were modified in accordance with the Globally Harmonized System of the United Nations (GHS). Caffaro and Cavallo (2015) state that pictograms attached to agricultural machinery are important tools to reduce the occurrence of accidents and injuries when properly noticed, understood and followed. Given that citizens from other countries are employed in Croatia in the field of agriculture, the language barrier should also be taken into account. Bagagiolo et al. (2019) investigate the understanding of signs attached to agricultural machinery and believe that this is crucial for warning users of remaining risks that cannot be eliminated by designing machinery and adopting protection.

Drift protection

Protection measures against drift, i.e. the danger of pesticides ending up on non-targeted surfaces, are:

- education of agricultural workers and the wider community about this phenomenon and its consequences
- use of only correct machines, devices, circuits and elements for pesticide application
- performing the procedure in optimal climatic conditions, which is spraying when there is no wind, and the air temperature is not too high
- application of nozzles according to the manufacturer's instructions
- research and testing of more efficient machines and equipment for a more rational application of PPP

The biggest disadvantage of protection machines is that they cannot completely deposit PPP on the plant, but a part ends up on a surface that does not need to be treated. This phenomenon is called drift, entrainment, uncontrolled removal of pesticides, etc. The occurrence of drift depends on weather conditions (wind and temperature), design characteristics of the device (nozzle selection), correctness of the device (uniform flow on all nozzles) and the skill of the tractor operator. Figure 1 schematically shows drift in atomizers and the impact on the environment, animals and humans.

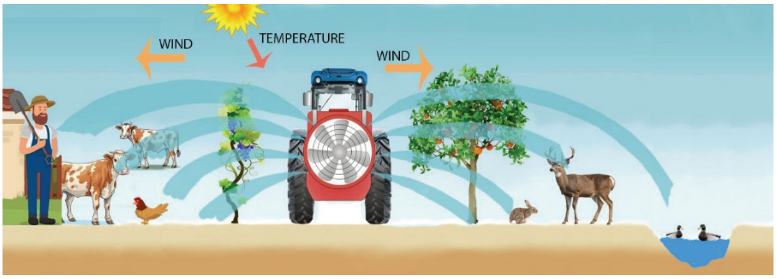


Figure 1. Drift during atomizer operation

The machines used in the plant protection process consist of several basic assemblies and elements such as a frame, a tank for PPP, a pump, a regulation assembly and nozzles. The most important elements that cause PPP losses or drift are the nozzles. The above occurs due to the use of incorrectly selected or defective nozzles. Ivković (2020) states that the nozzles represent the biggest problem of the proper operation of the technical system in the protection of plants, which is a consequence of the consumption of the outlet opening, which increases the flow, or the blockage of the nozzle itself.

- The selection of nozzles is a complex and expertly demanding procedure and is not the subject of research in this work. In practice, different designs of nozzles are used, and their selection depends on the type of agent, the device, the method of application and the type of culture on which the protection procedure is performed. According to the Law on the Sustainable Use of Pesticides (Official Gazette 46/2022), the correctness of the nozzles is also determined in the process of testing the protection machines. According to the HRN EN ISO 16122-3 standard, any nozzle that has a flow deviation of ±10% should be replaced.
- Petrović et al. (2020) investigate and compare a conventional and an atomizer with an ultrasonic system for selective application and report a significant reduction in soil and airborne liquid drift without compromising application quality.

Measures and protection against mechanical hazards

The most common mechanical hazards when working with protection machines are caused by contact with rotating working elements or burst pipes that are under pressure, through which the protection agent is transferred. Bellocio et al. (2019) investigate the issue of the use of a cardan shaft and state that contact with moving parts is the most common cause of accidents with agricultural machinery. They conclude that the main PTO guard is in unsatisfactory compliance. Cividino et al. (2018) also investigate the dangers that arise in the application of PTO. The results of their research show that 24.7% of the sampled tractors were missing guards and that this can be a fatal accident.
According to the regulation on pesticide application machines and test stations NN 141/2021 (Article 15), machines that meet the standards HRN EN ISO 16122-1:2015, HRN EN ISO 16122-2:2015, HRN EN ISO 16122-3:2015, HRN EN ISO 16122-4:2015

and HRN EN ISO 16122-5:2021 receive the mark. Figure 2 shows a cardan shaft with protective elements and safety markings, as it should be applied in practice.

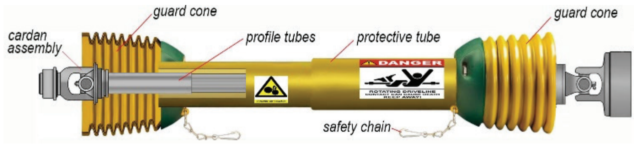


Figure 2. Display of a correct cardan shaft

Conclusions

Based on the researched literature of previous research on the negative impacts of the use of machines in the application of pesticides on human health and the environment, it can be concluded:

- The use of machines in the process of plant protection represents a significant risk from chemical and mechanical sources of danger from the aspect of human health and the natural environment.
- Knowing the rules of safety at work as well as the application of laws and regulations from this issue can significantly reduce the risk of danger to human health, and in some cases, even death.
- In the process of plant protection, only correct machines can be used that have been tested according to the applicable laws and regulations and if they are marked with danger signs according to the applicable standard.
- Employees who operate machines in the process of plant protection, but also manipulate with PPP, must be continuously educated, which is prescribed by law, and thus contribute to reducing the danger of this necessary and at the moment irreplaceable process in food production.

Literature

[1] About the Drift Reduction Technplogy Program (2021). EPA. *Available from* Introduction to Pesticide Drift | US EPA *Accessed:* 2024-4-14

[2] Ahmad, N.; Haq, Z.U.; Islam, M.A.; Haidree, S.R.; Mehmood, T. & Asam, H.M.: Ergonomic and safety prospects of farm machinery-a review, *International Journal of Biosciences*, **16** (2020) 6, 11-26, *Available from* https://www.researchgate.net/publication/369301802_Ergonomic_and_safety_prospects_of_farm_machinery-a_review *Accessed:* 2024-5-5.

[3] Anamarija Bokulić, Novaković, V., Žana Žalac. (2018). Sigurna uporaba sredstava za zaštitu bilja, Propisi s primjerima dobre prakse – rad s opasnim kemikalijama, Ministarstvo poljoprivrede, Zagreb. *Available from* http://uznr.mrms.hr/wp-content/uploads/prezentacije/skup25102018/Sigurna%20uporaba%20sredstva%20za%20za%C5%A1titu%20bilja.pdf *Accessed:* 2024-4-5

[4] Bagagiolo, G.; Vigoroso, L.; Caffaro, F.; Micheletti Cremasco, M. & Cavallo, E.: Conveying Safety Messages on Agricultural Machinery: The Comprehension of Safety Pictorials in a Group of Migrant Farmworkers in Italy, *International Journal of Environmental Research and Public Health*, **16** (2019) 4180, *Available from* https://www.mdpi.com/1660-4601/16/21/4180 *Accessed:* 2024-4-5

[5] Bagheri, A.; Emami, N.; Allahyari, M.S. & Damalas, C.: Pesticide handling practices, health risks, and determinants of safety behavior among Iranian apple farmers, *Human and Ecological Risk Assessment: An International Journal*, **24** (2018) 8, *Available from* https://www.tandfonline.com/doi/full/10.1080/10807039.2018.1443265 *Accessed:* 2024-4-5

[6] Božena Barić, (2014). Načela integrirane zaštite bilja, Glasilo biljne zaštite 5/2014.

[7] Brozović; M., Kovačević, D. & Bota, J.: Piktogrami kao informativni i regularni znakovi, *Available from* https://hrcak.srce.hr/file/319478 *Accessed*: 2024-04-22

[8] Caffaro, F. & Cavallo, E.: Comprehension of safety pictograms affixed to agricultural machinery: A survey of users, *Journal of Safety Research*, **55** (2015), 151-158, *Available from* *https://www.sciencedirect.com/science/article/abs/pii/S0022437515000778?via%3Dihub* *Accessed*: 2024-05-16

[9] Cavalier, H.; Trasande, L. & Porta, M.: Exposures to pesticides and risk of cancer: Evaluation of recent epidemiological evidence in humans and paths forward, *International Journal of Cancer*, **152** (2023) 5, 879-912, *Available from* *https://onlinelibrary.wiley.com/doi/10.1002/ijc.34300* *Accessed:* 2024-04-05

[10] CLP Pictograms, ECHA European chemicals agency. *Available from* https://echa.europa.eu/hr/regulations/clp/clp-pictograms *Accessed: 2024-04-05*

[11] Europska norma HRN EN ISO 16122-3 *Available from* https://repozitorij.hzn.hr/norm/HRN+EN+ISO+16122-3%3A2015 *Accessed:* 2024-04-05

[12] Fargnoli, M.; Lombardi, M.; Puri, D.; Casorri, L.; Masciarelli, E.; Mandić-Rajčević, S. & Colosio, C.: The Safe Use of Pesticides: A Risk Assessment Procedure for the Enhancement of Occupational Health and Safety (OHS) Management, *Environmental Research and Public Health*, **16** (2019) 310, *Available from* https://www.mdpi.com/1660-4601/16/3/310 *Accessed:* 2024-05-16

[13] Gavanski, D. & Petrović, V.: Istraživanje ponašanja poljoprivrednika prema ličnoj zaštitnoj opremi pri radu sa sredstvima za zaštitu bilja, *Biljni lekar*, **51** (2023) 5, 710-722, *Available from* https://scindeks.ceon.rs/Article.aspx?artid=0354-61602305710G *Accessed:* 2024-05-16

[14] Ivković, I.: Ispitivanje raspršivača agromehanika ENU 200 primjenom norme HRN EN ISO 16122-3. Diplomski rad. Sveučilište Josipa Jurja Strossmayera u Osijeku (2021)

Available from https://repozitorij.fazos.hr/islandora/object/pfos:2545 *Accessed*: 2024-05-16

[15] Jones, A., Jakob, M., McNamara, J. (2021). Poljoprivreda i šumarstvo: sektor sa ozbiljnim izazovima u oblasti zaštite i zdravlja na radu. European Agency for Safety and Health at Work. *Available from* https://osha.europa.eu/sites/default/files/documents/Policy_brief_agriculture_forestry_hr.pdf *Accessed:* 2024-04-05

[16] Kušec, V.: *Mehanizacija u ratarstvu*, Veleučilište u Križevcima, Križevci, ISBN 978-953-6205-49-3 Križevci (2024)

[17] Kušec, V.; Sito, S.; Fabijanić, G. & Mikinac, N.: Čimbenici u postupku zaštite ratarskih i povrtlarskih kultura s aspekta racionalnije uporabe pesticida, *Glasnik Zaštite Bilja*, **45** (2022) 4, 18-24

[18] Kušec, V., Sito, S., Šket, B., Fabijanić, G., Ciler, K. & Šket, M.: Zakonska regulativa i rizici primjene strojeva za zaštitu bilja, *Glasnik zaštite bilja br. 4*, (2017)

[19] Kušec, V.; Stojnović, M.; Sito, S.; Fabijanić, G.; Kušec, I. & Arar, M.: Opasnosti i mjere sigurnosti pri uporabi uređaja za zaštitu bilja u poljoprivredi, *Glasnik zaštite bilja 36*, ISSN 0350-9664, UDK 632, (2013), 57-64

[20] Lamberta, M.; Richardsona, J. & Grimbuhler, S.: Pesticide exposure and sprayer's task goals: comparison between vineyards and greenhouses, *Work*, **41** (2012) Supplement 1, 4995-5002, *Available from* https://content.iospress.com/articles/work/wor0045 *Accessed:* 2024-05-16

[21] Li, S.; Li, J.; Yu, S.; Wang, P.; Liu, H. & Yang, X.: Anti-Drift Technology Progress of Plant Protection Applied to Orchards: A Review, *Agronomy*, ***13*** (2023) 11:2679, *Available from* https://www.mdpi.com/2073-4395/13/11/2679 *Accessed:* 2024-04-05

[22] Lincoln, J.M. & Elliott, K.C.: Emerging technology in agriculture: Opportunities and considerations for occupational safety and health researchers, *Journal of Safety Research*, **86** (2023), 92-95, *Available from* https://www.sciencedirect.com/science/article/abs/pii/S0022437523000750?via%3Dihub *Accessed:* 2024-04-05

[23] Martinić, M. (2015). Opasnosti primjene pesticida. Završni rad. Veleučilište u Karlovcu. *Available from* https://repozitorij.vuka.hr/islandora/object/vuka:272 *Accessed:* 2024-04-05

[24] Mohameda, E.B.; Jarbouib, A.; Garouic, N.; Ibrahimd, S.; Alsalmana, A.M. & Abbassi, W.: The determinants of the responsible use of pesticides among date farmers in Qassim region, Saudi Arabia, *Cogent Food & Agriculture*, **10** (2024) 1, *Available from* https://www.tandfonline.com/doi/full/10.1080/23311932.2024.2314238 *Accessed:* 2024-04-16

[25] Moreira, A. & da Silva, M.V.: Pesticide Application as a Risk Factor/Behaviour for Workers' Health: A Systematic Review, *Environments*, **10** (2023) 9:160, *Available from* https://www.mdpi.com/2076-3298/10/9/160 *Accessed:* 2024-04-16

[26] Novaković, V.; Peček, G.; ... & Ševar, M.: *Priručnik za sigurno rukovanje i primjenu sredstava za zaštitu bilja. Ministarstvo poljoprivrede*, Ministarstvo poljoprivrede i Hrvatski centar za poljoprivredu, hranu i selo – Zavod za zaštitu bilja, 978-953-6718-19-1, Zagreb, (2015) *Available from* https://www.savjetodavna.hr/wp-content/uploads/2018/11/Priru%C4%8Dnik-za-sigurno-rukovanje-i-primjenu-sredstava-za-za%C5%A1titu-bilja_9_2_2015.pdf *Accessed:* 2024-04-16

[27] Palardy, N. 6 Centner, T.J.: Improvements in pesticide drift reduction technology (DRT) call for improving liability provisions to offer incentives for adoption, *Land Use Policy*, **69** (2017), 439-444, *Available from* *https://www.researchgate.net/publication/320331883_Improvements_in_pesticide_drift_reduction_technology_DRT_call_for_improving_liability_provisions_to_offer_incentives_for_adoption* *Accessed*: 2024-04-07

[28] Petrović; D.; Banaj, Đ.; Banaj, A.; Knežević, D.; Zeko, Z. & Tadić, V.: Utjecaj različitih tehničkih sustava i eksploatacijskih parametara na kvalitetu rada raspršivača u trajnom nasadu, *Agronomski glasnik*, **3** (2020), 93-106, 1 Petrovic 005 (srce.hr)

[29] Portela de-Assis, M.; Barcella, R.C.; Padilha, J.C.; Pohl, H.H. & Krug, S.B.F.: Health problems in agricultural workers occupationally exposed to pesticides, *Revista Brasileira de Medicina do Trabalho*, **18** (2020) 3, *Available from* https://www.researchgate.net/publication/347832260_Health_problems_in_agricultural_workers_occupationally_exposed_to_pesticides *Accessed:* 2024-04-16

[30] Pravilnik o izobrazbi za sigurno rukovanje i pravilnu primjenu pesticida, NN 80/2023, *Available from* https://narodne-novine.nn.hr/search.aspx?sortiraj=4&kategorija=1&godina=2023&broj=80&rpp=200&qtype=1&pretraga=da *Accessed*: 2024-03-12

[31] Pravilnik o stavljanju na tržište osobne zaštitne opreme. NN 89/2010, *Available from* NN 89/10 od 19.07.2010. Pravilnik o stavljanju na tržište osobne zaštitne opreme - Zakon.hr *Accessed:* 2024-05-16

[32] Soo, S.J.; Mehler, L. & Beckman, J.: Acute Pesticide Illnesses Associated with Off-Target Pesticide Drift from Agricultural Applications: 11 States, 1998–2006, *Environmental Health Perspectives*, **119** (2011) 8, 1162-1169, *Available from* *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3237344/* *Accessed:* 2024-04-05

[33] Tadić, V.; Banaj, Đ.; Petrović, D.; Horvat, D. & Lukinac, J.: Utjecaj tlaka i visine mlaznice na raspodjelu tekućine prskalice, *Agronomski glasnik*, **2** (2012) 3, 109-122 *Available from* *https://hrcak.srce.hr/95360* *Accessed:* 2024-05-16

[34] Tomas, R.S. & Buckmaster, D.: Relative Safety of Traditional Agricultural Tractor Power Take–Off (PTO) Drivelines Compared to Fluid Power – A Review, *Journal of*

Agricultural Safety and Health, **9** (2003) 3:241, *Available from* https://www.researchgate.net/publication/10570331_Relative_Safety_of_Traditional_Agricultural_Tractor_Power_Take-Off_PTO_Drivelines_Compared_to_Fluid_Power_-_A_Review *Accessed:* 2024-04-05

[35] Trupčević, Z.: Stavljanje osobne zaštitne opreme na tržište, *Sigurnost*, **52** (2010) 4, 411-415, *Available from* *https://hrcak.srce.hr/file/104579* *Accessed:* 2024-04-16

[36] Tudi, M.; Ruan, D.H.; Wang, L.; Lyu, J.; Sadler, R.; Connell, D.; Chu, C. & Phung, D.T.: Agriculture Development, Pesticide Application and Its Impact on the Environment, *Int. J. Environ. Res. Public Health*, **18** (2021) 3, *Available from* https://pubmed.ncbi.nlm.nih.gov/33513796/ *Accessed:* 2024-04-05

[37] Uredba (EZ) br. 1107/2009 Europskog parlamenta i Vijeća od 21. listopada 2009. o stavljanju na tržište sredstava za zaštitu bilja, *Available from* http://data.europa.eu/eli/reg/2009/1107/oj *Accessed*: 2024-4-10

[38] Zakon o održivoj uporabi pesticida, NN 46/2022 *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2022_04_46_573.html *Accessed*: 2024-4-10

THE CALCULATION OF THE TIME NORMS FOR A WHITE LAB COAT "LEON"

Bosiljka Šaravanja[1], Selma Imamagić[1], Anica Hursa Šajatović[1], Paula Marković[2]

[1] University of Zagreb, Faculty of Textile Technology, Prilaz baruna Filipovića 28a, 10000 Zagreb, Croatia, e-mail: bosiljka.saravanja@ttf.unizg.hr; selma.imamagic@ttf.unizg.hr; anica.hursa@ttf.unizg.hr

[2] DM TEKSTIL tailoring trade, Darinka Marković, Jaškovo 53A, Jaškovo 47280 Ozalj, Croatia, e-mail: pmilosevic@gmail.com

Abstract: *The white lab coat is a symbol of the medical profession. It is associated with professionalism, trust, confidence and purity. Designed as a knee-length full or half sleeve coat, it protects the doctor's personal clothing and allows him to carry necessary items. This paper shows an example of a white lab coat for men used for medical purposes. It describes the lab coat model "Leon" and gives an insight into the technological process of sewing this item. Mentioned process consists of 20 technological operations whose standard time was determined using time study method. For seven out of twenty technological operations of the technological process of sewing the "Leon" lab coat are given the calculation of the standard operation time (t_1) and illustrations. Finally, it is determined that 1101.57 seconds are required for the technological process of sewing this white lab coat.*

Keywords: *white lab coat, medical profession, technological process of sewing, operation breakdown*

1. INTRODUCTION

Lab coat along with the scrub is the main element of the healthcare apparel. Its white colour is associated with cleanliness and purity as well as with trust and confidence, respectively professionalism of doctors [1, 2]. As a result, the white lab coat has become a symbol of the medical profession [1, 3]. In addition to its symbolism, white lab coat is used for easier identification as healthcare professionals by patients and colleagues, for carrying essential items (e.g. medical items, work notes) and for protection of doctors' street clothes from unexpected exposures during the work shift [2, 4]. It is usually a knee-length, full- or half- sleeved coat with large pockets for holding commonly used medical equipment and resources [2, 5].

This paper provides an insight into the production of one white lab coat, respectively technical analysis and technological process of sewing men's lab coat "Leon".

2. THE TECHNICAL ANALYSIS OF LAB COAT

The men's lab coat "Leon" (Fig. 1) has single-breasted four button front opening. There are two hip and one breast topstitched patch pocket on the front. Backside of the coat is two pieced with topstitched center back seam and a vent. The back belt sits on the waistline area of the wearer. Long, two-piece set-in sleeves. Notched lapel sewn diagonally to the collar creating a step effect.

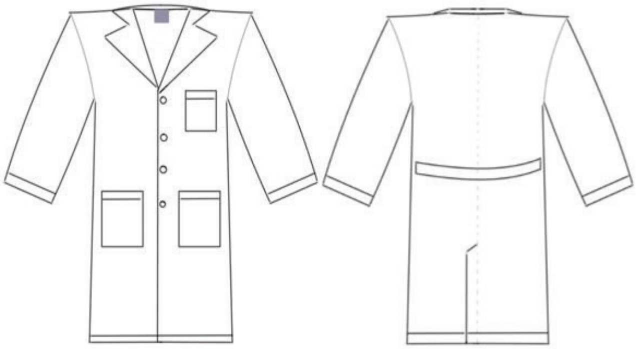


Figure 1: Men's white lab coat "Leon" [6]

3. THE TECHNOLOGICAL PROCESS OF SEWING LAB COAT

The technological process of sewing men's white lab coat "Leon" consists of 20 technological operations. Required time for performing each of these technological operations was determined using the time study method manually with a stopwatch and then adding time allowances to the observed time.

Firstly, observed time (t_o) is multiplied by the rating factor (RF) which represents the skill and competence of the worker. It ranges from 0.7 to 1.3, with values close to 0.7 signifying lower, 1.0 standard and 1.3 higher performance. As a result, the normal time of operation (t_n) is calculated [7, 8]:

$$t_n = t_o \cdot RF. \tag{1}$$

Secondly, the normal operation time (t_n) is corrected with the working condition coefficient (K_a) and the fatigue coefficient (K_n) to obtain the real operation time (t_s) [9]:

$$t_s = t_n \cdot (1 + K_a \cdot K_n). \tag{2}$$

Working condition coefficient (Ka) depends on the environmental factors - temperature, relative humidity and airborne substances in the workplace. When determining standard operation time for each technological operation of technological process of sewing lab coat "Leon", the indoor temperature was 23 °C and the relative humidity was 40 %. The dust load was insignificant. Accordingly, it is determined that the value of the coefficient of working conditions (Ka) for this workplace is 1.0 [9].

Fatigue coefficient (K_n) depends on the nature of the job (mass of the material being produced and the required body position). Here, the technological operations of technological process of sewing lab coat "Leon" are carried out in a seated position and the mass of the material used is less than 5 kg. Consequently, the value of the fatigue coefficient (K_n) for this workplace is determined to have minimum value, respectively 0.11 [9].

In addition, the real time of each element of the observed technological operation (t_s) are summed up and the ideal time (t_i) of the technological operation is gain:

$$t_i = \sum t_s. \tag{3}$$

In this paper the technological operations were not broken on the elements so the ideal time (t_i) is equal to real time ($t_s = t_i$).

Finally, the standard time (t_1) for each technological operation is obtained by is adding the additional time coefficient (K_d) to the ideal time (t_i) [9]:

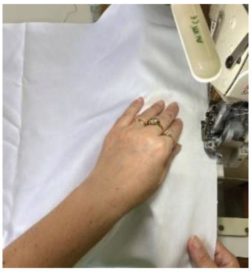
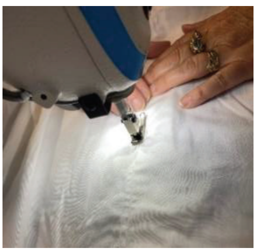
$$t_1 = t_i \cdot (1 + K_d). \tag{4}$$

The additional time coefficient (K_d) includes relaxation, personal-needs and machine delay allowances. In this case, its value is determined to be 0.12.

Table 1 shows pictorial representations of the characteristic technological operations of the production of the white coat "Leon". Furthermore, for each technological operation is shown the calculation of the standard operation time (t_1) based on the explained time study method.

Table 1: Illustrations and the calculation of the standard operation time for seven technological operations of the technological process of sewing the lab coat "Leon"

Operation name	**Illustration**	**Standard time calculation (t_1)**
Hip and chest patch pockets hem		t_o = 147.40 s RF = 0.95 K_a = 1.00, K_n = 0.11, K_d = 0.12 $t_n = t_o \cdot RF = 147.40\ s \cdot 0.95 = 140.03\ s$ $t_s = t_n \cdot (1 + K_a \cdot K_n) =$ $= 140.03\ s \cdot (1 + 0.11 \cdot 1.00) = 155.43\ s$ $t_i = \sum t_s = 155.43\ s$ $t_1 = t_i \cdot (1 + K_d) =$ $= 155.43\ s \cdot (1 + 0.12) =$ **174.09 s**

Center front overlock		$t_o = 47.70$ s $RF = 1.00$ $K_a = 1.00$, $K_n = 0.11$, $K_d = 0.12$ $t_n = t_o \cdot RF = 47.70\ s \cdot 1.00 = 47.70$ s $t_s = t_n \cdot (1 + K_a \cdot K_n) =$ $= 47.70\ s \cdot (1 + 0.11 \cdot 1.00) = 52.95$ s $t_i = \sum t_s = 52.95$ s $t_1 = t_i \cdot (1 + K_d) =$ $= 52.95\ s \cdot (1 + 0.12) = \mathbf{59.30\ s}$
Sew back vent extension part		$t_o = 8.70$ s $RF = 0.95$ $K_a = 1.00$, $K_n = 0.11$, $K_d = 0.12$ $t_n = t_o \cdot RF = 8.70\ s \cdot 0.95 = 8.27$ s $t_s = t_n \cdot (1 + K_a \cdot K_n) =$ $= 8.27\ s \cdot (1 + 0.11 \cdot 1.00) = 9.17$ s $t_i = \sum t_s = 9.17$ s $t_1 = t_i \cdot (1 + K_d) =$ $= 9.17\ s \cdot (1 + 0.12) = \mathbf{10.28\ s}$
Center back topstitch		$t_o = 50.38$ s $RF = 1.10$ $K_a = 1.00$, $K_n = 0.11$, $K_d = 0.12$ $t_n = t_o \cdot RF = 50.38\ s \cdot 1.10 = 55.42$ s $t_s = t_n \cdot (1 + K_a \cdot K_n) =$ $= 55.42\ s \cdot (1 + 0.11 \cdot 1.00) = 61.52$ s $t_i = \sum t_s = 61.52$ s $t_1 = t_i \cdot (1 + K_d) =$ $= 61.52\ s \cdot (1 + 0.12) = \mathbf{68.90\ s}$
Sleeve join seam		$t_o = 10.60$ s $RF = 0.90$ $K_a = 1.00$, $K_n = 0.11$, $K_d = 0.12$

		$t_n = t_o \cdot RF = 10.60\ s \cdot 0.90 = 9.54\ s$ $t_s = t_n \cdot (1 + K_a \cdot K_n) =$ $= 9.54\ s \cdot (1 + 0.11 \cdot 1.00) = 10.59\ s$ $t_i = \sum t_s = 10.59\ s$ $t_1 = t_i \cdot (1 + K_d) =$ $= 10.59\ s \cdot (1 + 0.12) = \mathbf{11.86\ s}$
Turn sleeve to face (bag out)		$t_o = 68.50\ s$ $RF = 0.95$ $K_a = 1.00,\ K_n = 0.11,\ K_d = 0.12$ $t_n = t_o \cdot RF = 68.50\ s \cdot 0.95 = 65.08\ s$ $t_s = t_n \cdot (1 + K_a \cdot K_n) =$ $= 65.08\ s \cdot (1 + 0.11 \cdot 1.00) = 72.24\ s$ $t_i = \sum t_s = 72.24\ s$ $t_1 = t_i \cdot (1 + K_d) =$ $= 72.24\ s \cdot (1 + 0.12) = \mathbf{80.90\ s}$

Determined values of the standard operation time required for twenty technological operations are added together. As a result, it is calculated that for the technological process of sewing lab coat “Leon” 1101.57 seconds are needed. Table 2 shows the sequence of the performing of each technological process of sewing “Leon” lab coat , names of technological operations, the type of machines required for their performing, the complexity of their performance and time required to perform each of them. Corresponding legends with descriptions of the machines and the complexity of the operations are given below Table 2.

Table 2: Operation breakdown of lab coat “Leon”

Ope. No.	**Operation name**	**Type of machine**	**Complexity of operation**	**Standard operation time (s)**
1.	Hip and chest patch pockets hem	SNLS	II	18.56
2.	Hip and chest patch pockets attach	SNLS	II	174.09
3.	Sew back belt	SNLS	II	38.91
4.	Center front overlock	SSM	II	59.30
5.	Center back overlock	SSM	II	59.30
6.	Sew back vent extension part	SSM	II	10.28

7.	Align back parts and make back vent	SNLS	II	41.89
8.	Center back topstitch	SNLS	II	68.90
9.	Back belt attach	SNLS	II	38.91
10.	Shoulder join	SSM	II	81.26
11.	Sleeve join seam	SSM	II	75.90
12.	Turn sleeve to face (bag out)	MNL	III	11.86
13.	Side seam	SSM	II	55.19
14.	Insert sleeve	SSM	II	80.90
15.	Side label seam	SNLS	II	8.61
16.	Notched collar make	SNLS	II	55.07
17.	Stitch notched collar to neckline	SNLS	II	36.73
18.	Notched collar close and topstitch	SNLS	II	118.69
19.	Sleeve hem	SNLS	II	10.88
20.	Bottom hem	SNLS	II	56.34
TOTAL STANDARD TIME FOR TECHNOLOGICAL PROCESS OF SEWING:				**1101.57**

Legend of machines and devices:

Type of machine/device	**Description**
SNLS	single needle lockstitch machine (plain sewing machine)
SSM	special sewing machine
MNL	manual work

Legend of complexity of operation:

Mark of complexity	**Description**
I	difficult to perform, must perform skilled worker
II	medium difficulty
III	simple operation, no skilled worker needed

Figure 2 shows a Gantt chart of the technological process of sewing the “Leon” lab coat. It visualizes the sequence and time needed to complete each activity in the technological process of sewing a lab coat.

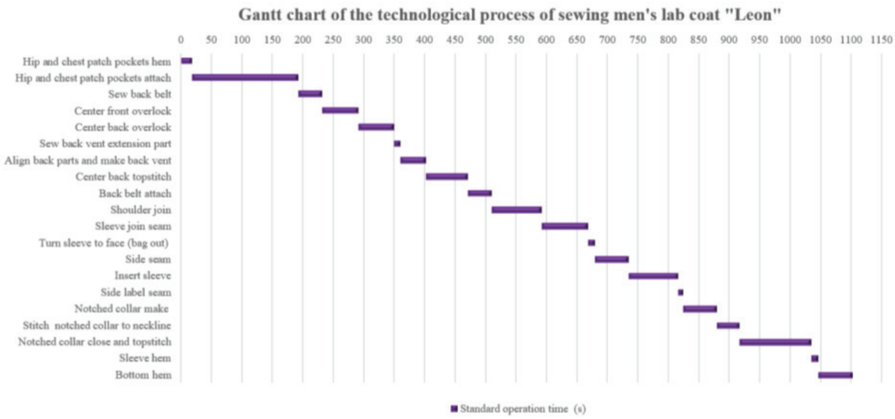


Figure 2: Gantt chart of the technological process of sewing men’s lab coat “Leon”

4. CONCLUSION

This work shows the technological process of sewing the white men’s lab coat model “Leon”. It consists of 20 technological operations, the duration of which was determined using the time study method. With the standard operation time (t_1) for each technological operation, the standard time for the technological process of sewing is calculated – a total of 1101.57 seconds are required. The above information is presented by the operation breakdown, the Gantt chart, the illustration and calculation of standard operation time (t_1) for seven out for twenty technological process of sewing of this garment.

REFERENCES

[1] Landry, M. et al: Patient Preferences for Doctor Attire: The White Coat's Place in the Medical Profession, *Ochsner Journal*, **13** (2013) 3, pp. 334-342, ISSN 2831-4107
[2] Kazory, A.: Physicians, Their Appearance, and the White Coat, *The American Journal of Medicine*, **121** (2008) 9, pp. 825-828, ISSN 1555-7162
[3] Hochberg, M. S.: History of medicine: The doctor’s white coat—an historical perspective, *Virtual Mentor*, **9** (2007) 4, pp. 310-314, ISSN 1937-7010
[4] Mitchell, A. et al: Role of healthcare apparel and other healthcare textiles in the transmission of pathogens: a review of the literature, *Journal of Hospital Infection*, **90** (2015) 4, pp. 285-292, ISSN 1532-2939
[5] Joshi, G.: The White Coat and Medical Profession, Journal of Krishna Institute of Medical Sciences University, **5** (2016) 2, pp. 151-154, ISSN 2231-4261

[6] Milošević, P.: Tehnološka analiza i određivanje vremenskih normativa izrade radne odjeće, diplomski rad, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet (2021)
[7] Ur Rehman, A. et al: Productivity Improvement Through Time Study Approach: A Case Study from an Apparel Manufacturing Industry of Pakistan, Procedia Manufacturing, 39 (2019), pp. 1447-1454, ISSN 2351-9789
[8] Diraj, R. A. et al: Implementation of Time Study on Hoodie Production and the Effect towards Productivity, *Proceedings of 1st International Conference On Textile Science & Engineering*, BUTEX, pp. 16-22, ISSN 2958-8197, Dhaka, January 2023
[9] Taboršak, D. & Buchberger, Č.: *Studij rada*, Novinsko izdavačko i štamparsko poduzeće – Varaždin (1966)

SPECIFICS OF OCCUPATIONAL SAFETY IN SMALL AND MICRO BREWERIES

Goran Šarić[1]
[1]Karlovac University of Applied Sciences, J.J. Strossmayer square 9, 47000 Karlovac, CROATIA, gsaric@vuka.hr

Abstract:
Although the beer production process in large, industrial and small, craft breweries is basically the same, there are still numerous differences. For example, industrial breweries have clearly separated brewhouse, fermentation cellar, filtration and beer processing plant, bottling plant and warehouse, while in small breweries all these processes usually take place in the same, very often relatively small room. In addition, most of the processes in industrial breweries are automated and optimized and in craft breweries a lot is still done manually, without automation and optimization. Also, the occupational safety systems introduced, differ considerably between these two different groups of breweries. There are currently 109 breweries in Croatia, of which only a few are large industrial breweries. Therefore, it is important to address the topic of occupational safety in small and micro breweries in order to draw attention to the potential deficiencies in occupational safety that such a method of beer production entails.

Keywords: *craft brewery, occupational safety, beer production*

1. INTRODUCTION

In recent ten years in Croatia and also around the world, there has been a huge surge in popularity of craft beer which resulted in a large increase in the number of small and micro breweries. According to European beer trends there were 109 active breweries in Croatia, of which more than 100 of small, craft breweries. [1] In comparison, in 2013 there were only 6 active breweries in Croatia (only counting big, industrial breweries while no data was available for the number of microbreweries). [2] Considering the size of the country, this is quite an impressive increase, but having in mind that Croatia is seventh in beer consumption per capita in Europe with 79 L/year in 2023, this shouldn't be very surprising. [1] As many small breweries have grown over the last decade, either through technological improvements in the production process, the consequent increase in capacity, the increase in the number of employees and acquired knowledge, the question arises as to how much progress has taken place in terms of occupational and health safety of workers. Big industrial breweries, as well as other big food and drink companies, have implemented numerous standards and techniques which have a job to ensure safety of their workers while in small and especially micro breweries those kinds of standards are not even remotely used for various reasons. This paper will explain the challenges that small brewers face, the limitations they have, and will propose solutions for the easiest and simplest ways to implement systems for occupational health and safety at work.

According to Article 17 of Croatian Law on Occupational Safety the general obligations of the employer considering the organization and implementation of occupational safety are as follows:

"1. The employer is obliged to organize and implement protection at work, taking into account risk prevention and notification, training, organization and resources.

2. The employer is obliged to carry out prevention in all work procedures, in the organization of work and in the management of work procedures, whereby he must provide workers with the highest possible level of protection at work.

3. When organizing and implementing occupational safety, the employer is obliged to respect the nature of the work performed and to adapt occupational safety to changing circumstances in order to improve the situation.

4. In organizing the work process and assigning tasks to the worker, the employer is obliged to take into account the worker's abilities that may affect occupational safety.

5. In order to improve the occupational safety and health protection of workers, the employer is obliged to improve the level of safety at work and harmonize work procedures with changes and progress in the field of technology, health care, ergonomics and other scientific and professional areas, and is obliged to organize them in such a way as to reduce the exposure of workers to hazards , harms and efforts prescribed in the rulebook from Article 18, paragraph 6 of the Law, and especially exposure to monotonous work, work with an imposed rhythm, work according to performance in a certain time (standardized work), in order to prevent injuries at work, occupational diseases and diseases in related to work.

6. The employer bears the costs of implementing occupational health and safety, i.e. its implementation must not be charged to the worker." [3]

Also, Article 20 of the same law states that "An employer who employs up to 49 workers can perform occupational safety tasks himself if he meets the prescribed conditions, or he can contract the performance of these tasks with an occupational safety specialist in an employment contract." [3] If the employer performs the occupational safety tasks himself or this is done by his authorized representative, they are obliged to meet certain conditions:

• for an occupational safety specialist of the first degree, or
• have acquired the necessary knowledge of occupational health and safety during their education, or
• have passed the state exam for construction or design work, which includes occupational safety, or
• passed the master's exam in the activity they perform, which included occupational safety.

As mandated by law, all small and micro breweries in Croatia should meet these criteria, but the question is whether they have implemented all necessary occupational safety norms and regulations into their business and production processes.

2. CHALLENGES IN SMALL BREWERIES

Even though the basic procedure of producing beer is very much the same in big, industrial breweries and in small and micro breweries, there are numerous small differences in how different tasks are performed. With modernization and automation, most of the work in big breweries is done by machines while only certain tasks require manual work (i.e. opening and cleaning of mash filter, dosing hop pellets or hop extracts etc.). On the other hand, most of the operations in small and micro breweries is done manually In combination with the lack of implementation of any kind of occupational health and safety standards, this significantly increases the risk of injuries at work.

2.1. Hazardous work in small and confined spaces

Because of high risk of microbiological infection, one of the main jobs in a brewery is properly cleaning and maintaining brewing equipment. This requires brewers to clean and service fermenters, silos, mash tuns, kettles and other equipment in brewery. Many of these small, cramped spaces fall within a definition of a confined space: large enough and configured in a manner that an employee can enter to perform work; limited or restricted means of entry or exit; and not designed for continuous employee occupancy. Small, and especially micro breweries fall short to safe and proper practices associated with entering and working in confined spaces, primarily because most of them are located in very small spaces that were often not originally intended for a production plant.
The proposed solutions and/or best practices include: breweries should inspect and evaluate their work areas to determine if any of them can qualify as confined space; employers and/or production managers must properly identify confined spaces as potentially dangerous by posting signs and warnings; if business operations require employees to enter confined spaces, as in the case of some areas in a brewery, monitoring the atmospheric conditions of the space should be required and emergency rescue plan should be established; employers must provide employees the proper training for entering confined spaces and employees should receive an entry permit before entering and/or performing work in the confined space.

2.2. Providing a workplace free from recognized hazards

The general requirement for safe workplace states that it should be free from recognized hazards that cause or are likely to cause death or serious physical harm. Included in this are ergonomic hazards which are much more relevant in craft breweries than in industrial ones because in the first mentioned most of the work is done manually, while the most of the work in large breweries is generally automated. Brewers in small breweries often have to lift heavy kegs and sacks of malt which, if done in the wrong way, can lead to injury.
The proposed solutions and/or best practices include: employees need to be taught and frequently reminded of proper lifting techniques; invest in and provide access to appropriate tools and equipment for lifting heavy items (such as forklifts) and ensure employees are properly trained to use them; consider setting work schedules so lifting duties can be shared by multiple employees, i.e. if sacs of malt have to be transported early in the morning, schedule multiple workers to cover that shift.

2.3. Safety management of highly hazardous chemicals

For proper cleaning and sanitation of the brewery, various dangerous and hazardous chemicals are used. They can be divided in three main categories: acids (low pH), bases (high pH) and flammable chemicals. Acidic (phosphoric, peroxy acetic acid, hydrochloric acid etc.) and alkaline (sodium hydroxide, sodium hypochlorite and potassium hydroxide etc.) chemicals are usually used for cleaning equipment, tanks and packaging materials. Both are very corrosive to human tissue and can be very dangerous to the eyes. Therefore, personal protection equipment is necessary when handling those kind of chemicals. If it is required to enter confined spaces, such as entering tanks for maintenance, it is critical that a proper hazard analysis is performed to determine any potential exposure to residual chemicals, whether airborne or in liquid form.

In addition to afore mentioned chemicals, certain gasses are used in the brewery - oxygen for wort/yeast aeration, carbon dioxide for various purposes (carbonation of beer, prepressurization and flushing of tanks, flushing the pipelines from air, prepressurization of bottles during filling etc.) and ammonia as a cooling agent. Between the three, ammonia is classified as hazardous chemical and if used certain rules should be followed. For example, in the area where ammonia is used, even though this gas has distinctive smell, gas concentration indicators should be installed. Few of the rules on what to do if there was ammonia spillage are as follows: one should not enter the contaminated area without full protective equipment; if there is any doubt that the air is polluted, it is mandatory to use a protective full face mask with the green “K” filter; in the case of ammonia concentrations in the air higher than 1,000 ppm, a self-contained breathing apparatus with compressed air must be used; do not approach the contaminated area without being accompanied by at least one fully equipped person [4]. Even though, oxygen and carbon dioxide are not classified as hazardous chemicals, certain precautions should be taken when handling these gases. Oxygen is very flammable so should not be exposed to open flame or sparks. Carbon dioxide is formed during fermentation so the area where fermenters are installed should be very well ventilated. Also, as a good precaution, carbon dioxide indicators can be installed near the ground since this gas is heavier than air and accumulates at the bottom of the room.

Having all this in mind, to avoid potential mistakes when handling the aforementioned substances and to minimize the possibility of injury brewers should develop written procedures for the safe operating and maintenance of chemicals, gases and refrigeration systems. Besides that, workers should always wear personal protective equipment (eye protection and gloves) when handling hazardous chemicals.

2.4. Control of hazardous energy

When workers are tasked with performing maintenance on brewery equipment, the accidental start-up of machinery or unintended release of stored energy can present serious risks. For example, safety switches should be installed on all lids/doors of brewhouse equipment (mash tun, lauter tun, whirlpool, boiler) which should ensure that when the lid is open, all operations inside the vessels are turned off. This allows safe entry into the vessels without the risk of injury due to the turning of the mixer in the mash tun or the loosening knives for spent grains bed in the lauter tun. There is also high risk of injury due to release of high pressure in the pipelines and in fermenters - serious injury may result when pressurized tanks or pipelines are opened if the pressure has not been reduced beforehand. Therefore, a good measure of precaution could be a simple warning sign on all lids on fermentation tanks and pipelines that are frequently opened for cleaning and/or inspection.

In general, good practices and procedures are necessary to disable machinery or equipment so as to prevent the unexpected startup or release of hazardous energy while employees perform service or maintenance activities. To avoid these things from happening brewers should develop, implement and enforce energy control programs and designate a worker to turn off and disconnect machinery or equipment from its energy source before performing service or maintenance.

2.5. Correct labeling of chemicals

As already before mentioned, variety of hazardous chemicals are used in brewery. To ensure chemical safety, all the necessary information about the identities and hazards of all chemicals should be available and understandable to workers. Besides the complete and easy to read labels, all chemical should have safety data sheets. All employees who handle hazardous chemicals must undergo training on how to properly handle, dispose and monitor the presence of chemicals.

2.6. The importance of using personal protective equipment

It may seem obvious that brewery workers should wear personal protective equipment when working around hazards such as boiling water or toxic chemicals. Unfortunately, due to lack of awareness of dangers and possible injuries, the need to get the job done as soon as possible and sometimes due to not having the right protective equipment, workers in craft breweries usually don't use them as often as they probably should. In a craft brewery, proper personal protective equipment might include coveralls, gloves, goggles or full face masks, which should be provided by the employer.

3. CONCLUSION

Even though independent craft breweries have a reputation to be fun, relaxed and modern, for professional and responsible management of a brewery of any size requires a high level of knowledge, training and education. As mentioned before, many of the craft breweries have come a long way since their initial start, but this doesn't mean that the gained knowledge is enough and that they should stop educating themselves on all topics, especially on one of the most neglected ones, proper occupational safety practices. In doing so, they will not only avoid law violations, but also protect their workers from injury.

To consolidate all the most important factors concerning occupational safety and health protection companies should organize safety training for their workers; production managers should provide workers with all the necessary protective equipment and ensure that they are using it when required; workers themselves should be aware of risks and hazards at work and attend training if provided by the employer; also they should understand that they are doing it for themselves, not for the employer or the legislator [5].

REFERENCES

[1] *European beer trends - Statistics report / 2023 edition*, The Brewers of Europe, Brussels, Belgium, (2023), pp. 12

[2] *Beer statistics / 2014 edition*, The Brewers of Europe, Brussels, Belgium, (2023), pp. 21
[3] *Croatian Law on Occupational Safety*, Official Gazette (Narodne Novine), NN 71/2014
[4] Plavšić, F.; Lovrić, Z.; Wolf Čoporda, A.; Ježić Vidović, I.Z.; Čepelak Dodig, D.; Gretić, D; Đurašević, S.: *Siguran rad s kemikalijama* (2nd edition), Croatian Institute of Public Health (Hrvatski azvod za javno zdravstvo), ISBN 978-953-97205-6-6, Zagreb, Croatia, (2014)
[5] Ikpeks, P.J.; Elechi C.E.: Predictors Of Occupational Safety Practices Among Brewery Industry Workers In Rivers State, Nigeria, *International Journal of Innovative Social & Science Education Research* **11**(3), (2023), pp. 10-19, ISSN: 2360-8978

SAFETY MEASURES IN ADDITIVE MANUFACTURING

Nikola Šimunić[1]; Tihana Kostadin[2]; Ivana Stipaničić[3]; Ivana Grgurić[4]

[1] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, CROATIA, nsimunic@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, CROATIA, tkostadin@vuka.hr

[3] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, 47000 Karlovac, CROATIA, ivana.sti.upravna@gmail.com (student)

[4] Technical school Karlovac, Ljudevita Jonkea 2a, 47000 Karlovac, CROATIA, grguric.ivana@gmail.com

Abstract: *Additive manufacturing, or 3D printing, transforms traditional manufacturing by building objects layer by layer from digital designs. It enables rapid prototyping, customization, and efficient production of complex geometries while minimizing material waste. When employing additive manufacturing, it's essential to ensure proper ventilation to minimize the inhalation of potentially harmful fumes and particles released during the manufacturing process. Additionally, wearing suitable personal protective equipment like gloves and safety glasses is crucial. Regular equipment maintenance, adherence to manufacturer guidelines and material safety data sheets, and thorough training for operators on machine operation and emergency protocols are also vital for maintaining safety standards. These measures collectively create a safe working environment, mitigating risks associated with exposure to airborne particles and ensuring the well-being of individuals involved in additive manufacturing operations.*

Keywords: *safety at work, additive manufacturing, safety standards*

1. INTRODUCTION

Additive manufacturing, commonly known as 3D printing, stands at the forefront of modern manufacturing, offering unparalleled opportunities for innovation and efficiency [1]. By manufacturing objects layer by layer from digital designs, additive manufacturing enables the realization of intricate geometries, rapid prototyping, and customizable production - all while minimizing material waste [1]. However, alongside its transformative potential, additive manufacturing brings forth significant safety considerations that demand attention. This review paper explores the essential safety measures required to mitigate risks associated with exposure to airborne particles and fumes during additive manufacturing processes [2]. From ensuring proper ventilation and personal protective equipment to rigorous equipment maintenance and operator training, this paper delves into the critical components of creating a safe working environment in additive manufacturing [3]. By examining these safety measures, we aim to underscore the importance of collective efforts in safeguarding the well-being of individuals involved in additive manufacturing operations.

2. ADDITIVE MANUFACTURING TECHNOLOGIES

A brief description of different types of additive manufacturing processes is given in the in the second chapter of this paper. These descriptions provide short overview of some commonly used additive manufacturing processes, each offering unique advantages and applications within various industries.

Fused Deposition Modeling (FDM) [4] involves the extrusion of thermoplastic filaments through a heated nozzle onto a build platform. The material is deposited layer by layer according to the digital design, solidifying upon cooling. FDM is widely used for its low cost and versatility in prototyping and small-scale production.

Stereolithography (SLA) [5] utilizes a photosensitive liquid resin that hardens when exposed to ultraviolet (UV) light. A build platform submerged in the resin gradually rises as layers are solidified by UV lasers or projectors (DLP - Digital Light Processing). SLA offers high resolution and surface quality, making it suitable for intricate and detailed parts (*Figure 1.)*.

Selective Laser Sintering (SLS) [6] employs a high-powered laser to selectively fuse powdered materials, typically polymers or metals (DMLS – Direct Metal Laser Sintering), layer by layer. The unsintered powder acts as support for the structure during printing. SLS is known for its capability to produce complex geometries and functional parts without the need for support structures.

PolyJet [7] technology operates similarly to inkjet printing, where liquid photopolymers are jetted onto a build platform and cured instantly with UV light. Multiple materials can be jetted simultaneously, allowing for the creation of multi-material and multi-color parts with high accuracy and fine details.

Continuous Liquid Interface Production (CLIP) [8] is a proprietary technology developed by Carbon3D that utilizes a combination of light and oxygen to rapidly cure liquid resins into solid parts. Unlike traditional layer-by-layer approaches, CLIP enables continuous printing, resulting in faster production times and improved surface quality.

Laminated Object Manufacturing (LOM) [9] technology uses adhesive-coated paper, plastic, or metal laminates as a 3D printing medium. These sheets of material are glued together layer-by-layer and cut into shape using a knife or with laser cutting. Objects created using LOM can then be further modified post process by machining or drilling.

3D printing [10] technology creates three-dimensional physical prototypes by solidifying layers of deposited powder using a liquid binder. Using 3DP technology, the 3D printer creates the model layer by layer, fixing the applied powder in each layer with a binder, and applies paint around the perimeter (color mode). After each layer, a moving lever lowers the work platform by the thickness of the layer and a new layer of powder is applied on top. The ink jet head applies the binder to the next cross-section, which binds to the already printed layers of the object. Each layer hardens based on the chemical reaction between the powder and the binder. This process is repeated until the entire model is built. After cleaning, the model must be fixed with certain coatings (epoxy resin) in order to increase the strength of the model.

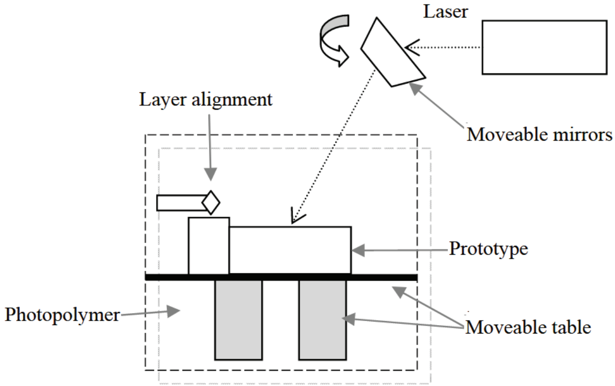


Figure 1: Stereolitography – schematic view [11]

3. POTENTIAL SOURCES OF DANGERS IN AM

Overview of potential sources of dangers associated with each additive manufacturing technology is presented in the continuation of this paper. Potential sources of dangers underscore the importance of implementing appropriate safety measures and protocols to mitigate risks and ensure the well-being of individuals involved in additive manufacturing operations.

3.1. Fused Deposition Modeling

Chemical Exposure: FDM uses thermoplastic filaments that release ultrafine particles (UFPs) and volatile organic compounds (VOCs) when melted. ABS filament emits styrene, a possible carcinogen, and PLA releases lactide, causing mild irritation. Prolonged inhalation can lead to respiratory issues [12].

Thermal Burns: FDM printers operate at high temperatures, with nozzles exceeding 200°C and build plates over 100°C. Accidental contact can cause severe burns. Proper training and heat-resistant gloves are essential to prevent injuries [13].

Mechanical Hazards: Moving parts of FDM printers, such as the print head and build plate, pose entanglement risks. Safety enclosures and operational guidelines are crucial to mitigate these hazards [14].

Fire Hazard: High temperatures and flammable materials present a fire risk. Proper handling, smoke detectors, fire extinguishers, and well-ventilated areas with supervision are necessary for safety [15].

Emissions: Melting thermoplastics release nanoparticles and toxic fumes, such as caprolactam from Nylon filaments, causing eye, skin, and respiratory irritation [12].

3.2. Stereolithography

Chemical Exposure: SLA resins contain photopolymers that can cause skin irritation, allergic reactions, and respiratory issues upon contact or inhalation. Use gloves and ensure good ventilation [12, 16].

UV Exposure: UV light used in curing can cause skin burns and eye damage. Wear protective clothing and UV-blocking eyewear [17].

Chemical Burns: Prolonged contact with SLA resins can cause chemical burns. Wash immediately with soap and water if contact occurs [16].

Inhalation Risks: VOCs released during printing can cause headaches, dizziness, and respiratory problems. Use fume extraction systems and work in well-ventilated areas [18].

Waste Disposal: Proper disposal of uncured resin and cleaning materials is essential to prevent environmental contamination and health hazards. Follow local regulations for hazardous waste disposal [19].

3.3. Selective Laser Sintering

Laser Exposure: SLS uses high-powered lasers, posing eye and skin damage risks. Use laser safety eyewear and proper shielding [20].

Powder Handling: SLS powders like nylon and metals can cause respiratory issues when inhaled. Use respiratory protection and ensure good ventilation [21].

Combustibility and Explosion Risk: Metal powders in SLS are highly combustible. Implement strict powder handling, proper storage, and use inert gas environments to reduce risks [22].

Thermal Burns: High temperatures in SLS can cause burns. Use heat-resistant gloves and exercise caution [23].

Chemical Exposure: SLS materials can release VOCs and hazardous chemicals. Ensure adequate ventilation and use fume extraction systems [18].

Post-Processing Hazards: Cleaning and finishing SLS parts can involve hazardous solvents and equipment. Follow proper handling procedures and use protective equipment [19].

3.4. PolyJet Printing

Exposure to Hazardous Materials: PolyJet photopolymers can cause skin irritation and respiratory problems. Use proper ventilation, protective clothing, and handling procedures [24].

UV Exposure: UV light used to cure PolyJet resins can harm eyes and skin. Ensure UV light is contained within the printer and use shielding [17].

Mechanical Hazards: Moving parts of PolyJet printers pose injury risks. Implement safety protocols and provide operator training [14].

Chemical Spills and Contamination: Spills of photopolymers or cleaning agents can contaminate the workspace. Use proper clean-up procedures and spill containment kits [19].

Fire Hazards: Electrical malfunctions in PolyJet printers can lead to fires. Maintain the printer, keep the area free of flammable materials, and have fire extinguishers available [15].

Waste Disposal Issues: Follow local regulations for disposing of unused resins and waste to prevent environmental contamination [19].

Inhalation of Particulate Matter: Post-processing steps can release fine particles, posing respiratory risks. Use ventilation systems and PPE like masks [21].

Noise Pollution: PolyJet printers can be noisy. Use soundproofing measures or provide hearing protection to mitigate hearing loss risks [25].

3.5. Continuous Liquid Interface Production

Exposure to Hazardous Chemicals: CLIP resins can cause skin irritation and respiratory issues. Use proper ventilation, gloves, masks, and handling procedures to mitigate risks [16].

UV Light Exposure: CLIP uses UV light to cure resins, which can harm skin and eyes. Ensure UV light is shielded and use UV-blocking eyewear [17].

Mechanical Hazards: Moving parts of CLIP printers pose injury risks. Implement safety protocols and provide operator training [14].

Chemical Spills and Contamination: Spills of resins or cleaning agents can contaminate the workspace. Use proper clean-up procedures and spill containment kits [19].

Fire Hazards: Electrical components and reactive resins pose fire risks. Maintain the printer, keep the area free of flammable materials, and have fire extinguishers available [15].

Waste Disposal Issues: Follow local regulations for disposing of unused resins and waste to prevent environmental contamination [19].

Inhalation of Particulate Matter: Printing and post-processing can release harmful particles. Use ventilation systems and masks to reduce exposure [21].

Noise Pollution: CLIP printers can be noisy. Use soundproofing measures or hearing protection to prevent hearing loss [25].

Thermal Burns: The curing process generates heat, posing burn risks. Use heat-resistant gloves and exercise caution [23].

3.6. Laminated Object Manufacturing

Exposure to Hazardous Materials: LOM uses adhesives that emit harmful VOCs. Ensure proper ventilation, wear PPE, and follow safety protocols to minimize exposure [18].

Mechanical Hazards: Moving parts like rollers and cutters pose injury risks. Use safety guards and emergency stops [14].

Fire Hazards: Flammable materials and adhesives in LOM can cause fires. Maintain equipment, keep the area free of ignition sources, and have fire extinguishers ready [15].

Chemical Spills and Contamination: Adhesives and solvents can spill, contaminating the workspace. Follow proper clean-up procedures and use spill containment kits [19].

Dust and Particulate Matter: Cutting and bonding generate dust, posing respiratory risks. Use ventilation systems and PPE [21].

Noise Pollution: LOM processes can be noisy. Use soundproofing measures or hearing protection to prevent hearing loss [25].

Thermal Burns: Heated elements in the cutting process can cause burns. Use heat-resistant gloves and be cautious [23].

Waste Disposal Issues: Dispose of waste materials according to local regulations to avoid environmental contamination [19].

3.7. 3D Print

Exposure to Hazardous Materials: Inhaling or contacting powders like plastics, metals, and ceramics used in 3D printing can cause respiratory issues and skin irritation. Use proper ventilation, masks, gloves, and handling procedures [18].

Chemical Exposure: Liquid binders and coatings emit VOCs, causing skin and eye irritation and respiratory problems. Ensure adequate ventilation and use fume extraction systems [16].

Dust and Particulate Matter: Applying and spreading powder generates fine particles that pose respiratory risks. Use ventilation systems and PPE [21].

Mechanical Hazards: Moving parts of the printer, like the print head and powder spreader, pose injury risks. Follow safety protocols and provide operator training [14].

Fire Hazards: Powders and binders are flammable. Maintain equipment, avoid ignition sources, and keep fire extinguishers available [15].

Thermal Burns: Heat from chemical reactions can cause burns. Use heat-resistant gloves and exercise caution [23].

Post-Processing Hazards: Post-processing involves hazardous solvents and equipment. Use proper handling procedures and protective gear [19].

Noise Pollution: 3D printers can be noisy. Use soundproofing or hearing protection to prevent hearing loss [25].

Waste Disposal Issues: Dispose of unused powders and binders according to local regulations to prevent environmental contamination [19].

4. CONCLUSION

In conclusion, the data gathered regarding safety at work when using additive manufacturing technologies underscores the critical importance of prioritizing safety measures to mitigate potential hazards. Each additive manufacturing process presents unique risks, including thermal hazards, chemical exposure, UV radiation, and airborne particle emissions. To ensure the well-being of individuals involved, it is imperative to implement comprehensive safety protocols, including proper ventilation, equipment maintenance, adherence to manufacturer guidelines, and thorough training for operators on machine operation and emergency procedures. Additionally, the use of Personal Safety Equipment (PSE), such as safety glasses, gloves, respirators, and protective clothing, is essential to minimize the risk of injury or illness. By proactively addressing safety concerns and promoting a culture of safety awareness, organizations can create a safer working environment for additive manufacturing operations, safeguarding the health and well-being of personnel involved.

REFERENCES

[1] Gibson, I.; Rosen, D. W.; Stucker, B.: Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer. (2014).

[2] ASTM International. ASTM F2792 - 12(2018) - Standard Terminology for Additive Manufacturing Technologies. ASTM International. (2018).

[3] Goodridge, R. D.; Hague, R. J.: Additive manufacturing: materials, processes, quantification and applications. Butterworth-Heinemann. (2018).

[4] Crump, S.: Apparatus and method for creating three-dimensional objects. U.S. Patent No. 5,121,329. (1992).

[5] Hull, C. W.: Apparatus for production of three-dimensional objects by stereolithography. U.S. Patent No. 4,575,330. (1986).

[6] Sachs, E.; Cima, M.; Cornie, J.; Deckman, H. Three-dimensional printing: rapid tooling and prototypes directly from a CAD model. Journal of Engineering for Industry, 114(4), 481-488. (1992).

[7] Credle, S.; Beaman, J. J.: A study of the processing of photopolymers using a solid-state UV laser. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 212(5), 385-395. (1998).

[8] Tumbleston, J. R.; Shirvanyants, D.; Ermoshkin, N.; Janusziewicz, R.; Johnson, A. R.; Kelly, D.; DeSimone, J. M.: Continuous liquid interface production of 3D objects. Science, 347(6228), 1349-1352. (2015).

[9] Gurr, M.; Mülhaupt, R.: Laminated Object manufacturing, Polymer Science: A Comprehensive Reference, (2012).

[10] Šimunić, N.; Benić, Z.; Brozović, M.: Postupci brze izrade prototipova // Zbornik Veleučilišta u Karlovcu, 1, 49-56. (2013).

[11] Krunić, S.; Perinić, M.; Maričić, S.: Načini brze izrade predserijskih proizvoda, Engineering Review, Vol 30/2010, str. 91-100. (2010)

[12] Azimi, P.; et al. (2016). "Emissions of ultrafine particles and volatile organic compounds from commercially available desktop three-dimensional printers with multiple filaments." Environmental Science & Technology, 50(3), 1260-1268.

[13] Occupational Safety and Health Administration (OSHA). "Safety Considerations for 3D Printing."

[14] Health and Safety Executive (HSE). "Additive Manufacturing (3D Printing) Guidance."

[15] Garcia, D.; Lee, H.: Fire Safety in 3D Printing Facilities. Fire Protection Engineering, 34(2), 78-92. (2021).

[16] Kim, Y.; et al. (2015). "Characterization of 3D Printer Airborne Particles and VOC Emissions Utilizing Multiple Filament Types in an Office Environment." International Journal of Environmental Research and Public Health, 12(12), 13719-13740.

[17] Johnson, R. A.; Kim, S.: UV Safety Guidelines for 3D Printing Technologies. Industrial Hygiene Review, 45(3), 210-223. (2020).

[18] Levy, G. N.; Schindel, R.; Kruth, J. P.: "Rapid Manufacturing and Rapid Tooling with Layer Manufacturing (LM) Technologies, State of the Art and Future Perspectives." CIRP Annals, 52(2), 589-609. (2003).

[19] Environmental Protection Agency (EPA). "Managing Hazardous Waste from Additive Manufacturing Processes."

[20] Occupational Safety and Health Administration (OSHA). "Combustible Dust: An Explosion Hazard."
[21] Williams, O.; et al.: "Respiratory exposure to metal oxide nanoparticles among additive manufacturing workers." Journal of Nanoparticle Research, 18(9), 270. (2016).
[22] Smith, J.; Taylor, L.: Chemical Safety in Additive Manufacturing: A Guide for PolyJet Printing. Journal of Occupational Health, 63(2), 145-157. (2021).
[23] Patel, S.; Williams, T.: Mechanical Safety in 3D Printing Technologies. Safety Science Journal, 60(5), 402-415. (2021).
[24] Nguyen, T.; Zhao, Y.: Handling and Disposal of Photopolymers in Additive Manufacturing. Environmental Health Perspectives, 130(1), 12-26. (2022).
[25] Clark, N., & Evans, R.: Noise Control in 3D Printing Operations. Occupational Safety and Health Administration (OSHA) Reports, 31(1), 122-135. (2022).

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

DANGERS AND PROTECTIVE MEASURES WHEN WORKING WITH ACIDS AND ALKILS IN POWER PLANT EL-TO ZAGREB

Domagoj Škarica[1], Budimir Mijović[2]

[1]HEP Proizvodnja d.o.o. – EL-TO Zagreb, Zagorska ulica 1, 10000 Zagreb, HRVATSKA, domagoj.skarica@gmail.com
[2]Tehnički fakultet, Univerzitet u Bihaću, Dr. Irfana Ljubijankića, 77000 Bihać, BOSNA I HERCEGOVINA, budimir.mijovic.hr@gmail.com

Abstract: Production consists of several production activities where the worker participating in the technological process can be exposed to various sources of danger and harms. This paper provides an overview of technological processes in EL-TO Zagreb where acids and bases are used, and the dangers faced by workers in these processes. The experimental section describes the protective measures that are applied when working with acids and bases in certain parts of the technological process. The experimental part is the calculation of the required volume of acids and bases for the neutralisation of wastewater and a description of measures taken according to the operational plan in the event of acid and base tanks contents leaking into the wastewater basin.

Key words: *production, technological process, dangers, harms, protective measures*

1. INTRODUCTION

The EL-TO Zagreb production facility is a power plant for the combined production of heat and electricity located in Trešnjevka, Zagreb. The history of EL-TO Zagreb began in 1907 with the commissioning of the thermal power plant called “Munjara”. Troughout history, it has changed its name several times, and since 1961 it has been given the current name EL-TO Zagreb. The 110kV switchgear positions EL-TO Zagreb as an important hub for the transmission and distribution of electricity in the city of Zagreb. The EL-TO Zagreb plant is connected to the central heating system of the city of Zagreb through a thermal power station, and it supplies technological steam via three steam pipelines [1]. The currently available production capacity is 50 MWe. The nominal capacity of heating heat is 200 MW_{therm} and the nominal capacity of tehnological steam is 80 MW_{therm}. The technological processes of obtaining technological steam, heating energy, and electricity are specific and demanding, posing numerous dangers to workers involved in these processes. Dangers include all working conditions and conditions related to work that can endanger the safety and health of workers [2]. By conducting a risk assessment, the employer is required to identify hazards, harms, and stresses for each workplace and the tasks performed at them. According to the Regulations on Risk Assessment (N.N. 112/14), hazards are categorized into mechanical hazards, fall hazards, electrical hazards, fire and explosion hazards, and thermal hazards. Harms are categorized into chemical, biological, and physical harms. Stresses can be classified as static-dynamic, psychophysiological, visual, and vocal stresses. Considering the number of employees at EL-TO Zagreb, occupational safety tasks are performed by two occupational safety experts, thereby meeting the conditions prescribed by Article 7 of the Regulations on Performing Occupational Safety Tasks (N.N. 126/19). In the technological processes of heat and electricity production and the production of technological steam, workers may be exposed to hazards during the conditioning of feedwater with acids and bases. By implementing adequate protective measures, the safety of workers when working with these substances is increased.

2. USE OF ACIDS AND ALKILS IN THE THERMAL ENERGY SECTOR

The production of technological steam, heat, and electricity is a demanding technological process that includes the use of chemicals. In the power sector, for the production of technological steam, heat, and electricity in technological processes, the most commonly used chemicals are: hydrochloric acid, sodium hydroxide, and ammonium hydroxide. Hydrochloric acid and sodium hydroxide are used for the regeneration of resin in ion exchangers, while sodium hydroxide is also used for conditioning water in the hot water system. Ammonium hydroxide is used for conditioning water in boiler plants.

The Chemicals Act (N.N. 150/05) defines chemicals as substances and preparations. The said law also defines hazardous chemicals, which are classified as: a) explosive chemicals, b) oxidizing chemicals, c) highly flammable chemicals, d) flammable chemicals, e) flammable chemicals, f) very toxic chemicals, g) toxic chemicals, h) harmful chemicals, i) corrosive chemicals, j) irritating chemicals, k) chemicals causing sensitization, l) carcinogenic chemicals, m) mutagenic chemicals, n) reproductive toxic chemicals, o) environmentally hazardous chemicals. According to the Chemicals Act (N.N. 150/05), hydrochloric acid belongs to hazardous and corrosive chemicals, sodium hydroxide belongs to corrosive chemicals, and ammonium hydroxide to hazardous and corrosive chemicals, and chemicals hazardous to the environment. The EL-TO Zagreb power plant must have instructions for safe work when handling these hazardous substances. A worker who directly handles these chemicals in the production process or in the process of production control must be professionally trained according to special regulations.

3. HAZARDS IN THE PRODUCTION OF DEMINERALIZED WATER

The first technical regulations for water quality in steam boilers in our country were adopted in 1957 with requirements that corresponded to the then constructions of water-tube and fire-tube shell boilers with large water spaces, low heat-loaded heating surfaces, primarily fired with solid fuel, and only occasionally with fuel oil [3]. At that time, water was softened by sedimentation using lime, sodium carbonate, sodium hydroxide, and trisodium phosphate. The use of ion exchangers was just beginning, primarily using the direct neutral ion exchange process. With the development of new constructions of steam and hot water boilers fired with liquid fuel and gas, with significantly higher heat load on the heating surface, and the effort to improve the thermal plant's efficiency and reduce the number of damages caused by poor water and steam quality, the technical requirements for water quality also changed [3]. To meet these requirements, water for technological needs began to be purified by chemical preparation using ion exchangers.

At EL-TO Zagreb, technological water for the needs of boiler plant operations is produced in the water chemical preparation plant. The plant has a production capacity of 3 x 150 m^3/h of demineralized water, consisting of three lines of ion exchangers. Each line consists of a cation exchanger, anion exchanger, and mixed ion exchanger, along with other associated devices necessary for production. The exchangers process raw water with a total hardness of 20-30 ° nj, and each ion exchanger line in the working cycle can produce 1800 m^3 of demineralized water. The produced demineralized water is stored in a steel tank with a capacity of 1000 m^3. For the regeneration of ion resins, there are five hydrochloric acid tanks with a concentration of 30-33%, each with a capacity of 50 m^3, and two sodium hydroxide tanks with a concentration of 48-50%, each with a capacity of 50 m^3, located on the exterior of the plant. The exterior of the plant also includes a wastewater treatment plant for wastewater generated in the demineralized water production process. It consists of a wastewater treatment station, five neutralization basins, an intermediate basin, and two sedimentation basins with associated pumps and equipment. Given that hydrochloric acid and sodium hydroxide, used in demineralized water production, are classified as hazardous and corrosive chemicals according to the Chemicals Act (N.N. 150/05), workers involved in production may be exposed to the dangers and risks associated with handling these chemicals. The automation of certain parts of the production and wastewater treatment processes has significantly reduced dangers and risks in the technological process. In parts of the process where automation was not possible, a trained worker, using personal protective equipment, performs work in the non-automated parts of the process. The regeneration of the cation exchanger is carried out by the counter-current principle by introducing a 6% hydrochloric acid solution from the top to the bottom of the exchanger. The regeneration of the anion exchanger is carried out by the counter-current principle by introducing a 2.5% sodium hydroxide solution from the top to the bottom of the exchanger. The regeneration of cationic and anionic resins in the mixed exchanger is performed in parallel by introducing a 4% sodium hydroxide solution from the top to the middle of the exchanger and introducing a 3.4% hydrochloric acid solution from the bottom to the middle of the exchanger. For the regeneration process, the acid and alkali tanks are made of steel and lined with material resistant to acids and alkalis. The alkali tanks are additionally thermally insulated and heated with steam to 30 °C to avoid crystallization of the alkali in colder weather conditions. For the safety and continuity of the production process and the specific requirements of their transport, hydrochloric acid and sodium hydroxide are ordered in larger quantities and stored in tanks. With the increase in the quantity of stored chemicals, the potential negative impact on workers and the environment also increases proportionally. Dangers can arise from the breach of the tank wall caused by the corrosive action of chemicals or due to mechanical damage to the pipeline or fittings between the tank and the water chemical preparation plant. The greatest danger may be faced by workers involved in the chemical tank filling process. An EL-TO Zagreb worker may be exposed to harmful chemical effects when taking samples from the tank to check the chemical density and during the tank filling process. The truck driver or rail tanker worker can expose themselves and the EL-TO Zagreb worker to danger due to improper connection of the chemical transfer pipes. Therefore, it is important that all persons involved in the tank filling process use prescribed personal protective equipment.

The wastewater treatment plant is a part of the production process designed to neutralize wastewater from the water chemical preparation plant. The water demineralization process is optimized so that the wastewater after the regeneration of the lines is within the prescribed pH range allowed for discharge into the public sewage system of the City of Zagreb. However, if certain deviations occur, the wastewater pre-treatment process is undertaken through neutralization. The plant has a water treatment capacity of 70 m^3/h. It consists of five interconnected neutralization basins, each with a capacity of 100 m^3, and two sedimentation basins with capacities of 100 m^3 and 150 m^3. The neutralization basins, shown in Figure 1, are equipped with two pH measurement probes each, and the sedimentation basins have their own separate pH measurement probe. After the neutralization process, the wastewater is pumped into the sedimentation basins. Treated water is discharged from the sedimentation basins into the public sewage system of the City of Zagreb.

In the wastewater treatment plant, a worker may be exposed to hazards from the corrosive effects of hydrochloric acid and sodium hydroxide, and the danger of inhaling corrosive fumes of hydrochloric acid. These hazards can arise from leaks in pump seals or any of the fitting elements. Another type of danger present in the wastewater treatment process is the harmful impact of wastewater on the public sewage system of the City of Zagreb and the environmental impact. This danger can occur due to careless handling of the hazardous water treatment process or due to malfunctioning pH measurement probes. The discharge of untreated wastewater would, over the long term, cause damage to the reinforced concrete parts of the public sewage system, posing a risk of wastewater leakage into the environment.

Figure 1. Neutralization basins

4. HAZARDS OF USING ALKALIS IN BOILER PLANTS

To prevent the formation of deposits in steam production devices, heat energy transfer devices, or cooling devices, it is necessary to condition the water used by these parts of the plant. Water is conditioned using dosing pumps to add the necessary chemicals to achieve and maintain the parameter values specified in the HRN M.E2.011 standard. The alkalis used to maintain the optimal pH value in boiler plants and the heating system are 25% ammonium hydroxide and 48-50% sodium hydroxide. Given that sodium hydroxide is classified as a corrosive chemical, and ammonium hydroxide is both hazardous and corrosive, and dangerous to the environment, handling these chemicals poses a risk to workers involved in the preparation of solutions needed for water conditioning in production.

Low-pressure boilers NTK1, NTK2, and NTK3 are steam boilers with a steam production of 39 t/h at a pressure of 17 bar and a temperature of 235°C. Boilers NTK1 and NTK2 are fed with water from a common feed tank with a capacity of 40 m³. Boiler NTK3 is fed from a separate feed tank with a capacity of 40 m³. The conditioning of the feed water is performed using dosing pumps that dose the prepared solution. The dosing station consists of two pumps with associated solution tanks located on the tank farm. Several types of hazardous events can occur to the worker responsible for preparing the conditioning solution for the feed water of low-pressure boilers. The first hazard a worker might encounter in this work process is during the retrieval of ammonium hydroxide from the chemical storage, where there could be leakage from a container of ammonium hydroxide or the presence of ammonium hydroxide vapors due to insufficient sealing of the container cap. The risk of spilling ammonium hydroxide can also occur during the transportation of the container from the chemical storage to the dosing station of the low-pressure boilers. At the dosing station, hazards can arise if the worker handles the ammonium container and transfer hoses carelessly. It is important to adhere to work instructions for preparing the dosing solution and to use personal protective equipment during preparation to avoid mistakes and ensure safety.

Boilers K8 and K9 are steam boilers with a steam production of 100 t/h at a pressure of 115 bar and a temperature of 520°C. Both boilers are fed with water from two feed tanks, each with a capacity of 60 m³. The conditioning of the feed water is performed using dosing pumps for dosing the necessary solution. The dosing pumps with associated tanks are located in the dosing station of the boiler plant. Depending on the amount of steam production, the amount of solution dosing and its concentration are adjusted. The exposure of workers to hazards in the process of preparing the conditioning solution begins with the retrieval of ammonium hydroxide from the chemical storage and its transport to the dosing station of boilers K8 and K9. At the dosing station, the worker can jeopardize their health by mishandling the ammonium hydroxide container and dosing hoses. Their health can be at risk if the worker does not follow the work instructions for solution preparation and does not use personal protective equipment.

Gas power plants PTE1 and PTE2 consist of two gas turbines with generators. Each gas turbine has its own waste heat boiler, UT1 and UT2. These are low-pressure boilers with a steam production of 65 t/h at a pressure of 17 bar and a temperature of 240°C. Both boilers are fed water from a single feed tank with a capacity of 102.5 m³. The feed tank of the boiler is conditioned with an ammonium hydroxide solution through two dosing pumps located in the dosing station. The dosing station also includes dosing equipment for direct conditioning of boiler water in boilers UT1 and UT2. It consists of two separate tanks with a capacity of 300 liters, intended for individual dosing of each boiler with a sodium hydroxide solution. In the process of preparing dosing solutions, the exposure of workers to hazards begins already in the storage area of ammonium hydroxide and sodium hydroxide, where there may be unwanted damage to the chemical containers or the release of their vapors through the container caps. The transport of these chemicals to the dosing station poses a danger to health and the environment, especially the transport of sodium hydroxide in case of container overturning and rupture. Careless handling of the hose for preparing the ammonium hydroxide solution can put the worker at risk of contact with it. A worker can be exposed to danger when adding sodium hydroxide to the dosing solution tank and through careless handling of the portable measuring container for sodium hydroxide. Any failure to use personal protective equipment when working with dosing chemicals poses a significant risk to the worker's health, particularly to the respiratory system, skin, and eyes.

The heating system water, which circulates through the western part of the city of Zagreb, is heated in heat exchangers. Depending on the needs of thermal energy consumers, heating system water can also be heated by heating boilers WK-3 and WK-4. The heating system is fed with conditioned water from two feed tanks. To maintain the pH value of the heating system water between pH 9 and pH 10, the feed tanks are conditioned with an ammonium hydroxide solution. Health and environmental hazards in the solution preparation process arise already during the retrieval of ammonium hydroxide and sodium hydroxide containers from the chemical storage and their transport to the dosing station of the heating system. The danger of contact with alkalis exists if the worker does not adhere to the work instructions for preparing the solutions and does not use personal protective equipment.

5. SAFETY MEASURES IN DEMINERALIZED WATER PRODUCTION

During the regular process of demineralized water production, workers are not exposed to the harmful effects of hydrochloric acid and sodium hydroxide, as it is a closed system. However, in the event of mechanical damage to the pipes supplying hydrochloric acid and sodium hydroxide to the ion exchangers, leaks from any armature elements installed on the pipeline, or leakage from the sealing part of the pumps supplying hydrochloric acid and sodium hydroxide to the chemical water treatment plant, workers may be exposed to their harmful effects. Before starting repairs, the worker undertaking safety measures before the work begins and the workers performing the repair must wear personal protective equipment prescribed for handling hydrochloric acid and sodium hydroxide. The storage tanks for hydrochloric acid and sodium hydroxide are made of steel and lined with materials resistant to acids and alkalis to prevent their harmful effects on the tank walls.

Neutralization of wastewater is necessary if the pH value of the water after regeneration of the demineralization line is not within the prescribed range defined by the Integrated Environmental Protection Conditions. Depending on the quality of the raw water, deviations in pH values from the range specified by the Integrated Environmental

Protection Conditions can occur. In such cases, neutralization is carried out to avoid damage to the public drainage system and to protect the environment.

In the experimental part, calculations were made to determine the required volumes of hydrochloric acid and sodium hydroxide for the neutralization of wastewater. In the first hypothetical situation, the volume of hydrochloric acid needed to neutralize 100 m³ of wastewater with a pH value of 11 was calculated. In the second hypothetical situation, the volume of sodium hydroxide needed to neutralize 100 m³ of wastewater with a pH value of 4.5 was calculated. The calculations were made using the following formulas:

$$V(HCl)_{added} = \frac{n(HCl)}{c(HCl)} \tag{1}$$

$$V(NaOH)_{added} = \frac{n(NaOH)}{c(NaOH)} \tag{2}$$

The results of the calculations for the required volumes of hydrochloric acid and sodium hydroxide for neutralization are presented in Table 1.

Table 1. Results of the calculations for the required volumes of hydrochloric acid and sodium hydroxide for neutralization

pH(waste water)	V(waste water)/l	V(HCl/NaOH)neut./l
11,0	100000	9,761
4,5	100000	0,174

From the obtained results, it is evident that small volumes of added hydrochloric acid and sodium hydroxide would be needed for neutralization to achieve an optimal pH value suitable for discharging wastewater into the public drainage system of the city.

6. SAFETY MEASURES FOR THE USE OF ALKALIS IN BOILER PLANTS

Alkalis used for conditioning feedwater in boilers and water from the heating system have corrosive properties. During handling, workers are typically exposed to skin contact, with potential exposure to the face, eyes, and other parts of the body in case of splashing or spillage. To prevent irritation to the skin, eyes, respiratory organs, and chemical burns, the use of personal protective equipment is mandatory in areas where alkalis are used in boiler plants. For working with ammonium hydroxide, personal protective equipment includes safety goggles, nitrile rubber gloves, protective overalls, footwear covering the entire foot, and a protective mask with a type K filter marked in green, and above the usage limitations for respirators and oxygen concentrations below 17% by volume, isolation apparatus must be used. For working with sodium hydroxide, personal protective equipment includes safety goggles or a face shield in case of vapor or aerosol formation that could injure the eyes, PVC, neoprene, or Barricade gloves, a snug-fitting apron, chemical-resistant boots or appropriate clothing, a particle filter marked with a P in white, and above the usage limitations for respirators and oxygen concentrations below 17% by volume, isolation apparatus must be used. Workers must use personal protective equipment in the chemical storage area when handling the necessary alkalis, during their transport to the boiler plant, and at the point of application in the dosing station.

The dosing station for low-pressure boilers NTK1 and NTK2 is marked with prohibition, obligation, and hazard signs. Safety instructions are located next to the dosing vessels. Dosing pumps with respective solution containers are installed on bunds. Bunds serve to collect spilled chemicals necessary for preparing the dosing solution or to contain the dosing solution in case of tank leakage. The floors of the boiler plant are coated with a substance resistant to acids and alkalis. Dosing the solution into the feed tank is a closed system and poses no danger to the worker. An emergency water source and an eye shower are provided nearby.

Low-pressure boiler NTK3 is of the same type as NTK1 and NTK2 but is a newer production block. Accordingly, almost identical but improved safety measures are applied. Signs for prohibition, obligation, and hazard are located at the block entrance, along with safety instructions at the dosing station. Dosing pumps with respective solution containers are placed on plastic bunds equipped with a liquid level sensor. The bund is located on a floor resistant to acid and alkali attack. Solution preparation is carried out as a closed system, and contact with chemicals required for conditioning occurs only during the replacement of their empty containers. Each chemical required for preparing the conditioning solution has its own pump and separate hoses and pipes with measuring vessels. An emergency water source and an eye shower are provided in case of accidents.

The dosing station for high-pressure boilers K8 and K9 is separated from the rest of the boiler plant by a metal fence and is marked with corresponding prohibition, obligation, and hazard signs. Safety instructions are placed next to the dosing vessels. Dosing the solution into the feed tanks is a closed system and poses no danger to the worker. Ammonium hydroxide for preparing the dosing solution is pumped using a pneumatic pump, and the prescribed personal protective equipment must be used during this process. Care must be taken when handling the transfer hose to avoid spills of ammonium hydroxide. An emergency water source and an eye shower are provided near the dosing station.

In the dosing station for conditioning feedwater in the gas-fired power plants PTE1 and PTE2, ammonium hydroxide and sodium hydroxide are used. Accordingly, the prescribed personal protective equipment is used. The station is properly marked with prohibition, obligation, and hazard signs, and includes safety instructions for handling the alkalis used. Dosing vessels with pumps are installed on plastic bunds, and the floor is resistant to alkali corrosion. Dosing solutions into the feed tank and direct dosing into boilers are closed systems and do not pose a danger to workers. Caution and protective measures are necessary during solution preparation due to handling of the transfer hose for pumping ammonium hydroxide into the measuring vessel. Extra care is particularly needed to prevent splashing during the preparation of sodium hydroxide solution for direct dosing into the boiler, as alkali is manually poured from a portable measuring container. An emergency water source with a rinsing hose is provided inside the dosing station.

The feedwater heating system dosing station consists of two parts. The station is appropriately marked with prohibition, obligation, and hazard signs, and includes instructions for safe handling of the alkalis used. The floors are made of materials resistant to alkalis. For preparation of the solution, ammonia hydroxide is used for dosing into the feedwater tank, and sodium hydroxide is used for direct dosing into the feedwater heating system to condition the water. Personal protective equipment measures must be taken when obtaining the necessary alkalis from their storage and during their transport to the dosing station. The ammonia hydroxide dosing pump and its tank are located within a separate enclosed space. Workers must handle the pump and hoses carefully to prevent leakage of the ammonia hydroxide solution. The sodium hydroxide dosing pumps with their respective tanks are located within a plastic tank. Workers must handle the pumps and hoses carefully to prevent leakage of the sodium hydroxide solution. An emergency water source and eye shower are provided nearby in case of accidents.

7. CONCLUSION

The production process in the power generation sector involves working with hazardous substances. During the production of demineralized water, workers may be exposed to the harmful effects of acids and alkalis during the regeneration process of the ion exchange line. Additionally, during the treatment of wastewater generated from the regeneration process, harmful effects on the environment may occur, in addition to those on the workers. Workers may also face exposure to alkalis during the conditioning of boiler feedwater and water in the heating system. The functionality of the wastewater neutralization method after the regeneration of ion exchange resins was experimentally verified. The wastewater neutralization method has proven to be effective as it requires small amounts of acid or alkali to adjust the pH of the wastewater within the prescribed range defined by the Integrated Environmental Protection Conditions Decision. All hazards associated with the harmful effects of acids and alkalis used have been identified, and necessary measures have been implemented at all workplaces to protect workers' health and comply with legal requirements.

LITERATURA

[1] EL-TO Zagreb, dostupno na: https://www.hep.hr/proizvodnja/termoelektrane-1560/termoelektrane-toplane/el-to-zagreb/1567 . Pristupano: 24.06.2024.

[2] Zakon o zaštiti na radu (N.N. 71/14, 118/14, 154/14, 94/18, 96/18)

[3] Šivak, M.: Tehnologija pripreme tehničkih voda u termoenergetici, Nakladnička djelatnost Marijan Šivak, Zagreb 2002, ISBN 953-97447-1-7

[4] Mijović, B.: Održavanje strojeva i uređaja, Veleučilište u Karlovcu, Karlovac 2019, ISBN 978-953-7343-74-3

THE INFLUENCE OF WASHING WITH PERACETIC ACID BLEACH ON THE PROPERTIES OF GREEN HOSPITAL PROTECTIVE COTTON FABRIC

Anita Tarbuk[1], Tihana Dekanić[1], Josip Marković[1,2], Katia Grgić[1]

[1] University of Zagreb Faculty of Textile Technology, Prilaz baruna Filipovića 28a, Zagreb, CROATIA, e-mail: anita.tarbuk@ttf.unizg.hr

[2] "DM TEKSTIL KROJAČKI OBRT" Ozalj

Abstract: *Peroxyacetic acid was introduced into the industrial washing process as an environmentally friendly bleaching and disinfecting agent. Therefore, in this study, green cotton fabric for surgical gowns and medical equipment covers was subjected to 25 washing cycles according to ISO 15797:2017 Washing procedures for white workwear and/or sensitive coloured trimmings – Peracetic acid bleach. The washing was carried out in the Wascator FOM71 CLS machine at 75 °C using the Reference Detergent A1 with optical brightener from WFK. The influence of peracetic acid bleach and optical brightener on fabric properties was analyzed by tensile properties, mass per unit area, yarn count and spectral characteristics after 1, 3, 5, 10, 15 and 25 washing cycles using standard methods. The results obtained were compared with HQS 705 and indicate that green cotton fabrics can be used in hospital environment.*

Keywords: *green cotton fabric, repeated washing, peracetic acid, mechanical properties, colour fastness*

1. INTRODUCTION

Washing is the process of removing stains and dirt in an aqueous medium. The washing effect is the result of mechanics, chemistry, temperature and time, so these parameters must be optimized. In addition to the esthetic aspect of the washed textiles, the hygiene aspect is also an important criterion for hospital textiles. A satisfactory washing effect can be achieved by choosing the right detergent in terms of its composition and by adding bleaching agents and disinfectants [1-4].

Peracetic acid (PAA) is a bleaching agent and a powerful disinfectant [5-7]. It has a bactericidal, virucidal, fungicidal and sporicidal effect and can therefore be used in various industries [5]. In textiles, the use of PAA as a bleaching and disinfecting agent in chemical bleaching and washing processes has recently attracted more attention. Peracetic acid has also been introduced into the industrial washing process as an environmentally friendly bleaching and disinfecting agent. It can be used at a pH value of 7 to 8 and at temperatures between 40 and 80 °C, which gives it an advantage over hydrogen peroxide. It splits the double bonds in pigments, resulting in washable, uncolored degradation products. During the washing process, PAA decomposes into oxygen and acetic acid, which are completely biodegradable and at the same time neutralize the wash bath [7].

Since oxygen-based bleaching agents and optical brighteners commonly used in detergent formulations strongly affect fabric properties, this study investigated their influence on the color fastness and mechanical properties of green cotton fabric for surgical gowns and medical equipment covers.

2. MATERIALS AND METHODS

Green cotton fabric for surgical gowns and equipment covers donated by "DM tekstil – krojački obrt", Ozalj, was selected to investigate the influence of repeated washing. The fabric has mass per unit area 171 g/m^2, a yarn finess 35 tex x 1, a yarn density of warp: 26 cm^{-1} and weft: 21.5 cm^{-1}, dyed with vat dyestuff and sanforized.

Fabric was subjected to 25 washing cycles according to ISO 15797:2017 *Washing procedures for white workwear and/or sensitive coloured trimmings – Peracetic acid bleach*. The washing was carried out in the Wascator FOM71 CLS machine at 75 °C. The 4 g/l of Reference Detergent A1 with optical brightener (WFK) and 2 g/l of peracetic acid bleach that contained 5% PAA and 20% H_2O_2 were used. Fabric properties were analyzed after 1, 3, 5, 10, 15 and 25 washing cycles using standard methods.

Mass per unit area was determined according to ISO 3801:1977 *Textiles — Woven fabrics — Determination of mass per unit length and mass per unit area*. Yarn count was determined according to ASTM D3775-07 *Standard Test Method for Warp (End) and Filling (Pick) Count of Woven Fabrics*. Tensile properties were determined on TensoLab Strength Tester (Mesdan, Italy) 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*. Distance between clamps was 100 mm, bursting speed 100 mm/min and pretension 2 N.

Remission was measured on a remission spectrophotometer Spectraflash SF 300 (Datacolor). The influence of oxygen based bleaches (PAA and H_2O_2) and optical brightener to fabric color was researched by determination of color fastness according to ISO 105-A05:1996 *Textiles — Tests for colour fastness — Part A05: Instrumental assessment of change in colour for determination of grey scale rating*. The colour difference was calculated automatically from remission. The color fastness was evaluated according to EN ISO 105-C06:2010 *Textiles — Tests for colour fastness — Part C06: Colour fastness to domestic and commercial laundering*.

The Hohenstein Institute has described quality standards (HQS) in HSQ 701-707: *Catalogue of requirements for the purchase of textiles suitable for rental services* [8]. The obtained color fastness and strength were compared to HQS 705: *Bed linen*.

3. RESULTS AND DISCUSSION

The influence of peracetic acid bleach and optical brightener on fabric properties was analyzed by tensile properties, mass per unit area, yarn count and spectral characteristics after 1, 3, 5, 10, 15 and 25 washing cycles using standard methods. The results are shown in Tables 1-3 and in Figures 1-2.

Table 1: Mass per unit area (*m*) and the yarn count (*N*) of warp and weft before and after 1, 3, 5, 10, 15 and 25 washing cycles of green cotton fabric

Fabric	m [g/m^2]	CV [%]	N_{warp} [cm^{-1}]	CV [%]	N_{weft} [cm^{-1}]	CV [%]
0	171.00	0.44	26.00	2.86	22.00	0.00
1W	177.52	0.42	26.67	3.02	22.00	0.00
3W	177.97	0.83	27.67	3.35	22.00	0.00
5W	179.65	0.09	27.67	2.98	22.33	3.33
10W	180.22	0.35	28.00	2.45	22.00	0.50
15W	182.12	0.65	28.00	2.14	23.00	2.02
25W	187.19	1.01	28.00	2.04	22.67	2.67

Table 2: Tensile properties of green cotton fabric - breaking force (*F*) and elongation (ε) and Color fastness before and after 1, 3, 5, 10, 15 and 25 washing cycles

Fabric	F [N]	CV [%]	ΔF [%]	ε [%]	CV [%]	Color fastness
0	593.0	7.24	0	8.58	3.05	5
1W	620.0	2.78	-4.35	7.80	2.49	4
3W	681.0	4.57	-12.92	9.12	2.68	4
5W	617.0	11.39	-3.89	9.05	7.41	3-4
10W	644.0	6.31	-7.92	9.67	3.54	3
15W	589.0	6.64	0.68	9.75	3.28	2-3
25W	567.0	12.75	4.59	10.11	5.09	2-3

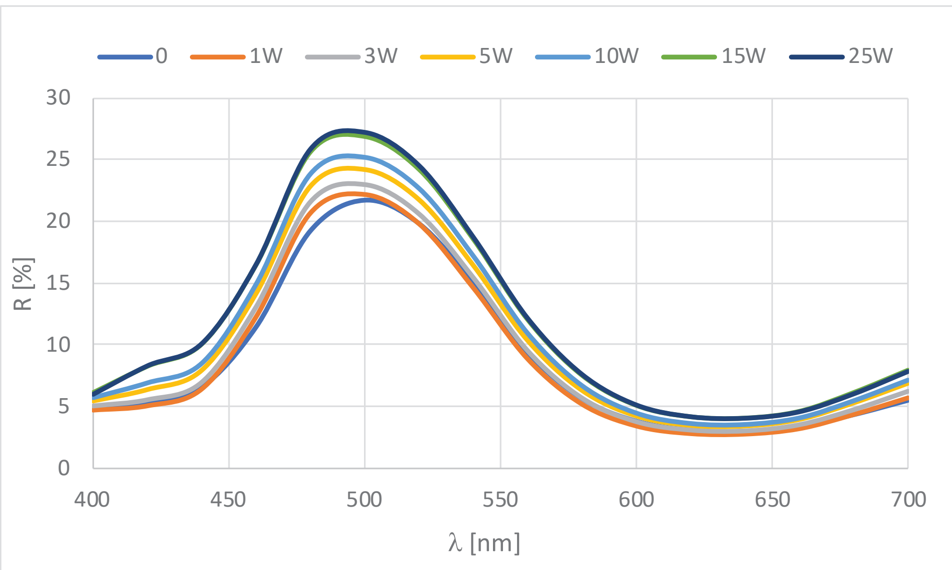


Figure 1: Remission (R) of green cotton fabric before and after 1, 3, 5, 10, 15 and 25 washing cycles: a. white, b. blue

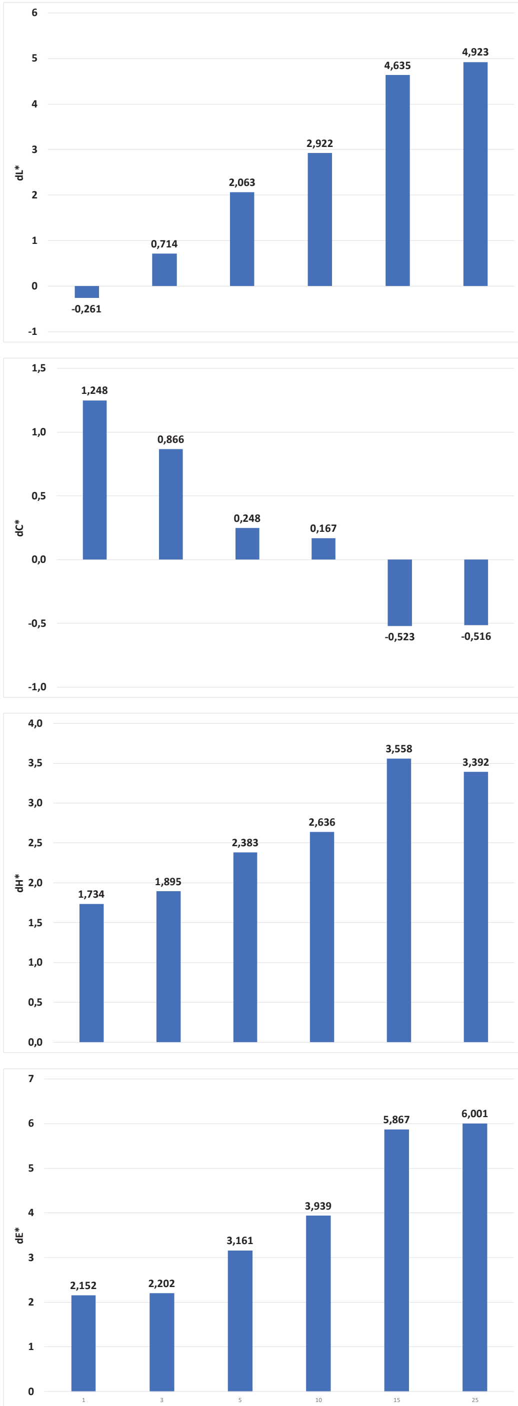


Figure 2: The differences in lightness, chromaticity, hue and total color difference of green cotton fabric before and after 1, 3, 5, 10, 15 and 25 washing cycles

As declared, fabric mass per unit area is 171 g/m^2. The results shown in Table 1 indicate that it increases with each wash. After 10 washes, it is 187 g/m^2, which corresponds to an increase of 8.6%. The reason for this is the shrinkage of the fabric. All wet treatments cause swelling of the cellulose materials, which leads to shrinkage of the fabric after drying. The yarn count confirms this finding, the number of warp per cm is 7.7% higher, and that of the weft is 4% higher.

The results of the breaking force (F) shown in Table 2 indicate an improvement in the mechanical properties. However, this is not the case. As the fabric shrank, the yarn count in the test strip increased, resulting in a "higher" breaking force. Up to the 10th washing cycle, the breaking force increases with increasing mass, so that no mechanical damage occurs. After the 15th washing cycle, however, the breaking force is lower regardless of the increase in mass. It can be assumed that oxidative damage occurs due to oxidative bleaching and the addition of disinfectants. After 25 washing cycles, a reduction in breaking force of 4.5% was observed. These results are consistent with other studies in which oxidative damage occurs at 25 and 50 wash cycles [9]. From the results of the elongation at break of the fabric, it can be seen that it increases with each washing cycle.

It is known that oxygen-based bleaching agents and optical brighteners significantly change the spectral characteristics of washed textiles after just one washing cycle [2, 11]. Therefore, the remission, colour fastness and total colour difference were determined as a result of the differences in lightness (dL*), chromaticity (dC*) and hue (dH*) before and after 1, 3, 5, 10, 15 and 25 washes. From the remission shown in Figure 1 and the color differences shown in Figure 2, it is clear that the color of the green cotton fabric changes considerably with repeated washing. This change can mainly be attributed to optical brighteners, as the fabric was dyed with vat dye, which has good resistance to oxidative bleaching. The presence of optical brighteners in the detergent leads to a shift in the reflectance spectrum due to the phenomenon of fluorescence, which causes a higher lightness, a lower chromaticity and a slight change in hue. The color fastness values are 4 to the 3rd, 3-4 after the 5th, 3 after the 10th and 2-3 after the 15th up to 25th. These changes are characteristic of textiles dyed in pastel shades [2].

Table 3: Comparison of obtained results after one washing cycle to the HQS 705

Standard	HSQ 705 requirements	1W
EN ISO 105-C06:2010	≥4	4
EN ISO 105-N02:2003 *(peroxide)*	≥4	
ISO 105-N01:1993 *(hypochlorite)*	≥4	
HRN EN ISO 13934-1:2008	≥500N	620 N

The results obtained were compared with HQS 705 in regard to color fastness and strength (Table 3). From the comparison of the color fastness after the first washing cycle of green cotton fabric with the HQS 705 criteria it can bee seen that fabric meets the requirements. If the ratings for peroxide or hypochlorite were taken into account, as there is no standard for peroxyacetic acid, the result would be the same. The fabric also meets the breaking force requirements, therefore it can be used in hospital environment.

4. CONCLUSION

The influence of repeated washing with peracetic acid bleach (PAA and H_2O_2) on the properties of green hospital protective cotton fabric was researched in this paper. The changes in mass per unit area, yarn count, tensile properties, and spectral characteristics were analysed after 1, 3, 5, 10, 15 and 25 washing cycles. Considering mechanical properties, it is evident that shrinkage of fabric occurs, but oxidative damage has been noticed after 25^{th} washing cycle. The reduction of 4.3% in breaking force still suggests good quality fabric. As far as the spectral characteristics are concerned, the effect can be mainly attributed to the presence of optical brighteners in the detergent, as the vat dye is resistant to oxidative bleaching.

Overall, the comparison of the results obtained with HQS 705 shows that the green cotton fabric meets the requirements for color fastness and breaking force, so it can be used in hospital environment.

ACKNOWLEDGEMENT

The work has been supported by Croatian Science Foundation under the project UIP-2017-05-8780 HPROTEX.

REFERENCES

[1] Pušić, T.; Soljačić, I.: Quality Control of Washing according to RAL-GZ 992 (In Croatian), *Tekstil*, **57** (2008) 6, pp. 296-302, ISSN 0492-5882

[2] Pušić, T.; Soljačić, I.: Changes in shade and ultraviolet protection of pastel dyed cotton fabrics during laundering with fluorescent compounds, *Colourage,* **56** (2009) 1, pp. 43-48, ISSN 0010-1826

[3] Pušić, T.; Soljačić, I.; Dekanić, T.: Cumulative effects of washing on properties of cotton fabrics and their blends, *H&PC Today* **9** (2014) 7/8, pp. 26-33, ISSN 2035-4614

[4] Neral, B.; Šostar-Turk, S.; Fijan, S.: Environmental Impacts of Various Disinfection Procedures during Laundering, *Tekstilec,* **54** (2011) 7-9, pp. 149-171, ISSN 2350-3696

[5] Kitis, M.: Disinfection of wastewater with peracetic acid: a review, *Environment International* **30** (2004) 1, 2004, pp. 47-55, ISSN 0160-4120

[6] Hickman, W. S.: Peracetic acid and its use in fibre bleaching, *Rev. Prog. Color.* **32** (2002), pp. 13-27, ISSN 1472-3581

[7] Forte Tavčer, P.; Križman, P.: Bleaching of cotton fibers for sanitary products with peracetic acid (In Croatian), *Tekstil,* **52** (2003) 7, pp. 309-315, ISSN 0492-5882

[8] *Hochenstein Quality Standard* (HQS) 701-707: Catalogue of requirements for the purchase of textiles suitable for rental services. Handbook, Hochenstein institute (2009)

[9] Pušić, T.; Fijan, S.; Soljačić, I.; Šostar-Turk, S.; Dekanić, T.: The New Approach for the Washing Performance, *Book of Proceedings of the 4th International Textile Clothing & Design Conference,* Dragčević, Z. (Ed), pp. 435-440, ISBN 978-953-7105-26-6, Dubrovnik, Oct 2008, University of Zagreb Faculty of Textile Technology, Zagreb (2008)

SAFETY AT WORK FOR THE CNC MACHINE OPERATOR

Ana Marija Žalac[1], Budimir Mijović[2]
[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA,
[2]Tehnički fakultet Bihać, Univerzitet u Bihaću, Bosna i Hercegovina

Abstract: *Particle separation processing is a key branch of the engineering industry, comprising almost 80% of the total volume of processed parts. The goal is to present the workplace of a CNC operator through an analysis of the basic construction, management and maintenance of CNC machines. By collecting data and analyzing the work environment, potential hazards, harms and efforts that operators face in the workplace have been identified. Noise is highlighted as one of the most prominent physical harms in the working environment, the measurement results of which require protective measures. Plans and strategies are discussed to eliminate or reduce these risks, in order to improve safety and productivity, with an emphasis on preserving the health and well-being of workers.*

Keywords: *CNC operator, CNC machines, risks, noise, safety measures.*

Sažetak: *Obrada odvajanjem čestica je ključna grana strojarske industrije, obuhvatajući gotovo 80% ukupnog volumena obrađenih dijelova. Cilj je prikazati radno mjesto CNC operatera kroz analizu osnovne konstrukcije, upravljanja i održavanja CNC strojeva. Prikupljajući podatke i analizirajući radno okruženje, identificirane su potencijalne opasnosti, štetnosti i napori s kojima se operateri susreću na radnom mjestu. Kao jedna od najistaknutijih fizikalnih štetnosti u radnoj okolini istaknuta je buka, čiji rezultati mjerenja zahtijevaju zaštitne mjere. Razmotreni su planovi i strategije za uklanjanje ili smanjenje tih rizika, kako bi se poboljšali sigurnost i produktivnost, s naglaskom na očuvanje zdravlja i dobrobiti radnika.*

Ključne riječi: *CNC operater, CNC strojevi, rizici, buka, mjere sigurnosti.*

1. INTRODUCTION

Particle separation processing is a technique that includes various processes by which a certain amount of particles are removed from the raw material in order to shape the finished products. Machine tools with precisely defined techniques and parameters are used for this process to ensure high product quality in the shortest possible time [1]. The primary difference between classic machine tools and CNC machines lies in the way they are controlled. Classic machines require manual control, where the operator directly manipulates the machine's controls. On the other hand, CNC machines use advanced computer technology for control, enabling more precise and complex operations, Figure 1. Also, CNC machines often have a greater degree of automation and programming, resulting in increased productivity and a reduction in the possibility of human error [2].

Figure 1. CNC machine - milling machine with 3 axes [2]

CNC machines are divided into two categories: conventional machining technology and new machining technology. Some of the conventional CNC machines are milling machines, which are also the most used CNC machines. They use rotary tools for processing by separating particles and can perform various functions such as drilling, deburring, threading, tapping, etc. [3]. The basic technical characteristic of CNC machines is division by axes, thus there are machines with 2, 3, 4 and 5 axes, which enable different levels of complexity of material processing.

2. BASICS OF CNC MACHINE

The construction of a CNC machine varies depending on its purpose, most machines share some basic components that enable it to move precisely as well as process materials. Some of the common basic parts are frame, table, control unit, spindle, slides and others. One of the basic parts of the machine construction is the tool head, which is responsible for the precise movement of the tool in order to perform the processing by separating the particles. Then there is the main part of the CNC machine that manages all aspects of the machining, the CNC controller. The CNC controller receives commands from the user from the CAD/CAM program and converts these commands into electrical signals that drive the motors to achieve the desired axis and tool movements [4].

3. RISK ASSESSMENT FOR THE JOB OF CNC OPERATOR

Risk assessment is the process of analyzing various aspects of unfavorable working conditions with the purpose of determining the level of risk of damage to workers' health (injuries at work, occupational diseases and work-related diseases) and disturbances in the work process that could cause harmful consequences for the safety and health of workers [5]. Based on the collected data on dangers, harms and efforts for the CNC operator's workplace, the following facts that he encounters during his work have been singled out:

- dangers (mechanical, falls, electric current),
- harm (chemical and physical),
- efforts (statodynamic and psychophysiological).

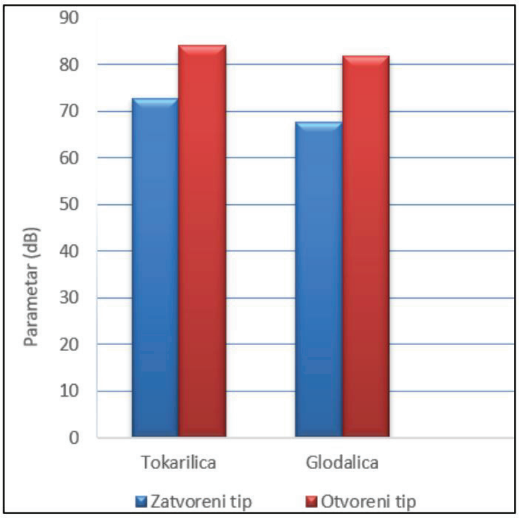
4. NOISE AT THE WORKPLACE

Modern progress in technology sets high demands, so it often happens that factory halls are densely packed with machines and built with materials with a low sound absorption coefficient, which results in intense noise and vibrations [6]. Noise is any unwanted sound that reaches the human ear. The impact of noise on the human body depends on its intensity, quality, duration, continuity or interruption. It has a negative effect on people, causing hearing damage, sleep disturbances, concentration disturbances, etc. The basic characteristic of sound lies in its frequency. The human ear can perceive frequencies between 16 Hz and 20,000 Hz. The decibel (dB) unit is used to measure sound volume. In addition to the standard decibel scale (dB), the dB(A) scale is often used, which considers the relative loudness of sound compared to the human ear. After various research, it was determined that the permissible noise level should be up to 80 dB in the workplace [6]. In the CNC operator's workplace, continuous noise comes from working on machines and devices. Since the CNC operator's job description states that he must always be near the machine, noise significantly affects his hearing. For the above reasons, the noise level of open and closed machines in the production facility was measured, Table 1.

Table 1. Noise measurement during metal machining [6]

Oznaka	1		2		3		4	
Stroj	**Tokarilica** (otvoreni tip)		**Tokarilica** (zatvoreni tip)		**Glodalica** (otvoreni tip)		**Glodalica** (zatvoreni tip)	
Vrijeme	08 h	18 h	08 h	18 h	08 h	18 h	08 h	18 h
Parametar (dB)	89.7	78.4	71.3	74.2	87.2	76.6	65.2	69.9

By comparing the open and closed type of machine, we concluded that the closed machine conducts much less noise, which is proven by the fact that the level is on average 13 dB lower than the open type, Graph 1.



Graph 1. Comparison of the equivalent noise level

After the measurement, it was noticed that the noise produced by some machines exceeds the permitted level of 80 dB. To reduce the noise intensity, it is necessary to wear personal protective equipment. It is also possible to isolate the machines by installing partition walls in rooms with noise greater than 80 dB, thereby reducing the overall noise burden on workers. Another approach to noise reduction may include the use of noise absorbers or the placement of noise absorption panels around machinery.

5. SAFETY MEASURES AT WORK

To achieve goals such as protecting the health and life of workers, it is necessary to apply appropriate safety measures at work. As a first measure, there are instructions for working safely, they are placed in a visible place near the machine and provide information about safety when working with the machine. Then there are the technical measures to protect the machines and they include a series of safety mechanisms designed to ensure the safety of the operator and prevent injuries while working with the machines. On the CNC milling machine, there is a built-in electronic safety protection on the door that prevents the worker from injury by allowing the system to start the processing process only after closing the machine door and establishing the electrical connection, Figure 2. Also, the door of the CNC milling machine is equipped with a protective bulletproof (tempered) glass that prevents liquids, shavings and other particles from escaping, while at the same time providing a clear view of the work piece.

Figure 2. Closed safety door on a 5-axis milling machine

There are also measures related to the worker, used when the safety risk cannot be avoided or limited to a sufficient extent by technical measures or organizational methods and procedures. And as a last measure, but no less important are basic protective means and equipment. The analysis of dangers, harms and efforts for the workplace CNC operator lists the personal protective equipment that workers should use in order to reduce the risk of injuries and diseases: -safety glasses, mask, headphones, gloves, clothes and shoes [7].

Figure 3. Obligation signs - personal protective equipment [7]

6. CONCLUSION

In manufacturing facilities with CNC machines, it is crucial to implement and follow appropriate safety measures to protect workers and ensure their well-being. This includes the use of protective equipment, posting safety signs, training workers in safety procedures, and regular maintenance of equipment and the work environment. After the measurement, it was found that the noise produced by some machines exceeds the permitted level of 80 dB. It is possible to isolate the machines by installing partition walls in rooms with a noise level greater than 80 dB. Continuous support from employers in the implementation of safety protocols is essential to ensure successful and safe work. Ultimately, investing in worker safety is not only a legal obligation, but also a moral responsibility that contributes to productivity, quality of work and the well-being of everyone involved in the production process.

LITERATURE

1. Pavić, A.; Tehnologija - Obrada odvajanjem čestica, udžbenik, Veleučilište u Karlovcu, Karlovac, 2013.

2. The difference between classic and CNC machines https://ba.jidemachinery.com/info/principles-and-characteristics-of-cnc machine-55042647.html, pristupljeno 15.04.2024

3. History of numerical control: http://hr.saikocnc.com/news/the-history-of-cnc-machining-76225069.html, pristupljeno 15.04.2024.

4. Basic division of CNC machines: https://smpcnc.hr/materijali/obradametala/o-cnc-strojevima/, pristupljeno 19.04.2024.

5. Risk assessment: http://www.hzzzsr.hr/index.php/rizici-na-radu/procjena rizika/, pristupljeno 25.04.2024

6. Noise: https://preventa.hr/zastita-na-radu-upit/buka-na-radu, pristupljeno 02.05.2024.

7. Vučinić, J., Vučinić, Z.: Osobna zaštitna sredstva i oprema, Veleučilište u Karlovcu, Karlovac, 2011.

8. Mijović, Budimir, Sigurno održavanje strojeva i uređaja, Karlovac, 2011.

AVERAGE DAILY SUNSHINE AND CLOUD COVER AS A GUIDE TO PRODUCTION AT SOLAR POWER PLANT "VUK"

Filip Žugčić[1]; Mario Fanjak[2]; Ivan Štedul[3]
[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, CROATIA, filip.zugcic@vuka.hr
[2] Medical school Karlovac, Andrije Štampara 5, 47000 Karlovac, CROATIA, mfanjak@yahoo.com
[3] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, CROATIA, ivan.stedul@vuka.hr

Abstract: *Growing amounts of money are being invested in the generation of electricity from renewable energy sources in an effort to meet the objectives of sustainable development, the energy crisis, and energy independence. As part of the Center for Sustainable Development project, the Karlovac University of Applied Sciences installed a 10 kW peak photovoltaic power plant. The purpose of this paper is to link the data on the electricity production from the PV VUK power plant, depending on the National Hydrometeorological Institute's data on the daily total sunshine and the mean daily cloud cover for Karlovac station.*

Keywords: *sustainable development, photovoltaic power plant, daily sunshine and cloud cover*

1. INTRODUCTION

The primary focus and obligation of the EU's member states, including Croatia, continues to be the generation of energy from renewable sources. The "Fit for 55 package" climate package outlines the EU's climate plans. By 2030, the EU wants to cut its greenhouse gas emissions by 55%, and by 2050, it wants to be carbon neutral. By 2030, the EU's final energy consumption will include 42.5% more energy from renewable sources thanks to the amended Directive on Energy from Renewable Sources. The goal for each member state should be to reach 45%. [1]

The information that was just provided highlights how crucial it is to use renewable energy sources while producing power in order to protect the environment, encourage sustainable growth, and guarantee energy independence.

We attempted to model the function of predicting the amount of electricity that the power plant could produce in June and July 2024 using data from the State Hydrometeorological Institute of Croatia (SHMI) for the period 2021–2023 on the daily sum of sunshine expressed in hours and average daily cloud cover expressed in tens (or percentages) and data from sunnyportal.com on the amount of electricity produced by the VUK solar power plant.

2. PHOTOVOLTAIC POWER PLANT "VUK" PRODUCTION

The VUK photovoltaic (PV) power plant, with a power of 10 kWp, was put into operation in July 2012 as part of the project "Center for Sustainable Development: Solar Photovoltaic System". [2] The project holder was the Polytechnic in Karlovac. Since its commissioning until today, it has produced 128,630 MWh of electricity while reducing carbon dioxide emissions into the atmosphere by 90 t. Sunnyportal's website displays all of these statistics in addition to the power plant's profitability and daily, monthly, and annual production. [3]

Figure 1 illustrates the electricity production from the PV power plant during the months of June and July in 2021–2023, which was the basis for the work. Since SHMI provided data on the average daily cloud cover and daily sunshine total for that period, the months June and July saw the highest electricity output of the year.

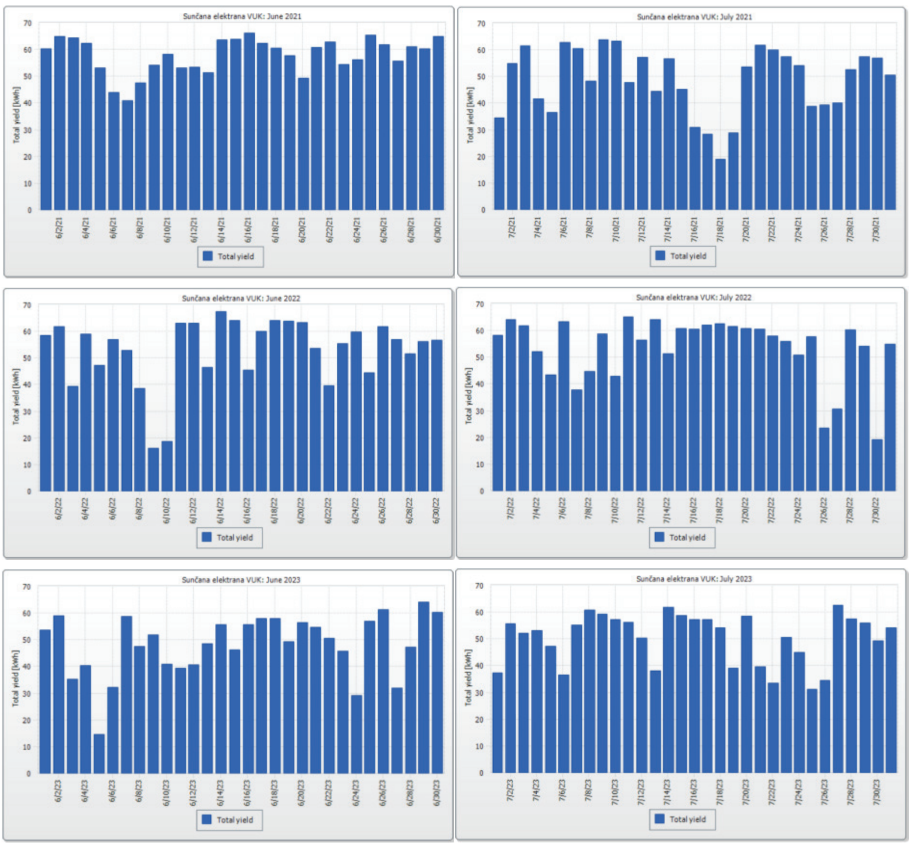


Figure 1: Production of PV VUK for the months of June and July in the period 2021-2023 [3]

3. STATE HYDROMETEOROLOGICAL INSTITUTE DATA

Data on total sunshine and average daily cloud cover in the period 2021-2023 for the measuring station Karlovac were obtained from the State Hydrometeorological Institute.

3.1. Average daily sunshine value

When there are no clouds, the heliograph strip is burned to measure the length of the sun's beams from sunrise to sunset. These measurements show how many hours the sun shone directly on a certain location. These facts have a practical value in that they provide information about the "insolation" of a specific area during a specific time of the year, or the number of hours a PV power plant at that location may use direct sunshine each day on average. [4]

Table 1 shows data of the daily sum of sunshine by day for June and July in the period from 2021 to 2023.

Table 1. Total amount of sunshine each day

Total amount of sunshine each day																																
Daily sum of sunshine (h) for Karlovac station for the period 2021 - 2023																																
Days of the month	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Monthly sum of sunshine
2021.																																
June	11,6	13	13,1	12,9	11,6	4,2	5,2	9,9	10,9	9,9	7,7	11,2	6,7	14,2	12,7	12,9	13,6	12,3	10,7	9,9	11,7	12,9	12,5	11,7	14	12,3	13,4	13,8	13,5	13,8		343,8
July	8,3	6,8	13	3,7	3,4	13,7	13,7	10,9	13,7	11,4	8,6	7,9	8,3	10,5	9,6	3	2,4	0,7	3,3	11,9	12,8	12,6	9,8	11,3	6,2	4,9	4,5	11,3	12,9	12,7	11,8	275,6
2022.																																
June	8,9	13,2	8,1	12,5	9,9	10,6	11,6	5,6	0,6	1,4	12,9	13,6	10	11,5	13,3	9,2	11	13,8	14	13,8	10,9	7	9,3	13,1	10,5	13,6	12,3	10,9	11,6	13,3		318
July	13,2	13,1	12,6	11,7	9,3	11,4	3,7	6,1	12,7	6,9	12,6	11,9	13,6	11,3	13,6	12,1	10,1	13,7	13,8	13,6	13,4	13,4	13	9	13	7,3	4	11	11,9	2	11,7	336,7
2023.																																
June	11,5	12,3	4,7	8	0	2,8	8,5	5,9	10,5	5	4	9,6	10,9	11,9	8,7	12	12,3	12,9	11,2	13,6	12,6	9,8	8,8	2,7	12,7	14	6,2	8,5	14,1	12,9		278,6
July	3,2	10,5	10,5	8,5	11,5	3,1	8,3	13,5	13,6	13,5	12	7,9	7,4	10,6	13,8	13,9	13,2	11,2	7,5	13,3	6,7	5,2	7,6	10,2	5,5	3,1	11,3	12,9	13,3	7	11,2	301

3.2. Average daily cloud cover

The term "cloud cover" describes how much of the sky is covered by clouds, or how big the cloud cover is in relation to the whole sky. Tenths of the covered sky, or values ranging from 0 to 10, are used to measure cloudiness; 0 denotes an entirely clean sky devoid of any clouds, while 10 denotes an entirely obscured sky. As an example, if we declare that the cloudiness is 2, it indicates that two tenths of the sky is cloudy and eight tenths are clear (this is because we regard the sky to be made up of ten parts, or 10 tenths). [6] Main and climatological stations provide data on cloud cover. When assessing the solar system's efficiency, it is crucial to consider that it essentially signifies the absence of direct solar radiation. [4]

Table 2 shows data of average daily cloud cover by day for June and July in the period from 2021 to 2023.

Table 2. Average daily cloud cover

Average daily cloud cover																																Average monthly cloud cover
Average daily cloud cover (tenths) for Karlovac station for the period 2021 - 2023																																
Days of the month	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
2021.																																
June	4,7	1,3	1,7	2,7	3	8,3	6,7	5,3	4,3	5,7	8	5,7	7	1,3	3	5	3,3	5	4,3	6	1,7	2,3	3,3	3	4,7	2,7	3	1	1,3	2,7	0	3,9
July	6,7	5,3	5,3	9,3	7,7	0	0	2,3	0,7	5,3	4,7	4	6,3	5	4,7	9,3	8,3	9,7	6,3	1,7	0,3	1,7	4	2	5,7	8	5,7	2,7	0,3	1,7	2	4,4
2022.																																
June	5	3,7	7,3	2,3	4,3	6	7	6,7	9,7	6,3	3	1,3	6	4,3	2	5,3	4,7	3	0,7	1,3	7,7	9	7,7	2,7	4	1	1,7	4,3	5,3	3		4,5
July	2,7	2,3	1,3	3	4	5,7	8,7	6,3	2,7	5,7	4,7	4,7	1	5	3,7	4	4	1	0	0,3	1,3	0,3	3	3,7	0,7	4	6,7	5	2	6,3	3,7	3,5
2023.																																
June	5,7	5,3	7	7,7	10	7,3	6,7	7,3	5,3	8	9,3	6	4	4,7	6	1,3	3,3	3	2	2,7	5,3	5,7	5,3	8,3	3,3	1,3	6,7	6,3	0,7	4		5,3
July	8,3	5,7	6	5,7	3	9,3	4	1,7	1,3	2,7	1,3	5,7	7,7	5	0	0,3	1	7	6,7	5,7	8,3	7	4,3	4	7,7	6,3	3,7	3	3,3	6,3	3,7	4,7

4. DEPENDENCY OF THE SOLAR POWER PLANT'S ELECTRICITY GENERATION ON THE TOTAL AMOUNT OF SUNSHINE AND CLOUD COVER EACH DAY

Photovoltaic systems work by means of a complicated interplay between multiple parameters. The essential factors in achieving optimal efficiency are temperature, angle of incidence, solar insolation, panel quality, and conversion efficiency. However, even though they have a lesser effect, factors like dust, humidity, shade, and spectral distribution should not be disregarded because they might have an impact on the long-term viability and functionality of solar systems. Therefore, to guarantee these systems' optimal effectiveness and contribution to a sustainable energy future, it is crucial to carefully plan, install, and maintain them. [5]

As it has already been explained, this study just looks at how sunshine and cloud cover affect the PV power plant VUK's output. The following diagrams show how the photovoltaic power plant VUK's output depends on daily cloud cover and sunshine hours throughout the months of June and July in the years 2021–2023.

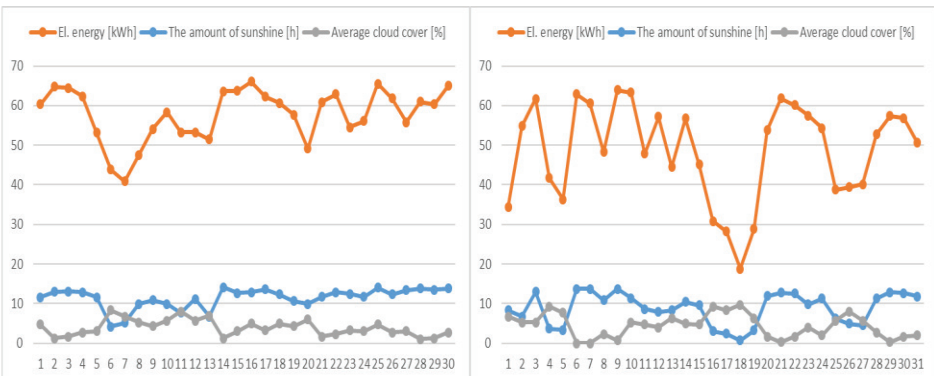


Figure 2. Dependence of electricity production on sunshine and cloud cover for June and July in 2021

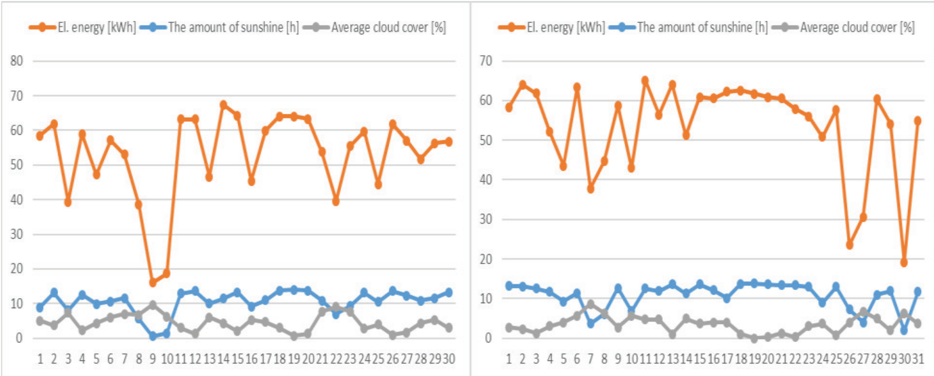


Figure 3. Dependence of electricity production on sunshine and cloud cover for June and July in 2022

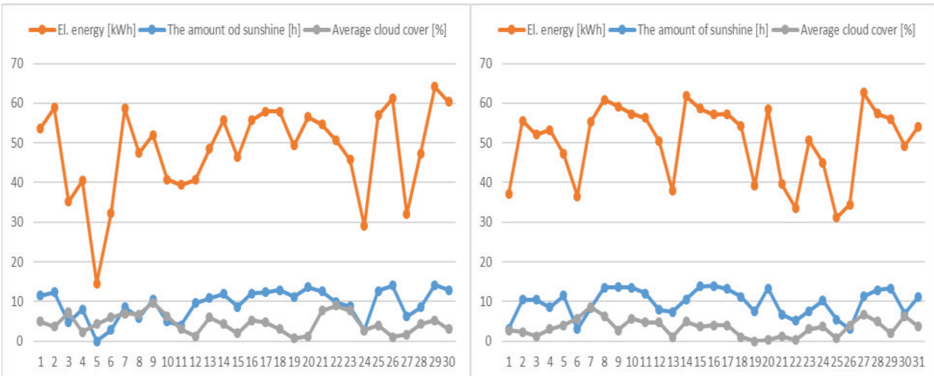


Figure 4. Dependence of electricity production on sunshine and cloud cover for June and July in 2023

5. CONCLUSION

We can see how sunshine and the average daily cloud cover directly correlate with the amount of electricity produced by the VUK photovoltaic power plant by looking at the graphs in the images above. It can also be concluded that the function of electricity production approximately follows the function of total sunshine during the day, while with regard to the function of average cloud cover, it is inversely proportional. The PV VUK power plant's minimum electricity production for the three years under consideration was 14.62 kWh on June 5, 2023. The measuring station Karlovac observed 43% of the sky covered in clouds on that particular day, with 0 hours of sunshine. There was a direct correlation between the amount of sunshine and the amount of electricity produced on June 22, 2023, with 9.8 hours of sunshine and 90% cloud cover translating to 50.59 kWh of electricity produced. This is the primary factor contributing to the electricity produced from the PV power plant. On June 14, 2022, a maximum of 67.41 kWh of electricity were produced. The total amount of sunshine and average cloud cover for that day was 11.5 hours and 43%. As said previously in the text, it's intriguing that that particular day did not have the optimum quantity of sunshine. This leads us to believe that a variety of factors influence how efficiently electricity is produced by the photovoltaic power plant.

Finally, solar power plants provide a responsible, renewable, and dependable alternative to fossil fuels for electricity generation during this crucial era of climate change and the energy crisis.

REFERENCES

[1] Widuto A.: Revision of the Renewable Energy Directive: Fit for 55 package, Available from https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698781/EPRS_BRI(2021)698781_EN.pdf , Accessed 2024-06-26.

[2] Project base of Karlovac University of Applied Sciences, Available from https://www.vuka.hr/istrazivanje_i_razvoj/projekti, Accessed 2024-06-26.

[3] Solar system VUK monitoring, Available from www.sunnyportal.com, Accessed 2024-06-26.

[4] Perčec Tadić M.: Klimatske informacije i obnovljivi izvori energije: Sunčevo zračenje, Available from http://klima.hr/razno/projekti2013/climrun_radionica1/WS_suncevo_zracenje.pdf, Accessed 2024-06-27.

[5] Vidović V.: Analiza parametara koji utječu na rad fotonaponskog sustava: Sveučilišni diplomski studij politehnika i informatika, Sveučilište u Rijeci, 2023, https://urn.nsk.hr/urn:nbn:hr:231:011969, Accessed 2024-06-28.

[6] Klimatološko meteorološki sector: Naputak za rad običnih klimatoloških postaja, Zagreb, 1993, Available from https://klima.hr/razno/dokumenti/naputak_omp.pdf, Accessed 2024-06-28.

5

ERGONOMICS

PRESERVING THE PHYSICAL AND MENTAL HEALTH OF EMPLOYEES AT THE WORKPLACE

Ines Baksa[1], Jasminka Horvatić[2], Sarajko Baksa[3]

[1] University of Applied Sciences in Security and Safety, Veslačka 2a, Zagreb, Croatia, ines_baksa@yahoo.com

[2] Open Mind Ltd., Savski gaj IX. 2a, Zagreb, Croatia, jasminka.horvatic@gmail.com

[3] Međimurje University of Applied Sciences in Čakovec, Bana Josipa Jelačića 22a, Čakovec, Croatia, sarajko_baksa@yahoo.com

Abstract: *Work place has significant influence on physical and mental health of employees. In order to influence on preservation of psycho - physical welfare of workers, it is important to consider influential factors, especially within technical areas of the production entity, for reasons because it is an area that is still insufficiently investigated. Authors with technical, interdisciplinary technical, and applied psychological critical approach have scientifically processed factors of quality of the working environment, given that it is supportive and stimulating working surroundings key to a conservation of physical and mental health. Furthermore, it has been established an important factor of quality of work on working place from the employees' point of view: balance between work and private life, as well as prevention of stress, recognition of stressors on working place and implementation strategy for their reduction. It includes education of employees about management of stress techniques and invigorating awareness of the physical and mental health.*

Keywords: *healthy working environment, physical and mental health, stress and burnout*

1. INTRODUCTION

Working place is a dominant domain in working life of an individual and the working environment is constantly changing to which people in their working activities have to adjust, especially towards industrialization, robotization and recent industrial revolutions. Employees are prone to stress, when requirements of work exceed ability of people to cope (or control) working requests and tasks. Therefore, employers should have to carry out preventive activities in order to optimize conformity between individual workers and his psychosocial, organizational, and physical work environment. The above is necessary to complement with the activities that promote health, and what aims to improvement of individual abilities facing challenges and strengthening of personal working and life skills.

Good mental health is important because it enables people to develop on many ways; emotionally, mentally, intellectually, and socially. Also, it is of use in the wider social and economic context, in places where people live and work, what leads to a social development and economic growth.

The work remains important characteristic of life for the majority of people; it has personal, economic, and social character. During the last few decades, nature of work has profoundly changed throughout Europe. There are fewer jobs that are defined as physical, and more of them have mental and emotional requirements, which in modern working environments become real challenge for the employee's [1].

2. EMPLOYEES' MENTAL AND PHYSICAL HEALTH FACTORS

It was found that mental and physical health of employees is connected primarily with the five factors related to work: Selection of vocation, Description of jobs and of tasks, Organization of work, Working environment and Personal income.

2.1. Vocational choice

Vocational choice is difficult decision for each person, especially for a young adolescent, because essentially effects on personally vital satisfaction and quality of life. When making career decisions experts can help with the procedure of professional guidance. Goal of professional guidance is determination of the abilities, professional interest, and contraindication for optimal choice of education and vocation in which will person long term perform some work with satisfaction, without having any psychophysical contraindication, with purpose of achieving economic independence and social competencies [2].

2.2. Description of jobs and tasks on working place

If a person has chosen optimal title according to personal abilities and interests, it is important to choose and appropriate position in the company on which will satisfy challenges at work accordingly to her/his own skills, because otherwise, the work would be stressful. Stress is the cause of mental and physical disorders. The ideal balance between individual skills and business requests is called Flow.

Flow is the state in which the worker is happy, because he has a challenging job, can control results, owns skills, and feels like it is working something important and purposeful. Persons which accomplished conditions for Flow, experience the call, they do not feel it stressful despite dedication to their work, they enjoy to work, what is visible from Figure 1 and 2 [3].

Figure 1. *Mental Health – Self Care Wheel* [4].

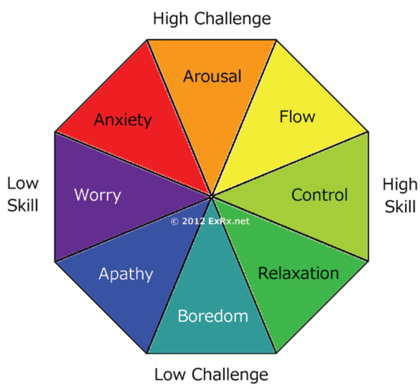


Figure 2. *Interaction Flow diagram of challenges and skill* [5].

Conditions for Flow; challenges equal to skill level, clear goals, knowledge what to do, deep concentration, sense of control, loss of sense of time, activity becomes meaningful, purposfullness to activity. Additional experiences during Flow are; the Ability to achieve goals and reliability, Inner clarity, Feeling of ecstasy and Feeling of serenity [3].

Satisfied workers will with their own creativity achieve default aim with the least efforts in the shortest possible time (OTLA principle). On the other hand, it was determined that dissatisfied workers have tendency to incapacitate themselves regarding fear, with possible mistakes, non-acceptance of responsibilities, finding deficiency in others, unrealistic evaluating of life been too much complex, rationalization of failure, and by self-assessment that they are incapable to think logically independently.

2.3. Organization of work

Rational schedule of human resources is one of the most important factors of efficiency and company’s economic success. It implies optimization between workers competence and theirs position in the company. When the employment of new workers occurs, it is desirable to select those who will be more efficient on positions where employee works alone on a relationship to those who, according to their personalities structure, do prefer teamwork. On the occasion when the new team member is employed it is recognized that, in addition to wanted competencies, personality’s structure and communication skills "fit" into existing group dynamics and rules of work.

Organization of work is a responsible work in scope of the managers. In addition to organizational abilities and knowing work of everyone subordinate, quality and successful boss should have better communication skills, to be fair and expresses positive relationship according to employees, in order that they are maximally motivate to work, without the workers experiencing it as a torture, but as honor and confidence which superiors expresses to them.

According to our experience, more often the managerial staff profile incompetent people with personalities disorders. Because of fear of competent individuals, bosses abuse such quality workers with overloading of business tasks, deprivation of information, disparagement and humiliation with tasks that are not in the description of workers work place, by searching for social isolation from sides of others employees, threats with termination of the employment contract or with the expectation that it will worker alone give cancellation due to toxic working atmosphere. Listed superiors’ behaviors are stressful for workers and consequently violate their mental and physical health.

Activation of humane reaction "fight or run away" is the most common psychosomatic answer on stressful situations which employees experience during telephone conversations, business meetings or readings to them disturbing e-mails. It is usually the faster heart beats, shallow faster breathing, and muscle convulsions. Long term stress exposure results in mental health disorders which manifests itself as anxious-depressed disorder or post-traumatic stressful disorder. Result of frustration and stress at work is often burnout syndrome [6].

2.3.1. Burnout at work

Burnout syndrome at work represents progressive loss of idealism, energy, and meaningfulness of own work. This syndrome arises as repercussions of frustrations and stress on working place. Although similar to syndrome of chronic fatigue, it differs by change of attitude according to business, what it is not characteristic of ordinary fatigue.

Persons which are exposed to a long-term stress at work, they often experience emotional exhaustion, depersonalization (creation feelings of insensitivity and cynicism towards others) and reduction in efficiency and motivations. Burnout at work can seriously result on physical and mental health and is therefore important to recognize symptoms and look for appropriate professional medical psychological support [7].

Symptoms of the burnout syndrome include physical, emotional, and behavioral changes;

a) *Physical changes*: exhaustion, chronic fatigue, increased variation of physical weight, reduced immunity, increased needs for opiates, cigarettes, alcohol, etc.,

b) *Emotional changes*: depressed mood, feeling of a loss sense, loss of motivations and enthusiasm when heading to work, feeling helplessness and sadness, loss of self-esteem and confidence,

c) *Behavioral changes*: loss of concentration, nervousness, explosiveness, negative behavior with colleagues at work, excessive sensitivity on physical environment (light, noise), excessive preoccupation by work [8].

Stages of the burnout usually develop gradually as they pass through several phases;

a) *"The honeymoon"* phase: Your work makes you happy, and you are fulfilled with enthusiasm, you feel content, none of the tasks is not heavy for you,

b) *Reality*: You notice that everything is not so perfect, your boss sets you more and harder tasks. You try to exert yourself, work harder, disappointment and frustration become everyday life. Gossip and ploy start on working place, you are coming home all later, and overtime hours are not paid. You realize that your job does not satisfy you, either socially nor financial,

c) *Disappointment phase*: You fell into the closed circle – you become tired and nervous, you suddenly loss or gain weight, and have sleeping problems. You feel anger and blame others for what is happening to you. You openly start to be critical towards your superiors and colleagues. You feel helpless. Anxiety and depression have become part of your everyday life, you are often ill,

d) *Alarm phase*: You are exhausted, yours mental and physical reserves are spent. You have a feeling of permanent failure; you lose confidence and belief in yourself. You feel unable to make any kind of changes in your life. This phase is serious and if you do not look for help, it can leave serious consequences on your health. Now your life does seem to you quite meaningless and you feel constant despair [7].

2.4. Working atmosphere

The author's non-invasive (non-contact) observational research carried out for 10 years indicate that dissatisfied employees are guided by thoughts about what others would do to make them to be pleasant and comfortable, in contrast to satisfied employees who have attitude, what can I do to make pleasant working atmosphere to my colleagues and myself? In accordance to clinical experience and carried out researches by the authors, inside the actual production lines and work places, most workers on question to describe optimal working atmosphere states expectations as follows:

1. Friendly and supporting associates,
2. Challenged work, personal development, advancement,
3. Good superior,
4. Decent balance between business and private occasions,
5. Diversity of working tasks,
6. The impression that you do something which is appreciated and has sense,
7. The impression that yours work contribute,
8. That you are part of successful team,
9. Recognition for a well-done job, and
10. Competitive income.

Working environment is significant for the workers and for the company, because satisfied employees; take over the responsibility, show optimism and self-confidence, establish good interpersonal relationships, divide job from actual persons, know how to give and to receive praise and reviews, prevent conflicts and reduce stress on work.

Pleasant working atmosphere can be insured by selection of workers before employment, on a way not to get hired people with personalities disorders, in particular narcissist disorder, because they threaten group or team dynamics, whether they are in management or collaborative position. These employees are prone to abuse their associates. The most reported mobbing is in healthcare, education, and others public institutions. Mobbing victims are employees who "stick out" for something. Ideal victim has the following characteristic; perfectionist, responsible, motivated, tidy, and conscientious person, more capable of others, sensitive on acknowledgments and objections, with expressed feeling for the social justice and irregularities at work. By using methods of observational scanning, it was concluded that because of feel of personal endangerment, narcissis, ignore her/him as if it does not exist, turn away from social life, victim usually gets inappropriate tasks, and her/his work is constantly criticizing. Associates in narcissus shadow, from fear of the possible revenge, interrupt conversation in the victim's presence. Described toxic atmosphere results in violation of mental and physical health of victims and others associates [9].

2.5. Personal income

Financial indicator of work effect is an important element of work satisfaction. It is also motivating possibility on advancement with corresponding financial effect.

Competent workers can agree on more modest income during only exceptionally brief time, after they will give dismissal of their employment contract, they will abandon the former work place and cross to the working places that are set in accordance with their financial expectations.

3. CONCLUSION

Conservation of employee's health is the key to productivity and welfare of each organization. Author's research indicates that; quality working environment, balance between business and private life, stress prevention, lifting awareness of the mental and physical health, programs for helping employees and their inclusion are key factors in creation of supportive work and healthy environment. Next established is organization that need actively work on these factors to ensure healthy and productively working environment, as well as successful and quality production of goods and services.

Healthy employees are foundation of a successful organization. Through continuously tracking and improvement of working conditions, support to employees and education about the importance of physical and mental health, organization can create acceptable environment in which employees feel appreciated, motivated, and capable to deal with the set work challenges. Even though, the conservation of employee's health it is not only the responsibility of employers, but a common goal that contributes to a better productivity, reduction of stress and increase of satisfaction at the working place.

The factors the were established by non-invasive observational methods that includes scanning of work at the workplace, and what authors applied in their research, contribute to creation of a productive, healthy, and supportive work environment.

REFERENCES

[1] Kuhn. K.: Challenge of modern working life to mental well-being and social inclusion, In *Mental health and well-being at the workplace – protection and inclusion in challenging times*, Anja Baumann and Matt Muijen, WHO Regional Office for Europe, and Wolfgang Gaebel, German Alliance for Mental Health, ISBN 978 92 890 0205 9, Copenhagen, Denmark, (2010), pp. 13-17

[2] Tocauer, L.; Ćuk, I.; Horvatić J. & Blaguški, K.: Ostvarivanje ciljeva rehabilitacije kroz suradnju Stručnog tima, roditelja i obitelji, *Zbornik radova: 6. Alpsko – Jadranski Simpozij za međunarodnu suradnju u rehabilitaciji*, Tobelbad, (1989).

[3] Csikszentmihalyi, M.: *Flow and the Foundations of Positive Psychology*, Springer Dordrecht Heidelberg New York, ISBN set: 978-94-017-9083-3, USA, (2014)

[4] Wooll, M.: How to achieve and improve emotional health, Available from https://www.betterup.com/blog/emotional-health-examples, Accessed: 2024-04-18

[5] ExRx.net: Flow - Challenge and Skills Effect on Mental State, Available from https://exrx.net/Psychology/ChallengeSkillMentalState , Accessed: 2024-02-14

[6] LeBlanc, N. & Marques, L.: How to handle stress at work, Harvard Health Blog, *Petra Kos Grabar* https://www.health.harvard.edu/blog/how-to-handle-stress-at-work-2019041716436, *Accessed:* 2024-04-24

[7] Sindrom sagorijevanja na radnom mjestu, Available from; http://tuzla.danas.info/2012/11/20/sindrom-sagorijevanja-na-radnom-mjestu/, Accessed: 2024-03-18

[8] Kos Grabar, P.: Burn out – Sagorijevanje na poslu, *Available from;* https://www.centaruspjeha.com/burn-out-sagorijevanje-na-poslu/, *Accessed:* 2024-03-16

[9] Baksa, S.; Horvatić, J. & Baksa, I.: Psychological Violence in the Workplace, *Proceedings of Risks and Safety against Physical and Mental Violence at the Workplace, The European Society of Safety Engineers (ESSE),* Vrdnik, Srbija, *October* 2023, Evropska Asocijacija Zaštite na radu, Novi Sad, (2023).

DIFFERENCE IN THE ANTHROPOMETRIC CHARACTERISTICS OF ATHLETES AND THE GENERAL POPULATION AND THEIR IMPACT ON HEALTH

Blaženka Brlobašić Šajatović, Renata Hrženjak, Ksenija Doležal

[1] University of Zagreb, Faculty of Textile Technology , Prilaz brauna Filipovića 28, Zagreb, CROATIA, blazenka.brlobasic@ttf.unizg.hr

Abstract: *The influence of sporting activities leads to changes in the morphological structure and relief surface of the body in people who actively exercise compared to people who do not exercise. Exercise brings about certain physical changes that lead to changes in the morphological structure: Increase in muscle mass, decrease in adipose tissue in certain areas of the body. If we compare the results of anthropometric measurements of the general population and the trained population, the difference in their body shapes and BMI becomes clear. Body shape affects the fit and construction of clothing, which underlines the importance of exercising. The study was conducted on a sample of the male population totaling 324 men aged 18 to 26. 162 soccer players with an average playing experience of 10.7 years and 162 untrained men from the general population were measured.*

Keywords: *football players, untrained, BMI*

1. INTRODUCTION

Based on the influence of sports activities, changes in the morphological structure (relief surface of the body) of people who are actively involved in sports compared to people who are inactive in sports were investigated. In addition to genetics, the athlete's constitution is influenced by the athlete's morphological, physiological, biochemical, immunobiological and psychophysical properties [1].

There is no special constitution for certain ages, because a child changes very quickly in its development, so it is only after the age of ten that it is possible to determine the first definition of individual types, and after the age of twenty, the constitutional types of an adult are defined [2]. With the appropriate training process and diet, it is possible to develop a certain type of body or the so-called. somatotype in a young athlete according to the characteristics of the optimal somatotype. The somatotype of young promising athletes, who are still in the period of growth and development, is similar to that of adult athletes [3].

Training brings about certain morphological changes such as: increase in muscle mass, elimination of fat and adipose tissue on certain parts of the body. With long-term training, muscle mass can increase between 30-60%. By anthropometric measurement of the sports population, body proportions are determined, on the basis of which certain changes in the morphological characteristics (relief body surface) of the athlete can be noticed, along with the analysis of specific physical differences acquired during long-term training. The shape of the human body changes according to gender and age. The distribution of fat tissue and muscles is different in women than in men, different in a child than in an adult, and different in the elderly, and all of these make up the shape of the body. Body composition changes significantly during growth and maturation. Total body mass consists of lean and fat mass. Lean body mass consists of muscles, skeleton and internal organs, and fat mass consists of essential and non-essential fat. Essential fat makes up 2-5% of lean body mass in the form of lipid components of cells, and non-essential or reserve fat is made up of subcutaneous adipose tissue. The ratio of fat and lean parts of the body changes during life, and it is possible to change it by external factors such as diet, exercise and sports activity [4].The values of subcutaneous fat tissue are different in men compared to women:

- men: below 8% fat is a low percentage, from 8-20% is normal, from 20-25% is a high percentage and over 25% is a very high percentage of fat tissue in the body.
- women: below 21% fat is a low percentage, from 21-33% is a normal percentage of fat, from 33-39% is high and over 39% is a very high percentage of fat tissue in the body.

The normal percentage of muscle mass for an average woman is 18-30%, and for a man 10-25% [62-64]. The highest ratio of the lean part to the fat part is reached around the age of 20, and then the ratio decreases in athletes, that is, physically active people (Figure 1). It is important to define the minimum percentage of body fat, because an excessively low amount of adipose tissue has a negative effect on health [5].

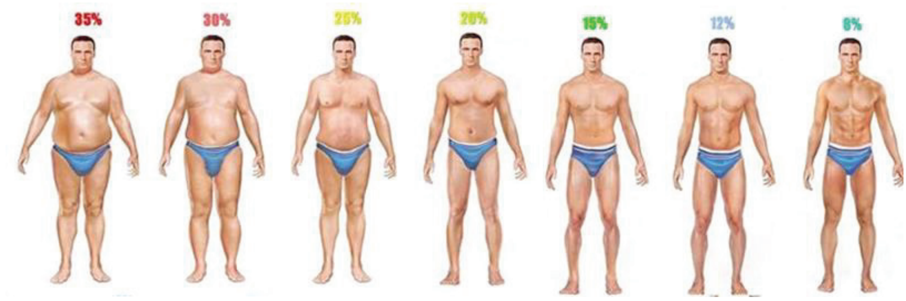


Figure 1. Body fat percentage decreases with sports activity [6]

After the age of 20, a normal increase in body fat is expected by 1%, and by the age of 60, the total normal increase is 4%, and the amount of subcutaneous fat after the age of 60 decreases. Body fat values up to 25% in men and 30% in women are considered normal values in adulthood. Based on the analysis of body composition, the percentage of body fat in athletes was obtained. Table 1 shows the optimal values of body fat in athletes in certain types of sports [7].

Table 1. Presentation of percentages of body fat in different types of sports [7]

Sports	*Man*	*Women*
Alpine skiing	7-15	10-18
Cycling	5-11	8-15
Gymnastics	5-12	8-16
Ice Hockey	8-16	12-16
Wrestling	5-16	-
Sliding	5-12	8-16
Basketball	6-12	10-16
Football	6-14	10-18
Volleyball	7-15	10-18
Swimming	6-12	10-18
Tennis	6-14	10-20
Bodybuilding	5-8	6-12
Rowing	6-14	8-16
Fencing	8-12	10-16
Golf	10-16	12-20

The shape and posture of the body is significantly affected by active participation in sports, and there is a clearly visible difference in the body structure of an athlete and a non-sporting person with the same body fat ratio of 10%.

2. BODY MASS

Belgian Flemish astronomer, mathematician, statistician, and sociologist, Lambert Adolphe Jacque Quetelet (1796-1874), has developed Body Mass Index (BMI), what he called “social physics” [8]. WorldHealth Organization (WHO) formerly called BMI the Quetelet index [9]. The aim of Quetelet’s datacollection was not for determining disease risk, but rather he was attempting to anthropometrically quantify the “average” man [10] .In the early and middle of the 20th century obesity was a problem of only high-income countries, such as almost every country of Europe and the USA. Low-income countries have burdened with high levels of under-nutrition, such as stunting, wasting, underweight, and infectious diseases .But in the 21st century, obesity has expanded to low- and middle- income countries of every region of the world .At present obesity is considered as one of the most fatal health issues worldwide. Hence, elapse of time; obesity remains not a local problem but becomes a global concern. Therefore, accurate measurement of obesity is needed for the treatment of underweight, overweight, and obese people

The Body Mass Index (BMI) is the relation between limited information, weight and height that does not account for body composition. It is defined as the body mass divided by the square of the body height, whose unit isnkg /m2 or lb / inch2 ; where height is measured in meters/inch, and mass in kilograms/pounds [10].

BMI = weight (kg)/height (m)^2

BMI cannot define the percentage of fat tissue in relation to muscle or bone mass, which are the basic parameters for assessing whether a certain person is obese or not. Individuals with a large body mass and high BMI index values cannot be automatically categorized as obese, for example in large-built people, the proportion of muscle and bone mass in relation to height is high, but this does not mean that they are obese. Therefore, BMI cannot be a measure for assessing health or obesity, but it is used as a good statistical measure of nutrition. The values of the recommended BMI are the same for both sexes, it amounts to 18.5 - 24.9 kg/m2 according to the classification of the World Health Organization for the European population. Such a calculation indicates the degree of risk of developing some diseases such as high blood pressure, diabetes, disorders of blood fat levels, vascular diseases including heart attack and stroke, gallstones, osteoarthritis, some types of cancer and others. The higher the index, the greater the risk of contracting the aforementioned diseas [11].

Table 2. BMI classification

BMI	***Classification***
<20	Malnutrition
20 - 25	Ideal weight
25 - 30	Excessive body mass
>30	Obesity

The above classification is according to the recommendations of the World Health Organization (WHO), however, these recommendations and categorization may differ from country to country - depending on the type of body structure. For example, residents of China and Japan (short Asians) with a BMI of more than 23.5 are already visibly overweight, and with a BMI of 27.5 they are clearly obese given their body structure and proportions (Table 2).

3. EXPERIMENTAL

The population of young men of trained and untrained population includes respondents aged 15 to 26 years old. a representative sample of subjects (untrained group) was selected by random selection from the general population. For the purposes of this research, a total of 162 football players were measured by conventional anthropometric measurement. Out of the total number of football player respondents, 53 respondents were measured using a 3D body scanner. The average age of the interviewed football players is 19.5 years, and the average playing experience is 10.7 years. For the purposes of this research, 54 anthropometric sizes for young men were determined using the conventional method, in accordance with EN 13402. The arithmetic mean of the football player's body height is 180.3 cm, the standard deviation is 5.64 cm, the body height ranges from 166.5 cm to 193 cm, and with 95% confidence it is estimated that the average body height is within the limits of 179.4 cm to 181.1 cm.

The arithmetic mean of the body height of the subjects of the untrained group of the general population is 179.4 cm, the standard deviation is 5.25 cm and ranges from 170 cm to 190 cm, and with 95% confidence it is estimated that the population average is within the limits of 178.6 cm to 180.2 cm. The total coefficient of variation for body height is 3%. (Table 3).

Table 3. Main body measurement

Main body measurements	***Group***	$\bar{x}$ [b]	***s*** [c]	***CV*** [d] ***(%)***	***95% CI*** [e]		***Range***	
					h_1	h_2	***Min.***	***Max.***
Body height (cm)	Football players	180,3	5,64	3,1	179,4	181,1	166,5	193,0
	Untrained	179,4	5,25	2,9	178,6	180,2	170,0	190,0
Body mass (kg)	Football players	74,3	7,33	9,9	73,1	75,4	60,0	100,0
	Untrained	73,9	10,76	14,6	72,3	75,6	55,0	105,0

Table 4. BMI

Main body measurements	***Group***	$\bar{x}$ [b]	***BMI***
Football players	Body height (cm)	180,3	22,86
	Body mass (kg)	74,3	
Untrained	Body height (cm	179,4	23,02
	Body mass (kg)	73,9	

The body height of football players is higher compared to the untrained population, and so is the body mass. However, the BMI is lower, which shows a lower proportion of fat tissue in the group of football players. According to BMI values, both groups belong to the ideal weight group (Table 4). [12].

4. CONCLUSION

The body mass index itself is not a perfect measure, because taller and/or more muscular people will generally have a higher body mass index, although the proportion of fat tissue will be relatively low, so when assessing the risk of developing obesity-related diseases. It is possible to influence body composition and the proportion of fat and lean components by changing eating habits and sports activities, in order to maintain the ratio of fat and lean components within favorable limits for health and physical fitness.

REFERENCES

[1] Ujević, D.,i sur..: Hrvatski antropometrijski sustav - Rezultati antropometrijskih mjerenja mladića dobi od 12, 5 do 20, 4 godine starosti, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, Zagreb, (2006). Surname, N.; Surname, N.: *Name of Book (in Italics)*, Publisher, ISBN, Place of Publication, (YYYY)

[2] Mišigoj Duraković Marjeta: Kinantropologija, Biološki aspekti tjelesnog vježbanja, kineziološki fakultet Sveučilišta u Zagrebu, Zagreb, 2008., ISBN 978-953-6378-73-9

[3] Mišigoj-Duraković, M., Heimer, S.: Neke karakteristike somatotipa u mladih sportaša - košarkaša i odbojkaša, Športsko-medicinske objave, 22(9-12),1985., 239-244

[4] Joy Bauer: Nutricionizam, prevela s engleskog Vesna Bosanac, Hena Com, Zagreb, 2005., ISBN 953-6510-92-8

[5] Mišigoj-Durakovi M., Heimer S. i Matković B.: Morphological and functional characteristic of the student population at the University of Zagreb, Kineziologija, Zagreb, 30 (2), (1998)

[6] http://www.thefitspirationalblonde.wordpress.com, *Accessed*: 2024-06-21

[7] Čolakhodžić E., Skender N., Pistotnik B.: The Changes of Body Composition Dimensionality Among Soccer Players at the Age Period 12 to 14 Years*US-China Education Review A 5 657-665, US-China Education Review, 2011, ISSN 1548-6613, dostupno na http://www.davidpublishing.com/davidpublishing, *Accessed*: 2024-06-21

[8] Mardolkar, M., (2017). Body Mass Index (BMI) Data Analysis and Classification. International Journal of Computer Science and Mobile Computing, 6(2), 8-16.

[9] WHO, Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation. Geneva,Switzerland: World Health Organization. (2000).

[10] D. Mohajan at all.: Body Mass Index (BMI) is a Popular Anthropometric Tool to to Measure Obesity Among Adults, *Paradigm Academic Press Journal of Innovations in Medical Research* ISSN 2788-702APR..**2**, NO.425 (2023)

[11] https://www.plivazdravlje.hr/zdravlje-online/bmi, *Accessed*: 2024-06-21

[12] Brlobašić Šajatović B.:Investigation of body proportions of trained and untrained population as factor in the processes of garment construction, PhD Thesis, University of Zagreb, Croatia, (2014)

ANALYSIS OF ENVIRONMENTAL HEAT ON A WORKER IN A SAW MILL

Minka Ćehić[1], Hasan Talić[2], Selma Mujanić[3]

[1] University of Bihać, Pape Ivana Pavla II 2/2, Bihać, Bosnia and Herzegovina, minka.cehic@unbi.ba

[2] University of Bihać, Pape Ivana Pavla II 2/2, Bihać, Bosnia and Herzegovina, hasan.talic@unbi.ba

[3] University of Bihać, Pape Ivana Pavla II 2/2, Bihać, Bosnia and Herzegovina, selmamujanic14@gmail.com

Abstract: *The exposure of workers in sawmills to various hazards such as mechanical injuries, noise, wood dust and extreme climatic conditions represents a significant challenge for their health and safety. Climate change, especially the increase in temperatures, has further aggravated these problems, putting workers at risk of heat stress. This research analyzed the influence of temperature on working conditions in a sawmill in Bosnia and Herzegovina. Measurements have shown that workers in the log yard and log preparation are exposed to high temperatures, which leads to serious health problems such as heat stroke, dehydration and reduced work capacity. In parallel with that, workers in the internal parts of the sawmill, such as sawdust processing, have somewhat more favorable conditions. Therefore, it is necessary to take adequate protective measures and adapt working conditions in order to protect the health and safety of workers in sawmills, especially in the context of increasingly frequent extreme climatic conditions.*

Keywords: *sawmills, working conditions, thermal stress, protection, workers' health*

1. INTRODUCTION

The exposure of sawmill workers is a complex and important part of the production process. This industry sector often faces specific challenges related to the safety and health of workers, which requires careful consideration and the application of adequate protection measures. Workers in sawmills are exposed to: various mechanical dangers, as a result of working with large pieces of wood and machines, danger from the influence of wood dust, high noise, unfavorable microclimatic conditions, increased physical effort because physical work is still evident in these jobs [1].

The research conducted in Turkey includes the analysis of demographic, physical and environmental, and ergonomic factors on working comfort in sawmills. The workers detected the following problems: noise 38%, wood dust 24%, ventilation 5%, vibrations 2%, heat/cold 8%, and other problems 23%, which include evaporation of resins or oils, stressful working conditions due to market requirements, insufficient or inadequate training of workers, age structure of workers and others [2]. It is also possible to find a large number of papers that analyze the impact of noise and wood dust on human health, and when it comes to heat or cold, the impact of a cold climate is usually analyzed [1].

However, in recent years we have witnessed significant changes in the climate and increasingly higher temperatures. The last decade (2011-2020) was the warmest on record as the increase in global mean temperature was 1.0 - 1.1°C compared to the pre-industrial period. In the same period, the global mean temperature in Europe grew even faster, by 1.7° - 1.9°C. Data from the EURO-CORDEX18 initiative predict that by the end of the 21st century, the temperature of the European mainland will increase by 1.4° - 4.2°C, that is, by 2.7 - 6.2°C compared to the period in 1971 -2000. [3].

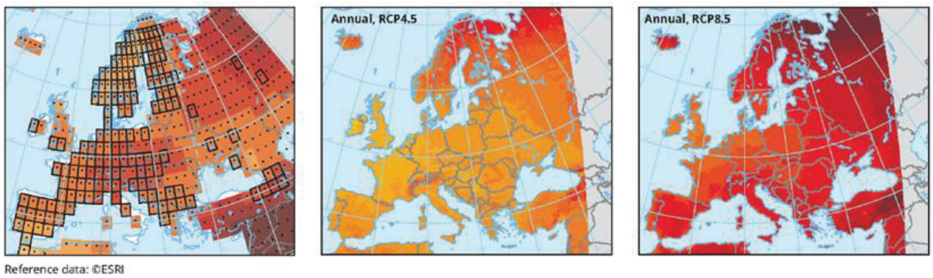


Figure 1. Average temperature of Europe: a) for the period 1960-2019. yr.; b) predicted land temperature changes until 2071-2100 according to RCP4.5 and c) predicted land temperature changes until 2071-2100. according to the RCP8.5 scenario.

This rise in temperature causes an increasing risk of heat waves. Although today the area of Europe is not in the area of increased risk, still the assessment for the period up to 2085 shows that parts of Europe, specifically Bosnia and Herzegovina, will be at a risky level, which requires certain interventions regarding the protection of workers' health.

2. DETERMINATION OF WORKING CONDITIONS AND INFLUENCE OF HEAT ON HUMAN HEALTH

Climate change affects the safety and health of workers through increased temperatures, exposure to ultraviolet radiation, contact with pathogens, indoor and outdoor air pollution, and extreme weather conditions. These changes can amplify existing risks or create new ones, such as heat-related disorders, vector- and water-borne diseases, accidents, allergies, and cancer.

To determine the working conditions when performing various tasks outdoors, the value of air temperature, relative humidity, the effect of solar radiation and wind speed should be taken into account, and this can be done using the parameters known as thermal indices. WBGT - wet bulb global temperature and humidex index - HI are used to analyze outdoor working conditions at high temperatures [8].

Table 1. Heat Stress Calculator

CATEGORY	HEAT INDEX	POSSIBLE CONSEQUENCES
Extreme danger	54°C and higher	Heatstroke even without activity with prolonged exposure.
Danger	41°C - 54°C	Heat cramps even without

		further activity.
Extreme coution	32°C - 41°C	Sunburn, cramps, exhaustion, heatstroke with prolonged exposure and/or physical activity

Table 1 shows possible consequences depending on exposure to different temperatures in the interval from 27°C to 54°C and more. If you work in strong and direct sunlight or wear special protective clothing, the WBGT value should be increased by the values of the type: polypropylene coveralls +0.5, polyolefin coveralls +1, coveralls made of thin material, double layer +3 and waterproof suit + 11.

Considering the measured Humidex index, it is necessary to take certain measures to protect the worker. HUMIDEKS 1 - refers to an unacclimatized worker performing moderately heavy physical work and HUMIDEKS 2 - refers to an acclimatized worker performing moderately heavy physical work, shown in table 2 [8].

Tabela 2. Advice for workers regarding the Humidex index

H 1 (°C)	ADVICE	H 2 (°C)
25 - 29	It is mandatory to provide workers with drinking water.	32 - 35
30 - 33	Warn workers about heat stress, encourage them to drink extra water, control temperature and humidity.	36 - 39
34 - 37	Warn workers of the danger, warn them to drink additional amounts of water, ensure that they are trained to recognize heat stress.	40 - 42
38 - 39	Work while ensuring 15 min break every 1 hour, drink at least 2.5 dl of water every 20 min, if you notice symptoms of heat stress, you must seek medical help.	43 - 44
40 - 41	Work with a break of 30 minutes every hour with a previously prescribed provision on such work..	45 - 46
42 - 44	If possible, work with a 45-minute break in an hour with a previously prescribed provision on such work.	47 - 49
45 i više	Only an occupational medicine specialist can approve the continuation of work.	50 and higher

The human body reacts to heat by redistributing blood flow to the skin, where heat is transferred to the environment through dilation of blood vessels or vasodilatation, and through sweating and evaporative heat loss. This thermoregulatory response increases cardiac oxygen demand, which can exceed supply among those with common (underlying) heart disease and ultimately lead to cardiac ischemia, infarction, and collapse. When the thermoregulatory capacity of the body is exceeded, heat stroke can develop. Extreme heat can affect concentration and cause mental fatigue, dehydration, exhaustion, worsening heart, respiratory and kidney disease and potentially heatstroke, exhaustion and syncope if the body cannot maintain its normal temperature. Intense physical work can additionally contribute to the internal production of body heat. Prolonged exposure to heat can result in impaired judgment, reduced alertness and fatigue, increasing the risk of accidents.

3. EXPERIMENTAL TESTING OF THE TEMPERATURE AT THE WORKPLACES INSIDE THE SAWMILL PLANT

Work that takes place at sawmills does not belong to the group of jobs and the working hours are determined independently of the characteristics of the surrounding climate and are the same throughout the year (eg from 7:00 a.m. to 4:00 p.m.). It is known that certain tasks within the sawmill production process are performed outdoors, while other tasks are performed inside the production hall or in semi-closed, covered areas.

What is the temperature change inside the sawmill and what effect does it have on the workers was investigated in the sawmill "Asim-comerc" in Bužim, Bosnia and Herzegovina. The production hall is semi-closed, while the warehouse is exposed. Testing was done at three production locations during working hours on hot days, the testing consisted of two parts. The first part included measuring the temperature and recording the heat distribution with a thermal imaging camera type FLIR, and the second part included surveying workers about work comfort in the workplace. The questionnaire contained information about the age of the worker, the feeling of work comfort, the complaints the worker feels, the protection measures he takes, health problems, the period of worst exposure and the position of the workplace.

3.1. Results and Analysis

The test was conducted in a sawmill at 3 workplaces, namely: log storage - forklift operator, log preparation - log chopping and washing worker, sawdust processing - circular saw worker. Tests were performed there and a display of temperature measurement and recording of heat distribution with a thermal imaging camera was given.

Figure 2. A snapshot of heat distribution at the log warehouse workplace - a worker on a transport forklift

One worker works on a forklift for transporting logs at the log depot, where he is exposed to direct sunlight during the day. The measured temperature is 36°C and the relative humidity is 51%, while it is even higher in direct sunlight. The forklift from picture 1 shows a maximum temperature of 56°C. The forklift does not have air conditioning and the worker says in the questionnaire that sometimes it is almost impossible to sit inside the forklift. The worker is aged 50-55 years, and he stated the following items: generally very hot, the most pronounced part of the body is the head and trunk, he drinks large amounts of water and takes short breaks as much as his work allows, the heat makes him nervous, reduces his performance, has occasional headaches and additional stress, the hardest time to work is 1:00 p.m.-4:00 p.m.

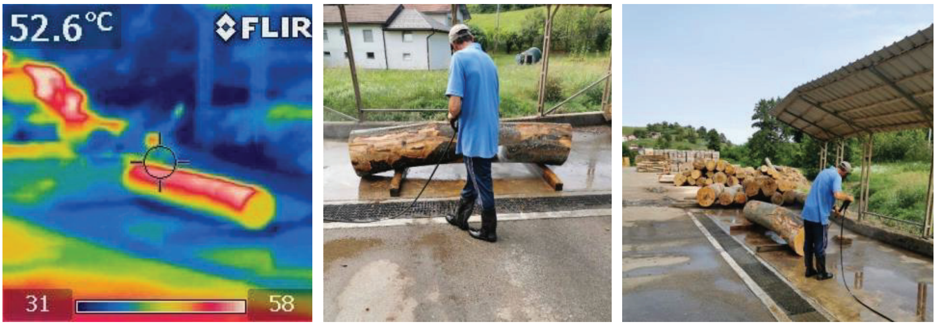


Figure 3. A snapshot of heat distribution at the log preparation workplace - a worker cutting and washing logs

The workplace for the preparation and washing of logs is also directly exposed to the sun, the measured temperature is 36°C, the relative humidity is 56%, while in direct sunlight the temperature is higher, as shown by the video where certain parts such as the log and the asphalt floor reached a temperature of 58°C. The worker is aged 45-50 years, and he stated the following items: generally very hot, the most pronounced part of the body is the head, arms and legs, he drinks large amounts of water and takes short breaks, the heat makes him nervous and stressed, reduces his effect, it occasionally creates mild burns on his body, the time when it is most difficult to work is 14:00-16:00, the lightening factor when washing the water freshens the air and increases comfort.

Figure 4. A snapshot of heat distribution at the sawdust processing workplace - worker on a circular saw for cutting

At the workplace for processing sawdust, which is not directly exposed to the sun, it is located in a covered area where one side of the building is open. The measured temperature inside is 28°C. The worker is between the ages of 45-50 and 35-40, and he reported the following items: generally very hot, the most pronounced part of the body is the head and torso, he drinks large amounts of water and takes short breaks, the heat makes him nervous, reduces performance, the time when it is most difficult to work 14:00-16:00, the facilitating thing is that they are not directly exposed to the sun.

Based on the measurement and survey of the workers, it is possible to see the problems of the workers who are exposed to external weather conditions, with a focus on the summer period and extreme heat. Also, these workplaces are most exposed in winter weather conditions, i.e. the impact of cold on workers and their productivity.

4. CONCLUSION

Examining working conditions at sawmills, especially in the context of exposure to high temperatures, showed significant challenges and the need to apply adequate protective measures. Workers at log warehouses, in the preparation of logs and processing sawdust are exposed to different levels of heat, which directly affects their health and work comfort. Maximum temperatures measured at workplaces have reached over 56°C, which poses a serious health risk, including possible symptoms such as nervousness, reduced performance, headaches and even heat stroke.

The use of thermal indices such as IVGT and the humidex index enables the assessment of the risk of heat stress, which allows the adoption of proper protective measures such as ensuring sufficient hydration, frequent breaks and adequate ventilation. It is necessary to continuously monitor working conditions and educate workers about self-protection measures in order to reduce the negative impact of extreme weather conditions on their workplace. It is also necessary to organize jobs in the form of replacing heavier physical work with machines, rotating jobs, avoiding work in the hottest periods of the day, working in shifts, ensuring acclimatization time, introducing additional workforce, providing better protective equipment and the like.

Given the expected rise in temperatures in the region, further research and implementation of specific worker protection protocols will be key to preserving their health and productivity

REFERENCES

[1] Croatian Institute for Health Protection and Safety at Work: *Guidelines for good practice safe work in sawmills*, 2016

[2] Sütçü, A.; Semerci, N.T.: *Occupational health problems of sawmill workers processing red pine in turkey*, Applied Ecology and Environmental Research 17(4): 7625-7639., International scientific journal, 2019

[3] Daalen K., Füssel H.M, Kazimierczak A., Romanello M.: *Responding to the health risks of climate change in Europe*, Lancet Countdown; European Environment Agency, 2021

[4] Polak K.: *Influence of thermal microclimate factors on workers' health and working environment*, University of Zagreb, Faculty of Metallurgy, 2023

[5] Masuda Y., Parsons L., Spector J., Battisti D., and other: *Impacts of warming on outdoor workerwell-being in the tropics and adaptation options*, One Earth Review, Volume 7, Issue 3, P 382-400, March 15, Elsevier Inc.

[6] EEA (European Environment Agency): *Climate change as a threat to health and well-being in Europe: focus on heat and infectious diseases*, EEA Report No 7/2022, ISBN: 978-92-9480-508-9 ISSN: 1977-8449 doi: 10.2800/67519

[7] B. Mijović.: *Applied ergonomics, University of Karlovac*, ISBN 978-953-7343-23-1, Karlovac 2008

[8] Croatian Institute of Public Health - Department of Occupational Medicine: *Good Practice Guidelines - Working outdoors in high temperature conditions*, 2016

PSYCHOSOCIAL RISKS AMONG HEALTHCARE WORKERS IN LEGAL THEORY AND PRACTICE

Ria Horvat[1], Sandra Debeljak[2], Kristina Dundović[3]

[1] Preventa d.o.o., Čakovečka 1, 42000 Varaždin, Croatia, rhorvat@veleri.hr

[2] University of Applied Sciences of Rijeka, Vukovarska 58, 51000 Rijeka, Croatia, sdebeljak@veleri.hr

[3] University of Applied Sciences of Rijeka, Vukovarska 58, 51000 Rijeka, Croatia, kdundovic@veleri.hr

Abstract: *In an era of increasing focus on employee well-being, the study of psychosocial risks in the workplace has become a key area of interest. This paper analyzes the psychosocial risks encountered by healthcare workers within legal theory and practice. The main focus is on stress, which is the most prevalent psychosocial risk. The paper examines international, European, and national legal frameworks related to workplace stress. To explore psychosocial risks among healthcare workers, a study was conducted involving 49 participants from a hospital in the Republic of Croatia. The research results provide insights into various aspects of psychosocial risks faced by healthcare workers in a hospital work environment. Factors such as workplace stress, interpersonal relationships, perceptions of organizational support, and awareness of legal regulations related to psychosocial risks were analyzed.*

Keywords: *psychosocial risks, stress, healthcare workers, legal regulation in the field of psychosocial.*

1. INTRODUCTION

Psychosocial risks are various factors that arise in the workplace and can negatively impact the mental and emotional health of workers. In modern society, psychosocial risks are becoming an increasingly significant problem, especially in the healthcare sector. Healthcare workers, due to the nature of their job, are exposed to high levels of stress and psychosocial risks, which can lead to reduced work efficiency, increased sick leave rates, and even leaving the profession. When workers are exposed to elevated levels of psychosocial risks on a daily basis, it causes work-related stress and numerous other negative consequences that can be psychological, physical, and social. [1] Stress in employees can manifest on four levels: emotional, psychological, physical, and behavioral.

Emotional reactions include restlessness, anxiety, sensitivity, mood changes, and irritability. Psychological reactions involve difficulties in learning new skills, as well as problems with concentration and memory. Physical reactions include headaches, sweating, chest pain, sleep difficulties, and heartburn. Behavioral reactions pertain to changes in appetite, increased consumption of alcohol, cigarettes, and coffee, behavioral disorders, and dependency on social relationships. [2]

The health and social care sector is one of the largest sectors in Europe, employing about 11% of all workers in the European Union. The sector has been continuously growing over the past decade and is likely to continue growing in the near future, given the aging European population. From the analysis of psychosocial risks in the healthcare and social care sector conducted within EU-OSHA, the frequency of psychosocial risks at work and complaints related to mental health is highest in the healthcare and social care sector compared to other sectors. Typical psychosocial risks in the healthcare and social care sector include high workloads, time pressure, emotional demands (such as exposure to traumatic events, dealing with pain and dying individuals), cognitive demands (such as making decisions under pressure), third-party violence, internal harassment, long working hours and shift work, often with insufficient time, skills, job control, and social support due to understaffing. [3] Managing psychosocial risks and stress can be approached similarly to managing any other workplace risks. The most crucial element in managing psychosocial risks is considered to be proper and timely assessment. The goal of assessment is to determine what works and what doesn't in a specific organizational context. [4] Compared to other sectors, organizations in the healthcare and social care sector appear to be more inclined to engage in managing psychosocial risks. Additionally, barriers to managing psychosocial risks (e.g., reluctance to openly discuss these issues, lack of expertise, lack of awareness) are less frequently reported in the healthcare and social care sector compared to other sectors. For effective management of psychosocial risks in the healthcare and social care sector, it is important to continuously assess and monitor the prevalence and consequences of existing, as well as new and emerging (technology-induced) risks. Appropriate measures need to be identified or developed to target these risks, implemented, and evaluated. [3]

The issue investigated in the paper concerns the psychosocial risks that healthcare workers encounter daily in the workplace. The research subject includes an analysis of the legal framework regulating the health and safety protection of healthcare workers, as well as the practical aspects of implementing these applicable legal rules.

2. INTERNATIONAL AND EUROPEAN LEGAL FRAMEWORKS IN THE FIELD OF OCCUPATIONAL HEALTH AND PSYCHOSOCIAL RISKS

Mental health in the workplace is receiving increasing attention in international and European discussions. According to the United Nations Sustainable Development Goals, ensuring worker rights protection and creating a safe working environment for all employees is set as one of the goals for sustainable development by 2030. The EU Council has called on Member States to take a series of measures: promoting quality employment, strengthening mental health protection in the workplace, and providing full support to workers based on their mental health. Additionally, the European

Commission has been

urged to consider policies aimed at reducing psychosocial risks at work and promoting collaboration between national initiatives. Given the crucial importance of mental health in the workplace, the European Commission has outlined a comprehensive approach in its document and proposed EU-level initiatives to address psychosocial risks in the workplace. The European Economic and Social Committee has also proposed a series of measures at the EU level, including specific legislation. Mental health in the workplace means that individuals can use their abilities, cope with stress, and be productive. Quality working conditions are crucial for maintaining mental health, so it is important to align human resources services, medical care, and occupational health protection to ensure a healthy work environment. [5]

1.1. "Framework Directive" on safety and health at work - Directive 89/391/EEC

The Council Directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (OJ L 183, 9.6.1989) ensures minimum conditions related to health and safety in the European Union, while also allowing Member States to introduce or maintain stricter measures. In 1989, the Framework Directive brought significant changes. Its aim was to ensure a uniform standard of safety and health for all workers, except domestic workers and certain activities in public and military services. Employers were obligated to take appropriate preventive measures to ensure a safer and healthier working environment. A key element of the Directive was the introduction of the risk assessment principle, defining its main components such as hazard identification, worker participation, implementation of appropriate measures focusing on risk elimination at the source, and documentation and regular assessment of workplace hazards. By introducing the obligation to take preventive measures, the importance of new approaches to safety and health management, integrated into general management procedures, was emphasized. [6]

The Framework Directive on safety and health at work imposes a legal obligation on employers to prevent, assess, and mitigate safety and health risks, including psychosocial risks, in the workplace.

After the pandemic, mental health has become part of the political debate at the EU level. Consequently, the European Parliament resolution calls on EU institutions and member states to focus on the increasing incidence of mental health issues related to work and find ways to contribute to their prevention. In the European Commission's Communication on a comprehensive approach to mental health from June 2023, it proposes the possibility of an EU-level initiative on psychosocial risks in the medium term. [7]

1.2. The importance of EU-OSHA in implementing programs in the field of occupational health protection and protection against psychosocial risks in the healthcare sector

The European Agency for Safety and Health at Work (EU-OSHA) conducts surveys among workers on occupational safety and health, and gathers reliable data across Europe. By conducting surveys across Europe, a wide range of opinions from different people regarding safety and health at work are collected, which helps in understanding diverse

perspectives of individuals with different characteristics. Additionally, EU-OSHA surveys aid in identifying new and emerging risks. [4]

One of EU-OSHA's activities is the project "Healthcare and Social Services Sector and Occupational Safety and Health," implemented from 2022 to 2026. The project aims to provide a comprehensive understanding of various challenges faced by the sector regarding occupational safety and health to raise awareness and guide policy development. Workers in this industry are exposed to various health and safety risks, including psychosocial, ergonomic, biological, chemical, and physical risks. It is also important to highlight contextual factors affecting workers in this sector, such as population aging, workforce aging, and the need for long-term reforms in healthcare and care systems. The aim of this global project is to provide useful information and tools to improve the safety and well- being of workers in the healthcare and social services sectors. [8]

The HEROS project: Safety and Health Risks for Healthcare Workers study was published in 2023, analyzing the challenges and risks related to health and safety at work for healthcare workers in the European Union. Key health and safety challenges facing nurses and healthcare workers have been identified, including an aging workforce, staff shortages, low wages, long working hours, multiple employments, and inadequate funding. When it comes to health and safety risks, the most common ones include staff shortages, overwork, job-related stress, workplace violence and harassment, and burnout. HEROS proposes more effective coordination of health and safety regulations for healthcare workers at the European, national, and organizational levels. It also promotes the role of social partners such as unions and employer associations within different national systems. [9]

3. NATIONAL REGULATIONS REGARDING PSYCHOSOCIAL RISKS

The national legislation of the Republic of Croatia, as a member of the European Union, regarding occupational health and safety is largely based on European legislation. The European Union requires its member states to implement all European directives related to occupational health and safety. [10]

According to the Occupational Health and Safety Act (NN 71/14, 118/14, 154/14, 94/18, 96/18, hereinafter referred to as the Occupational Health and Safety Act), work- related stress consists of health and psychological changes resulting from the cumulative impact of work stressors over time, manifested as physiological, emotional, and cognitive reactions, as well as changes in worker behavior (article 3, paragraph 1, item 28 of the Occupational Health and Safety Act). [11] The employer is obliged to implement prevention of work-related stress or stress related to work caused particularly by factors such as job content, organization of work, work environment, poor communication, and interpersonal relationships, in order to minimize the need for workers to cope with difficulties due to prolonged exposure to intense pressure, and to eliminate the possibility of reducing workers' productivity and worsening their health condition. If there are indications of work-related stress or stress related to work, the employer is obliged to pay special attention to the organization of work and work procedures, working conditions and environment, communication, and subjective factors (article 51 of the Occupational Safety and Health Act). [11]

In addition to the obligations mentioned, according to the Regulation on Risk Assessment (NN 112/14, 129/19, hereinafter referred to as the Regulation on Risk Assessment), the employer is also required to avoid and prevent stressors in the work environment and during work activities of employees. [12] In Annex III of this Regulation, psychophysiological efforts are listed based on which employers are obligated to classify these risks for each workplace (Annex III, Part III, point 2 of the Regulation on Risk Assessment). [13]

Besides employers, obligations for preventing work-related stress are also prescribed for workers and their representatives. Workers are required to follow the employer's instructions and prevent, eliminate, or reduce work stress. Workers and their representatives have an obligation to collaborate with their employers to prevent, eliminate, or reduce work-related stress (article 52 of the Occupational Safety and Health Act). [11]

According to article 1 of the Regulation on the Protection of Workers Exposed to Static- dynamic, Psychophysiological, and Other Workloads (NN 73/21, hereinafter referred to as the Regulation on the Protection of Workers Exposed to Workloads), measures, rules, procedures, and activities for the occupational safety and health protection of workers exposed to static-dynamic, psychophysiological, and other workloads are prescribed. [14] The Regulation specify precise obligations for employers and workers regarding the assessment and management of psychosocial risks in the workplace. The employer is required, as part of the risk assessment, to assess psychosocial risks. During this assessment, the employer should consider the psychosocial risks in the workplace as defined in Annex V of this Regulation. When the risk assessment determines that a specific psychosocial risk is assessed as significant, specialists in occupational medicine should be involved in the development and implementation of preventive measures. If necessary, psychologists, as determined by the specialist in occupational medicine, should also be included. (article 13 of the Regulation on the Protection of Workers Exposed to Static-dynamic, Psychophysiological, and Other Work Strains). [14]

Besides employers, workers also play a crucial role in managing psychosocial risks. According to Article 14, they are required to follow the employer's instructions for preventing, removing, or reducing psychosocial risks and consequent stress at work. Additionally, workers and their representatives should collaborate with the employer to identify and mitigate psychosocial risks in the workplace (article 13 of the Regulation on the Protection of Workers Exposed to Static-dynamic, Psychophysiological, and Other Work Strains). [14]

4. ANALYSIS OF ATTITUDES OF HEALTHCARE WORKERS REGARDING PSYCHOSOCIAL RISKS

To enhance employees' well-being, psychosocial risks in the workplace have become a key area of interest. For this purpose, a study was conducted within a healthcare institution in the Republic of Croatia aimed at gaining deeper understanding of these risks, particularly among healthcare workers, whose role is crucial in providing quality healthcare. According to data from 2022, the total number of employees in the studied healthcare institution was 974, out of which 773 were healthcare workers. To investigate psychosocial risks among these employees, a survey was conducted involving 49 respondents. Among the 49 respondents, 8 were male and the remaining 41 were female, which accounts for 83.7% women and 16.3% men. The survey was prepared using a Google Forms template, and respondents completed it using electronic devices. The survey was conducted anonymously, and respondents had access to the survey throughout April 2024.

The research results provide insights into various aspects of psychosocial risks faced by healthcare professionals in their work environment. Factors such as workplace stress, interpersonal relationships, perception of organizational support, and knowledge of legal regulations related to psychosocial risks were analyzed. The obtained results can serve as a foundation for further interventions and adjustments in the work environment aimed at improving working conditions and enhancing employee well-being.

4.1. Demographic Data of Respondents

The majority of respondents in this study are between 25 and 35 years old, comprising 42.9% of the total. Conversely, the smallest group consists of workers older than 55 years, making up 6.4%. There were 12 respondents aged 36 to 45 (24.5%), 8 respondents aged 46 to 55 (16.3%), and 5 respondents younger than 25 (10.2%). Regarding work experience, the majority of respondents have been employed as healthcare professionals for over 10 years (51%), indicating stability and longevity in their careers within this sector. In contrast, only one person has been working for less than a year (2.1%). There are 13 respondents with 1 to 5 years of experience (26.5%), and 10 respondents with 6 to 10 years of experience (20.4%). These data on work experience provide insight into the diversity of experience among healthcare professionals, showcasing different stages of careers within the healthcare sector. Among the respondents, the most numerous are nurses and medical technicians, totaling 25, including five respondents with a bachelor's degree in nursing and one with a bachelor's degree in medical technology. There are nine physiotherapists and two radiologists. Midwives are represented by four respondents, one of whom is an assistant midwife. Health laboratory technicians/bachelors in medical laboratory diagnostics account for three respondents, including one health laboratory technician and two with a bachelor's degree in medical laboratory diagnostics. There are six doctors in total, including specialists in various fields such as surgery, vascular surgery, physical medicine and rehabilitation, cardiology, and gynecology. These data demonstrate the diversity of professionals in the healthcare sector, ranging from nurses to specialist doctors, highlighting the complexity and variety of responsibilities and competencies within the healthcare field.

4.2. Psychosocial Risks in the Workplace

Analysis of the responses to the question "How often do you experience stress at work?" revealed a significant level of stress among the respondents. The largest group, comprising 23 respondents (46.9%), often experiences stress at the workplace. This suggests that stress is a major challenge for most healthcare professionals, potentially affecting their well-being and productivity. Seventeen respondents (34.7%) experience occasional stress, indicating that stress is still present but with less intensity. It can be said that this stress still significantly impacts the work of healthcare professionals. Nine respondents (18.4%) reported experiencing constant stress at the workplace, which is particularly concerning, similar to the previous findings. Although this group is the smallest, it is still a substantial percentage, suggesting that these individuals are continuously exposed to high stress, affecting their health and performance. It is important to mention that none of the respondents reported experiencing stress at work rarely or never. Based on the results of this analysis, there is a clear need for implementing workplace stress management strategies to improve overall well-being and employee productivity.

The majority of respondents (34 of them) identified increased work pace as the main source of stress. This suggests that the speed of work is a challenge for most healthcare workers and can impact their ability to manage tasks effectively. Additionally, unpredictability of the job was highlighted as an important source of stress by 31 respondents. This unpredictability can create anxiety and make planning and organizing more difficult. Twenty respondents identified lack of resources, both material and human, as a significant source of stress. This suggests that insufficient resources may limit healthcare workers' ability to provide optimal patient care. Additionally, 21 respondents mentioned difficulties in communicating with patients as a source of stress. Communication is crucial for successful interaction with patients, so a lack of communication skills or communication problems can further burden healthcare professionals. Emotional exhaustion, identified by 7 respondents, indicates that healthcare jobs are emotionally demanding and can contribute to burnout and exhaustion at work. Lack of time for rest and recovery was also cited as a source of stress by 18 respondents, highlighting the importance of achieving a balance between work and personal life. Finally, 17 respondents identified lack of support from colleagues or supervisors as a source of stress. Perceptions of inadequate support in the work environment can have a negative impact on work climate and the well-being of healthcare workers. Overall, these results underscore the importance of recognizing and managing various sources of workplace stress to ensure the health and well-being of healthcare professionals and to improve the quality of care provided to patients.

Analysis of responses regarding the impact of psychosocial risks on physical health reveals varying perceptions among respondents. The majority, 25 respondents (51%), stated that psychosocial risks have mildly affected their physical health. This response suggests that while there are some effects, they have not significantly compromised their physical well-being. Ten respondents (20.4%) report that psychosocial risks have significantly affected their physical health. This group highlights a more severe impact of stress and other psychosocial factors on their physical condition, which may include symptoms such as muscle tension, headaches, or sleep problems. Two individuals are uncertain about the impact of psychosocial risks on their physical health, which may indicate a lack of awareness or understanding of this connection. Furthermore, 12 respondents (24.5%) claim that psychosocial risks have not affected their physical health. This could suggest that these respondents either have well-developed coping strategies for stress or that their physical response to stress is not pronounced. This question provides insight into the diverse reactions of individuals to psychosocial risks and underscores the importance of providing support and resources for stress management to preserve the physical and mental health of the workforce.

In the subsequent section of the questionnaire, respondents were asked about their satisfaction with the current work environment and atmosphere in their organization. One person (2%) expressed very low satisfaction, rating it 1 on the provided scale. This suggests a serious issue in the work environment that requires urgent attention and intervention. Four

individuals (8.2%) rated their satisfaction as 2 on the scale, indicating slight dissatisfaction with the work environment. This may point to certain shortcomings or challenges in the work atmosphere, although it may not be severe enough to significantly undermine their satisfaction. The largest group of respondents, 20 individuals (40.8%), rated their satisfaction with the work environment as a 3 on the scale, indicating a neutral opinion or mild satisfaction. Seventeen respondents (34.7%) gave a rating of 4, suggesting high satisfaction with the work environment. This indicates that the majority of respondents view their work environment positively and are satisfied with it. Seven respondents (14.3%) rated the highest score, 5 on the scale, indicating extremely high satisfaction with the work environment. The results of this analysis demonstrate diversity in perceptions of the work atmosphere among respondents, with some expressing extremely negative views and others indicating highly positive opinions. Analyzing this question highlights the need for further research and interventions to improve the work atmosphere and employee satisfaction.

4.3. Mechanisms for Managing and Addressing Psychosocial Risks

The majority of respondents, 24 of them (49%), stated that support is provided to them sometimes. This suggests there is diversity in how often supervisors recognize and respond to the psychosocial risks of their employees, which may result in inconsistent experiences of support. Eleven respondents (22.4%) rarely receive support from their supervisors, which may indicate insufficient awareness or commitment from supervisors in addressing the psychosocial risks of their employees. Six respondents (12.2%) never receive support from their supervisors in addressing psychosocial risks. This response highlights a serious lack of support and engagement from supervisors in creating a healthy work environment. On the other hand, eight respondents (16.3%) stated that they always receive support from their supervisors in addressing psychosocial risks. Although it is a positive result that some respondents always receive support from their supervisors, the prevalence of those who do not indicates a need for improvement in most cases. There is always room to enhance awareness and practices among supervisors in recognizing and supporting employees in addressing psychosocial risks. By providing adequate support, organizations can contribute to improving employee well-being and satisfaction, as well as creating a more productive work environment.

By analyzing the responses regarding the availability of mechanisms for reporting and managing workplace stress, it becomes evident that there is diversity in perceptions among respondents regarding the availability of resources. Eight respondents, accounting for 16.3%, stated that such mechanisms are not available at all. This highlights a serious lack of resources for managing workplace stress, potentially indicating a lack of awareness or investment by employers in support programs for employees. Nine respondents (18.4%) were unsure whether such mechanisms are available, indicating a lack of information or communication about the availability of stress management resources. Only five respondents (10.2%) stated that such mechanisms are fully available, indicating the presence of adequate support programs for managing workplace stress. However, 27 respondents (55.1%) mentioned that these mechanisms are only partially available, suggesting the existence of some resources but indicating that they may not be sufficient or adequately meeting the needs of employees in managing stress. Results from responses to this question underscore the need to improve the availability of resources for managing workplace stress to ensure the well-being and productivity of employees. Providing adequate support mechanisms can be crucial in creating a healthier and more productive work environment.

Through the following question, the aim was to ascertain whether respondents had ever participated in education or training focused on correctly identifying, preventing, and managing psychosocial risks. The responses indicate that seven respondents (14.3%) were unsure whether they had participated in education or training related to psychosocial risks. This uncertainty may suggest a lack of clear information or insufficient transparency regarding the offered educational programs on psychosocial risks. Additionally, 38.8% of respondents (19 individuals) have participated in education or training on recognizing, preventing, and managing psychosocial risks. This number indicates that there is some awareness and initiative among the workforce regarding education on these important topics. However, on the other hand, 23 respondents (46.9%) have not participated in any education or training, which may indicate a lack of opportunities or resources for education on psychosocial risks in the workplace. These responses highlight the need for widely accessible education and training on recognizing, preventing, and managing psychosocial risks to ensure a healthier and safer work environment. Providing such educational resources can be crucial for empowering employees and building resilience to stressful situations in the workplace.

4.4. Awareness of Healthcare Professionals Regarding Regulations on Psychosocial Risks

Out of a total of 49 respondents, only three individuals are familiar with the relevant national laws and regulations that govern health and safety at work, especially concerning psychosocial risks. This indicates that there is a small but aware group of employees who are informed about rights and obligations regarding psychosocial risks in the workplace. 15 respondents (30.6%) are not familiar with the relevant national laws and regulations, and 5 of them (10.2%) have not even heard of them. This may indicate a lack of accessible information or insufficient attention given to education about rights and laws related to health and safety at work. Partial familiarity is reported by 26 respondents (53.1%), suggesting that there is some level of awareness about the laws and regulations, but perhaps lacking complete understanding or appreciation of their significance in the context of psychosocial risks in the workplace. To create a safe and healthy work environment for healthcare professionals, it is essential to provide clear information about relevant national laws and regulations that pertain to health and safety at work, especially concerning psychosocial risks.

Out of the total number of respondents, only 4.1%, or two healthcare professionals, are familiar with the guidelines and recommendations of the European Agency for Safety and Health at Work (EU-OSHA) for managing psychosocial risks. This indicates a very low level of awareness among the respondents regarding this area, highlighting the need for improved approaches to education and information on this important topic. 15 respondents indicate awareness of the guidelines and recommendations of EU-OSHA, but also a lack of complete familiarity. Specifically, 30.6% of healthcare professionals are only partially familiar with EU-OSHA guidelines and recommendations. The majority of respondents, 32 individuals (65.3%), stated that they are not familiar with EU-OSHA guidelines and recommendations. This group constitutes the majority of respondents and suggests a significant lack of awareness or access to information regarding these guidelines and recommendations.

When it comes to the European Union Directive concerning the protection of workers from work-related psychosocial risks (Directive 89/391/EEC), 73.4% of respondents are not familiar with this directive. This majority of respondents indicates a significant lack of awareness and access to information about the legal frameworks that regulate the protection of workers from psychosocial risks in the workplace. On the other hand, there are only two individuals, or 4.1% of respondents, who are familiar with the European Union Directive. Eleven respondents (22.4%) stated they are partially familiar with it. The responses from participants highlight the need for improved access to information and education about this important legal regulation.

The results of the question "Do you think European regulations should be stricter regarding the protection of workers from psychosocial risks at work?" imply strong support for stricter European regulations regarding the protection of workers from psychosocial risks at work. Most respondents, 55.1% (27 respondents), support stricter regulations, indicating widespread awareness of the need for stronger protection of workers in the workplace. Only two individuals expressed opposition to stricter regulations, while eight people were unsure (16.3%) and 12 respondents indicated they did not know the answer to this question (24.5%). These results demonstrate a strong argument for strengthening European regulations to ensure a safer and healthier working environment for all workers.

4.5. Leaving the healthcare sector

The majority of respondents, 29 of them, or 59.2%, have considered leaving the healthcare sector due to the psychosocial risks they have experienced. This indicates serious challenges and dissatisfaction that some healthcare workers feel regarding their work environment. On the other hand, 16 respondents (32.7%) have not considered leaving the healthcare sector due to psychosocial risks, suggesting that there are those who are able to cope with these challenges or are perhaps satisfied with other aspects of their job. Four individuals expressed uncertainty on this issue (8.2%), which may indicate the complexity of the situation or the need for further consideration or support in decision-making.

4.6. How to improve management of psychosocial risks

The last two questions in the survey allowed respondents to answer independently and suggest measures to improve the management of psychosocial risks. The responses to how to improve the management of psychosocial risks in their organization were very similar. Only nine respondents answered that they were unsure or didn't know how to improve the management of psychosocial risks, while the remaining respondents provided specific answers. From the other responses of the respondents, a variety of suggestions and recommendations can be drawn to improve the management of psychosocial risks in their organizations:

✓ Better communication - respondents highlighted the need for improved communication within the team and among colleagues to facilitate understanding and support.

✓ Training and workshops - suggestions include organizing educational sessions and psychological workshops to enhance employees' knowledge in recognizing and managing psychosocial risks.

✓ Psychological support - respondents emphasized the importance of access to conversations with psychologists and providing psychological support for employees.

✓ Workload reduction - some suggested reducing the workload or increasing the number of employees to relieve the current staff.

✓ Improved interpersonal relationships - there was an emphasis on the need to improve interpersonal relationships and foster respect among colleagues to create a more positive work atmosphere.

✓ Patients - there was a highlighted need to control the justification of patients coming to the emergency department and to show more respect from patients towards the employees.

In response to the last question, where employees were free to write anything they considered relevant or important regarding psychosocial risks in the workplace, 13 respondents provided answers. Two respondents emphasized the need for greater support at work, stressing the importance of support and recognition from supervisors and colleagues. One respondent mentioned that the issue of psychosocial risks is unsolvable, while the remaining 10 respondents said they had nothing further to add.

4.7. Review of the survey results

The analysis of the survey results on psychosocial risks in the healthcare sector raises a series of questions and challenges that require serious attention. It is clear that a large number of healthcare workers regularly experience workplace stress, which can have a negative impact on their physical and mental health, as well as their quality of life. At the same time, respondents are dissatisfied with the current work environment and atmosphere, with a significant number of employees considering leaving the healthcare sector due to psychosocial risks. These results underscore the need for a deeper understanding of the causes of stress and dissatisfaction, as well as the development of specific strategies and programs to improve working conditions and support employees. The suggestions provided by respondents, such as better communication, education, and support, highlight the need for an interdisciplinary approach that includes various organizational-level interventions. Furthermore, the lack of awareness regarding relevant regulations and guidelines for managing psychosocial risks underscores the need for enhanced education and information for healthcare workers about their rights and options for protecting their health at work. The overall results provide valuable insights into the current state of the healthcare sector and emphasize the urgency of implementing measures to improve employee well-being and ensure the sustainability of a work environment that supports their productivity, satisfaction, and safety.

5. CONCLUSION

Psychosocial risks refer to job factors that arise from inadequate job planning, organization, and management, as well as from a poor social environment in the workplace. These risks can lead to serious psychological, physical, and social consequences. They encompass emotional, social, and psychological aspects that contribute to stress and other negative outcomes affecting workers' mental and physical health. They are particularly pronounced among healthcare workers due to the specific conditions of their work, high levels of responsibility, unpredictability of situations, and frequent exposure to human suffering, which further burdens their mental resources. In the healthcare sector, psychosocial risks can lead to decreased motivation, increased occurrence of health issues, and reduced productivity, negatively impacting all participants within the organization. In Croatia, the Law on Occupational Safety and Health imposes obligations on employers and workers regarding the reduction of stress and psychosocial risks in the workplace. Particularly important is the Regulation on the Protection of Workers Exposed to Static, Psychophysiological, and Other Strains at Work, which defines measures and procedures for assessing and managing these risks in detail. Additionally, guidelines from the European Agency for Safety and Health at Work (EU-OSHA) provide a framework for systematically identifying, preventing, and intervening in relation to psychosocial risks. They promote strategies of primary, secondary, and tertiary prevention.

The results of the survey conducted among healthcare workers have highlighted a significant level of stress and a lack of support in the workplace. Healthcare professionals emphasized the need for better communication, education, and support as key steps to improve the management of psychosocial risks. It is recommended to implement specific measures such as regular stress management programs, education on EU-OSHA guidelines and relevant directives, and improvement of the working environment. Strengthening team support and communication within organizations is also crucial. These measures will not only contribute to preserving workers' mental health but will also result in increased productivity and overall success of the healthcare system. Continuous education and informing workers about their rights and obligations, as well as providing adequate support through counseling and developing stress management mechanisms, are crucial for creating a healthy and safe work environment.

REFERENCES

[1] Psihosocijalni rizici i stres na radu, Hrvatski zavod za javno zdravstvo – Služba za medicinu rada, 2016., dostupno na: https://www.hzzzsr.hr/index.php/psihosocijalni-rizici/psihosocijalni-rizici-i-stres-na-radu/ (12.3.2024.)

[2] Šimunić, M., Stres na radnom mjestu: Psihologinja otkriva simptome i kako smanjiti stress na poslu, Kreni zdravo, 2022., dostupno na: https://krenizdravo.dnevnik.hr/zdravlje/mentalno_zdravlje/stres-na-radnom-mjestu-kako- smanjiti-stres-na-poslu (22.3.2024.)

[3] Psychosocial risks in the health and social care sector, Discussion paper, EU-OSHA, 2023., dostupno na:

https://osha.europa.eu/sites/default/files/Psychosocial_risk_management_social_care_en_.p df (22.3.2024.)

[4] Europska ispitivanja javnog mnijenja o sigurnosti i zdravlju na radu, Europska agencija za sigurnost i zdravlje na radu, dostupno na: https://osha.europa.eu/hr/facts-and- figures/european-opinion-polls-safety-and-health-work (21.3.2024.)

[5] Begović, V., Vijeće EU o mentalnom zdravlju i radu, Portal Sigurnost, 2023., dostupno na: https://www.sigurnost.eu/vijece-eu-o-mentalnom-zdravlju-i-radu/ (15.3.2024.)

[6] Okvirna direktiva o sigurnosti i zdravlju na radu, Europska agencija za sigurnost i zdravlje na radu, 2021., dostupno na: https://osha.europa.eu/hr/legislation/directives/the- osh-framework-directive/the-osh-framework-directive-introduction (1.4.2024.)

[7] Psihosocijalni rizici koji utječu na dobrobit radnika: Pouke nakon pandemije bolesti COVID-19, sažetak, Eurofond, 2023., dostupno na: https://www.eurofound.europa.eu/sites/default/files/2023-12/ef23001hr1.pdf (12.4.2024.)

[8] Sektor zdravstvene i socijalne skrbi i sigurnost i zdravlje na radu, Europska agencija za sigurnost i zdravlje na radu, dostupno na: https://osha.europa.eu/hr/themes/health-and- social-care-sector-osh (19.3.2024.)

[9] HEROS project: safety and health risks for healthcare workers, European Agency for Safety and Healt at Work, 2024., dostupno na: https://osha.europa.eu/en/oshnews/heros- project-safety-and-health-risks-healthcare-workers (23.3.2024.)

[10] Safety and Health Legislation, European Agency for Safety and Healt at Work, 2021., dostupno na: https://osha.europa.eu/en/safety-and-health-legislation (18.3.2024.)

[11] Zakon o zaštiti na radu, NN br. 71/14, 118/14, 154/14 , 94/18, 96/18

[12] Jukić, A., Pravna klinika: Stres na radu ili u vezi s radom, Radnička prava, 15. 3. 2022., dostupno na: https://radnickaprava.org/tekstovi/pravna-klinika/pravna-klinika-stres- na-radu-ili-u-vezi-s-radom (6.4.2024.)

[13] Pravilnik o izradi procjene rizika, NN br. 112/14., 129/19.

[14] Pravilnik o zaštiti na radu radnika izloženih statodinamičkim, psihofiziološkim i drugim naporima na radu, NN br. 73/21.

EXAMINATION OF NOISE WITHIN THE WORK ENVIRONMENT DURING THE SEWING TECHNOLOGICAL PROCESS

Snježana Kirin[1] Kristijan Kalcina(student) & Marinela Vulić[1]
[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac,
snjezana.kirin@vuka.hr, marinela.vulic@vuka.hr

Abstract: *The harmful effects of noise in production processes on human health are significant. They encompass both direct and indirect consequences, including psychophysical stress, fatigue, reduced work capacity, and disruption of speech communication. Regulations and standards determine the acceptable noise levels for individual production processes with the goal of preserving the health of workers. A comprehensive analysis was conducted on the noise level within the technological operation of sewing, encompassing a total of 16 machines. The set consisted of 9 overlock sewing machines and 7 universal sewing machines. The measured values indicate that the equivalent noise level of five specific overlock sewing machines exceeds the allowable 80 dB(A) limit.*

Keywords: *sewing process, noise, workload of workers*

1. INTRODUCTION

The garment industry is characterized by its labour-intensive nature and serves as the concluding phase of textile processing. During this stage, the two-dimensional cutting parts undergo a transformation into a three-dimensional garment. Due to the seasonal nature and fashion-oriented nature of the garment industry, it is crucial to establish and manage production systems in a well-coordinated manner. This ensures timely delivery to the market, aligning with marketing activities and strategies.

During the sewing technological process, work is conducted on machines, which is characterized by machine-hand work, where man and machine work together and simultaneously. The task is typically carried out in a sitting posture, with the worker utilizing their torso and hands to operate the sewing machine, while using their feet to control the stitching speed during the sewing process [1-3].

To ensure successful work and maximize productivity in the sewing process, it is crucial to establish a harmonious relationship between the worker, machine, and environment. This can be achieved by designing the workplace according to ergonomic principles, selecting suitable working methods, and providing favourable working conditions. By doing so, the workload and fatigue of the worker can be minimized, leading to improved production quality and reduced costs [4,5].

The workplace should provide comfortable working conditions to ensure optimal performance. Specifically, for tasks like technological sewing work that require high levels of concentration, the noise level should not exceed 80 dB(A) according to the rulebook on the protection of workers from exposure to noise at work[6]. The impact of noise on individuals can vary depending on its volume and duration. It has the potential to disrupt verbal communication, hinder workers' concentration, and even cause hearing damage that can lead to mental and physical fatigue [7].

2. NOISE

Unwanted and disruptive, noise is a sound that is transmitted through the air by the vibration of particles [8]. It is possible to categorize according to propagation type, source location, or penetration paths. Airborne and structural radiation are differentiated based on their propagation methods. It is classified as either internal or external. Furthermore, and it can be categorized into infrasound (up to 16 Hz), sound (16-20000 Hz), or ultrasound (> 20 000 Hz) based on the frequency range. Depending on the mode of operation, the noise can manifest itself as either continuous or intermittent [4].

A distinction is made between three types of noise at workplaces in production processes [6, 9]: The noise generated by the machines that the worker operates, the noise produced by machines and devices that the worker does not operate, and the noise generated by non-production sources such as air conditioning devices and transportation, all contribute to the overall noise in the workplace.

The workers' sensitivity to noise is influenced by various factors, including the specific characteristics of the noise itself, the individual attributes of the person being exposed (such as the condition of their hearing organs, age, and personal sensitivity to noise), as well as the duration, type, and manner of exposure. Additionally, the position of the person in relation to the noise source, the presence or absence of noise during rest periods within working hours, and even during leisure time can also impact their sensitivity to noise [10].

The excessive noise present in the workplace during the production process poses a significant obstacle to effective verbal communication, as it distracts workers from their work objectives. This, in turn, generates mental tension, restlessness, and if prolonged, can result in fatigue, general irritability, and hearing impairments. Consequently, productivity is diminished, and the occurrence of errors at work is heightened [11].

Noise in the sewing technological process should not exceed 80 dB(A) according to the Rulebook on the protection of workers from exposure to noise at work [6], Noise protection law [12] and HRN EN ISO 9612:Acoustics -- Determination of occupational noise exposure [13].

In order to mitigate noise in the sewing technological process, it is advisable to adopt organizational and technical measures. This can be achieved by regularly maintaining and servicing devices, as well as carefully selecting machines and devices that emit lower levels of noise [14].

3. EXPERIMENTAL PART

During the working day, a comprehensive examination of the noise level in the production facility was carried out on a total of 16 sewing machines, comprising nine special overlock-sewing machines and seven universal sewing machines. The purpose was to investigate whether there are excessive noise levels in the manufacturing facilities of the clothing industry. Meeting the requirements of manufacturing small batches of clothing involves the utilization of approximately 25 machines on a daily basis. During the duration of the investigation, workers at various workplaces conducted their tasks utilizing the exact same technological process consistently throughout the entire recording period with the machines in operation. A division of machines into production lines allows for the implementation of the line system of work, increasing productivity and efficiency.

To measure the noise level, a METREL MULTINORM M1620 digital noise meter was employed alongside an A1146 sound probe.

The measurements were performed for a period of 5 minutes at specified workplaces. At the workplace, the microphone of the sound mete was placed at the same level as the worker's ear during the measurement.

4. RESULTS AND DISCUSSION

In order to measure the noise levels, a real production process was implemented, involving nine specialized overlock sewing machines and seven universal sewing machines. By conducting measurements and applying statistical analysis, it was possible to determine the values of the equivalent noise level (LCeg), the highest time-weighted noise level (LAFmax), and the lowest evaluated noise level (LAFmin) at the selected workplaces.

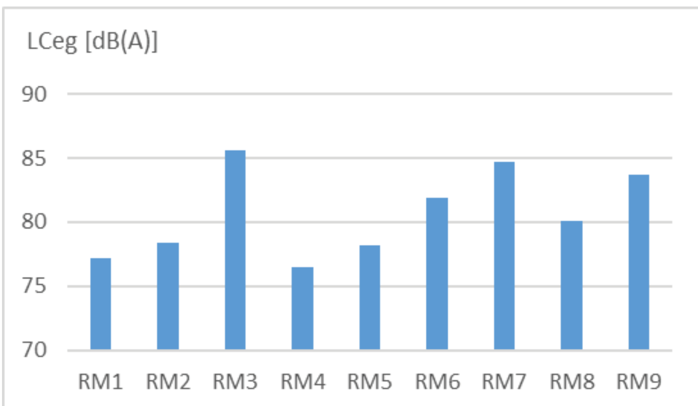


Figure 1: Illustration of the equivalent noise level on special sewing machines

During the analysis of nine specific overlock-sewing machines, the equivalent noise level was determined to range from 76.5 to 85.6 dB(A) (Figure 1). The noise levels recorded on RM3, RM6, RM7, and RM9 are 85.6 dB(A), 81.9 dB(A), 84.7 dB(A), and 83.7 dB(A) respectively, exceeding the allowable limit of 80 dB(A).

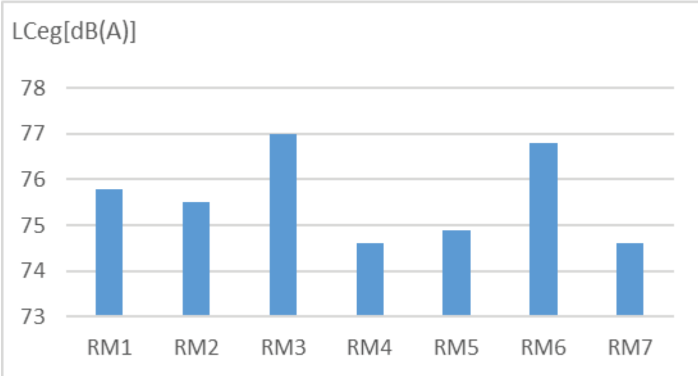


Figure 2: Illustration of the equivalent noise level on universal sewing machines

The analysis of the equivalent noise level of seven universal sewing machines has revealed that it varies from 74.6 dB(A) to 77 dB(A).

As per the guidelines outlined in the Rulebook on the protection of workers from exposure to noise at work the performance of technological sewing tasks falls under a category of occupations that involve primarily repetitive physical duties requiring precision and the use of hearing to monitor the environment, with a maximum permissible noise level of 80 dB(A). Throughout this investigation, the noise level exceeds 80 dB(A) on five specific overlock-sewing machines. Noise levels exceeding 80 dB(A) can be attributed to multiple factors associated with the sewing machine itself. These include the machine's specific type, its construction, the presence of additional devices, and the impact of its age. Verifying the condition of the mechanical and driving parts is crucial, and if viable, consider replacing them with modern sewing machines that produce reduced noise levels.

The results of the highest time-weighted noise level (LAFmax) and the lowest time-weighted noise level (LAFmin) are illustrated in Figures 3 and 4.

Figure 3 displays the highest time-weighted noise levels for special overlock sewing machines, which are recorded to be above 80 dB(A) and vary between 84.5 dB(A) (RM5) and 95.7 dB(A) (RM9). Noise levels for special overlock sewing machines typically fall between 63.3 dB(A) (RM1) and 69.6 dB(A) (RM6) when measured as the lowest time-weighted noise levels (LAFmin).

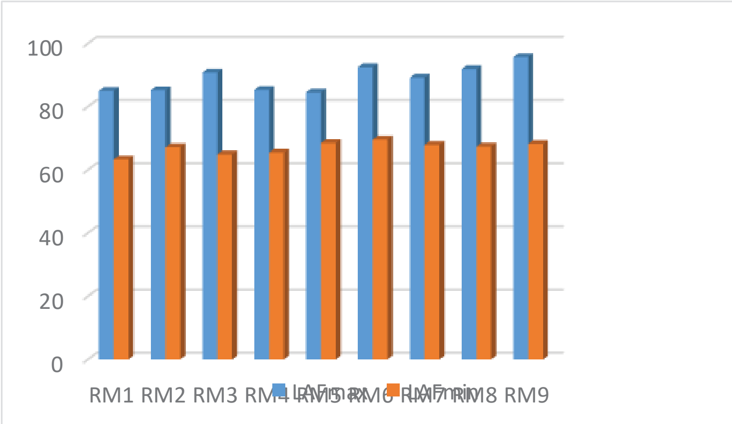


Figure 3: Illustration of the highest and lowest time-weighted noise levels for special overlock-sewing machines

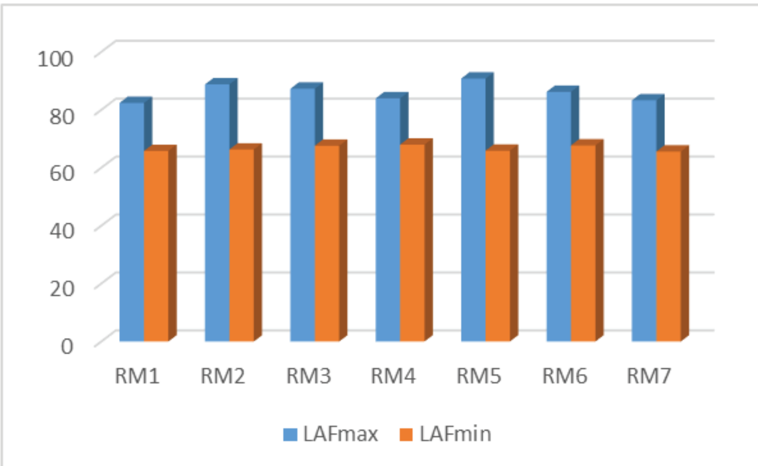


Figure 4. Illustration of the time-weighted noise levels of universal sewing machines, including the highest and lowest measurements

The maximum time-weighted noise levels (LAFmax) for universal sewing machines are illustrated in Figure 4, varying from 82.4 dB(A) (RM1) to 90.8 dB(A) (RM5). For universal sewing machines, the lowest time-weighted noise level (LAFmin) usually falls within the range of 65.8 dB(A) (RM1) to 68.0 dB(A) (RM4).

The differences between the highest and lowest time-weighted noise levels are substantial, and they can be attributed to the operational procedures involved in sewing. During the technological process, sewing machines are initially started from an idle state, then operated at their designated speed, and finally returned to idle. This sequence of actions leads to the production of noises with varying intensities, thus accounting for the significant differences between the highest and lowest noise levels.

5. CONCLUSION

To optimize productivity and ensure high-quality work, it is essential to establish a well-structured working environment with ergonomically designed workplaces. By doing so, workers' efficiency can be improved while simultaneously reducing their workload.

The analysis conducted examined the noise levels within the actual sewing process of the working environment, revealing that five particular overlock sewing machines produce noise exceeding 80 dB(A). Consequently, it is recommended that an examination be carried out on these workplaces to evaluate their technical and mechanical precision.

In the event that the working conditions within production facilities, such as excessive noise levels, exceed the acceptable thresholds, detrimental consequences arise. These consequences directly impact the efficiency, workload, and fatigue experienced by workers, consequently disrupting the smooth flow of the production process. As a result, productivity levels decrease, the quality of workpieces diminishes, valuable time is lost, and ultimately, profits are reduced.

REFERENCES

[1] Singh, G., Vasudev, H.: Human Factor Considerations in Sewing Machine for Workstation Desing, International Journal of Advance Research, Ideas and Innovations in Technology **1**, (2014), 1, 10-15, ISSN 2249-8958

[2] Mehta, R.: Major Health Risk Factor prevailing in Garment Manufacturing Units of Jaipur, Journal of Ergonomics **2**, (2012), 2, 1-3, ISSN 2168-7556

[3] Polajnar, A.,Verhovnik, V.: Oblikovanje dela in delovnih mest, Udžbenik Univerze v Mariboru, Fakulteta za strojništvo, Maribor, 2000, ISBN 86-435-0341-X

[4] Kirin, S., Lauš, K.: Istraživanje razine buke u tehnološkom procesu šivanja, Sigurnost 53, 3, 2011,243-250

[5] Kirin, S.: Prilog istraživanju razine buke u procesu strojnog punjenja boca vodom, Sigurnost 59, 2, 2017, 109-115

[6] Pravilnik o zaštiti radnika od izloženosti buci na radu˙(NN 148/2023)

[7] Rogina Car, B.: Obilježja radnog mjesta u tehnološkom procesu šivanja odjeće, Sigurnost 63, 2, 2021, 181-188

[8] 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

[9] Mijović, B. I sur.: Prilog istraživanju buke u odjevnoj industriji, Sigurnost 43, 3,2001,199-208

[10] Horvat, J.,Regent A.: Osobna zaštitna oprema, Udžbenik Veleučilišta u Rijeci, Rijeka (2009.), ISBN 978-953-6911-43-1

[11] 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.

[12] Zakon o zaštiti od buke (NN 20/03)

[13] HRN EN ISO 9612: Akustika- određivanje izloženosti buci na radu, www.hzn.hr, pristupljeno 19.01.2020.

[14] Trbojević, N.: Osnove zaštite od buke i vibracija, Udžbenik Veleučilišta u Karlovcu, Karlovac, (2011.), ISBN 978-953-73343-53-8

INVESTIGATION OF WORKPLACE LIGHTING IN THE PROCESS OF TECHNOLOGICAL SEWING

Snježana Kirin[1]; Manuela Žakula [2]; Luka Babić[3]
[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac,
snjezana.kirin@vuka.hr, manuela.zakula@vuka.hr, luka.babic@student.vuka.hr

Abstract : *Workers in the technological process of sewing must have a high level of visual focus when dealing with materials of various sizes, shades, and colors to notice features and components, discern colors, and contrast. Adequate lighting at individual workplaces contributes to higher productivity and quality of work and reduces the possibility of vision problems among workers. The paper examined the intensity of lighting in the technological process of sewing in a real production process with 15 sewing machines. The workplaces had general lighting as well as a combination of general and additional lighting. The results obtained show that in the production facility in accordance with the HRN EN 12464-1:2021 standard, the general lighting is insufficient for work, while the values for the combination of general and additional lighting are too high. It is necessary to place additional lighting in a proper manner at workplace*

Keywords : *technological sewing process, HRN EN 12464-1:2021; lighting*

1. INTRODUCTION

The process of sewing clothes accounts for up to 70% of the overall time needed to manufacture clothing. Sitting is the posture used for technological sewing activities. This kind of work system demands a high level of precision in execution. It requires the worker to coordinate their movements while maintaining visual focus on the central field of vision. At the same time, the worker must guide the sewing process with controlled foot movement, which regulates the speed of sewing and the distance of the seam line from the edge of the workpiece. They also need to ensure the compatibility of the workpiece edges, the joining length to the end of the seam [1].

The lighting of the workplace and the working environment in which a particular task is carried out is crucial to achieving satisfactory visual requirements.

Natural daylight and artificial lighting (electric light) illuminate the workplace, ensuring a smooth work process [2].

Artificial lighting is provided by a general lighting system, i.e. light sources installed to illuminate the entire room, or by a system that combines general lighting with an additional source to illuminate a specific area or location in an enclosed space [3].

The appropriate lighting of work environments and the workplace itself include selecting the intensity, distribution, and kind of illumination such that work tasks may be completed comfortably and successfully. Figure 1 shows the characteristics that determine the quality of lighting at the workplace, divided into three groups: visual ambience, visual ability and visual comfort [4].

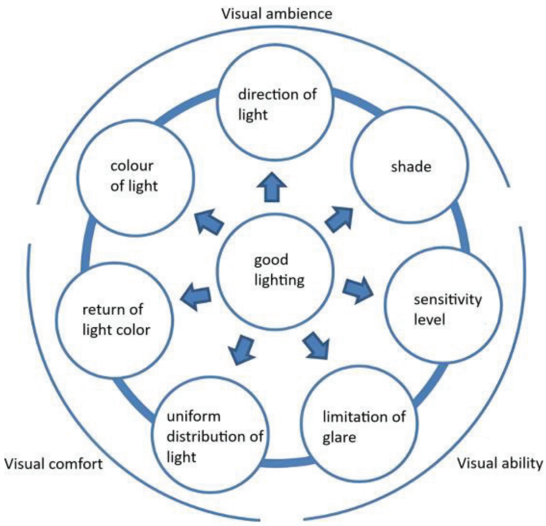


Figure 1: Basic components for lighting [4]

In order to have a proper lighting setup and a well-distributed flow of light, it is important that the light sources are not within the worker's field of vision while they are working. Additionally, the line from the worker's eye to the light source should be at an angle greater than 30° to the horizontal.

2. THE INFLUENCE OF LIGHTING ON THE DESIGN OF WORKPLACES IN THE TECHNOLOGICAL SEWING PROCESS

The visual skills necessary for the technological process of sewing are manifested in the recognition of the complex structure of the workpieces. This includes the ability to recognize the intricate structure of the fabric pieces, notice even the slightest variations in shape, color, and shade, and react quickly and accurately based on visual observations. To carry out a technological operation that involves processing information about the position of the seam, the edges of the material, and the length of the material layers, the worker must possess excellent sensory abilities in the organs of vision, accommodation, and adaptation of the eye. These abilities are crucial for performing the task effectively and efficiently. The extremely good visual skills of the workers are crucial for the coordination of movements, the speed of sewing and the accuracy of execution. When working in work systems where a high degree of visual control is required, the workplace must be designed in such a way that visual zones are used in the comfortable area of the transfer of the gaze by moving the head line and in the comfortable area of eye rotation and head movement [5].

The optimal lighting for the technological process of sewing is primarily determined by the visual complexity and difficulty of the task, as well as the condition of the worker's visual apparatus. Poor lighting in the work area and workplace, as well as glare in the field of vision, cause visual fatigue, which manifests as painful eye irritation, double vision, headaches, decreased ability to accommodate, reduced visual acuity, contrast adjustment, and perception speed. Visual fatigue reduces productivity and work quality, increases the number of work errors and accidents at work, and causes visual disorders in general. Inadequate workplace lighting often results in an unfavourable working posture, as the worker tries to reduce the distance between the eyes and the work object, which leads to an increase in the angle of curvature of the spine and a greater flexion of the head. When designing the working environment, it is critical to provide appropriate and bright lighting for a comfortable working posture (Figure 2).

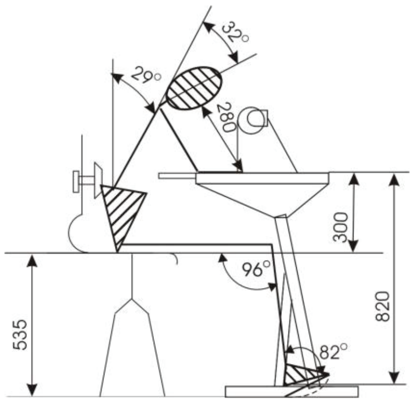


Figure 2: Illustration of an unfavourable workplace caused by poor lighting [6]

In sewing technological processes according to the Ordinance on occupational safety for the workplace [7] and the HRN EN 12464-1:2021 standard - Light and lighting - Lighting of workplaces-part 1: Internal working spaces [8] lighting per workplace should be between 750 and 1000 lx, taking into account the visual comfort (feeling of satisfaction) that contributes to productivity, the ability to perform work tasks for a longer period of time and safety. In addition to general lighting, garment factories have additional lighting fixtures in their workplaces. Optimum additional lighting is achieved by equipping workplaces with LED light sources. When selecting and installing lighting in the workspace, care must be taken to avoid changing the microclimatic conditions at the workplace itself or increasing reflection from the work surface of machines and materials [9].

3. EXPERIMENTAL PART

‚Fifteen sewing machines were selected for the investigation of lighting intensity in the technological process of sewing. The measurements were taken under general lighting as well as general and additional lighting on individual sewing machines. The measurement lasted one day and took place in a real production plant. In the technological process of sewing, windows are installed along the working area and covered with dark curtains to keep daylight from reaching the sewing machines. Artificial lighting is provided by 36-watt fluorescent tubes mounted above the sewing machines, with a lamp made up of two tubes. The general lighting is located 3,.2 meters from the floor. Each workplace has extra LED lighting. The METREL measuring device and the corresponding lux probe were used to perform the measurement.

The measured values were processed using the Excel computer program.

4. RESULTS AND DISCUSSION

In the technological process of sewing, the lighting intensity was measured at 15 workplaces (RM1-RM15) with general lighting and a combination of general and additional lighting during a working day.

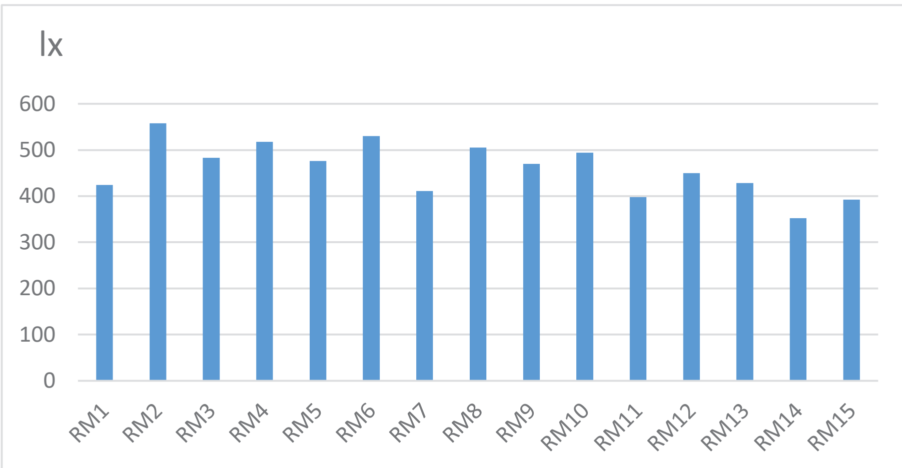


Figure 3: Measured average value of general lighting for each workplace

Figure 3 shows the average lighting levels measured for each workplace, with values ranging from 352 lx (RM14) to 558 (RM2). The measured values for each workplace show that the lighting using only general lighting is below the minimum permissible value for this type of work task, which must be at least 750 lx according to HRN EN12464-1:2021. It is therefore important that female workers have additional lighting at their workplace.

Figure 4 shows measured mean lighting intensity values for workplaces with a combination of illumination (general and additional lighting). The measured values per workplace indicate that the combined lighting ranges between 969 lx and 4682 lx. According to the HRN EN 12464-1:2021 standard, the lighting in the technological process of sewing must be 750 lx, which, according to the data obtained, indicates that the lighting is too strong. The lighting was measured in front of the sewing needle, and the values change depending on how the worker places the additional lighting. RM3 (3089 lx), RM5 (4682 lx), RM6 (4950 lx), and RM8 (2888 lx) all had extremely high lighting levels. Other values range from 969 lx to 2191 lx. As a result, additional lighting would be required in the workplace, as too much light is also harmful to workers' eyes.

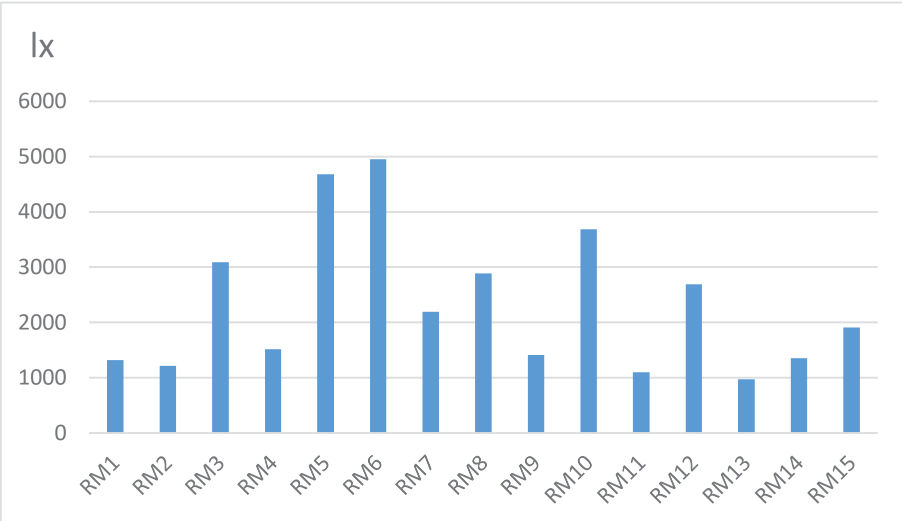


Figure 4: Measured average lighting values for a combination of general and additional lightin

Workers put a lot of strain on their eyesight while performing their work tasks in the technological process of sewing, which leads to a decrease in productivity and quality of work, as well as potential vision issues. After analysing the results, it appears that the workplace has insufficient general lighting. Additionally, the extra lighting was too powerful due to a faulty installation.

5. CONCLUSION

The lighting intensity was measured in 15 workplaces with general lighting and a combination of general and additional lighting during the actual production process of clothes manufacturing, as part of the technological process of sewing.

The findings indicate that general lighting in some workplaces is insufficient, with values falling below the recommended 750 lx under the HRN EN 12464-1:2021 standard. With a combination of general and additional lighting in any location, the lighting is also unfavourable, ranging from 969 lx to 4950 lx for workplaces. Unfavourable lighting is caused by an improperly installed additional lighting unit. As a result, extra lighting fixtures would have to be installed at the workplaces.

Too little or too much light in the workplace strains workers' eyesight, reducing productivity and work quality while also causing visual problems.

REFERENCES

[1] Kirin, S., Dragčević, Z., Firšt Rogale, S: Workplace redesing in the computer-aided technological sewing process, Tekstil **63**, (2014.), 1-2, 14-26, ISSN 0492-5882

[2] Podhorsky, R. I sur.: Električno osvjetljenje, Tehnička enciklopedija, 4 svezak, Hrvatski leksikografski zavod, Zagreb, 1973,263-282

[3] Doko Jelinić, J. I sur.: Rasvjeta radnog okoliša u aluminijskoj industriji, Sigurost 52,4, 2010, 381-386

[4] Balantič, Z., Polajnar, A., Jevšnik, S.: Ergonomija v teoriji in praksi, Nacionalni inštitut za javno zdravje, Ljubljana, 2016., ISBN 978-961-6911-91-7

[5] Kirin, S.: oblikovanje radnih metoda u tehnološkom procesu šivanja, Sveučilište u Zagrebu Tekstilno-tehnološki faulted, Zagreb,2020

[6] Kirin, S., Dragčević, Z., Polajnar, A.: Radno opterećenje i zamor u tehnološkom procesu šivanja, Tekstil **53** (2004.), 5, 226-243, ISSN 0492-5882

[7] Pravilnik o zaštiti na radu za mjesto rada (NN 29/13)

[8] HRN EN 12464-1:2021**:** Svjetlo i rasvjeta - Rasvjeta radnih mjesta - 1. dio: Unutrašnji radni prostori, http://www.hzn.hr/, prestupljeno 20.04.2024..

[9] Hiba, C.: Impoving Working Conditions and Productivity in the Garment Industy, www.ilo.org/wemsp5/group/public/--ed--/--safework/---/wems_228220.pdf., pristupljeno 20.04.2024.

ANALYSIS OF STATODYNAMIC LOAD IN THE TECHNOLOGICAL PROCESS OF SEWING

Snježana Kirin;[1]Anica Hursa Šajatović;[2]

[1] Karlovac University of Applied Sciences, J. J. Strossmayer's Square 9, HR-47000 Karlovac, Croatia: snjezana.kirin@vuka.hr; boris.habulim@student.vuka.hr

[2] University of Zagreb, Faculty of Textile Technology, Department of Clothing Technology, Prilaz baruna Filipovića 28a, HR-10000 Zagreb, Croatia, anica.hursa@ttf.unizg.hr

Abstract: *During the entire work shift, a worker engaged in the technological process of sewing performs sewing operations in a sitting posture. The mobility of the body in sitting working posture is limited by the kinematic systems that control the arms, head and partly the trunk. In the technological process of sewing, it is therefore necessary to design the workplace and the working method in a favourable way, i.e. to combine production technology, technic, ergonomics and work organisation in such a way that an optimal working effect is achieved without causing stress or fatigue to the workers.*

The study examined the technological process of sewing the shoulder seam using the OWAS technique and evaluated the angle of curvature of the spine and head. The analysis revealed an ideal working posture for the worker with pronounced curvature angles in the spine and head. A proposal was made for the redesign of the workplace.

Keywords: *technological sewing process, OWAS method, curvature of the spine and head angle*

1. INTRODUCTION

In the technological process of sewing, the work process is carried out on machines characterized by hand-machine work, where man and machine work together and simultaneously. The work is usually performed in a sitting posture, with the worker using the upper body and hands to perform machine-hand and auxiliary suboperations, and the feet to achieve the required sewing speed in machine-hand sewing suboperations [1, 2].

An effective system requires a high degree of precision in the execution and coordination of the workers' movements as well as visual concentration on the central field of vision. In addition, the sewing process is monitored by controlled foot movements that regulate the sewing speed, control the distance of the seam line from the edge of the workpiece, align the edges of the workpiece and determine the length of the seam [3].

In order to carry out the sewing process effectively with a continuous flow of material, ergonomically designed individual workstations and a favourable working method with appropriate time constraints are essential. This leads to more efficient technological operation, higher machine utilisation and a noticeable reduction in the physical and mental stress experienced by workers [4-6].

When considering the overall design of the workplace and the working environment in the sewing process, five ergonomic principles can be applied [7]:

(a) Anthropometric working conditions, i.e. adapting the dimensions of the workstation to the anthropometric measurements of the worker and ensuring suitable reach zones and fields of vision.

b) Optimization of work processes, i.e. the development of a work framework that enables the achievement of maximum productivity, efficient use of workstations and resources, cost efficiency, quality and timely completion of tasks while reducing the workload of workers. Effective organization of the work process requires a comprehensive understanding of all factors involved, including the skills of workers, the tools used and the technologies and techniques involved in the work process.

c) Determination of working time, i.e. determination of production time for an average trained worker, taking into account the workload of the worker, the influence of the conditions of the working environment, prescribed eating and drinking breaks, physiological needs and justified organizational losses.

d) Proper handling of materials and tools includes their strategic placement in the workplace to minimize the physical effort required by workers in handling them.

e) Creating an optimal work environment involves adjusting workplace conditions, including temperature, relative humidity, noise levels, lighting, airflow and colors, to ensure maximum comfort and productivity for workers.

The application of ergonomic principles in the design of workplaces can significantly shorten the duration of technological operations, reduce the workload and fatigue of workers and ultimately lead to higher hourly and daily output.

2. FATIGUE IN THE TECHNOLOGICAL SEWING PROCESS

The process of sewing is a combination of static and dynamic muscle work, with the static component consisting of sitting while the upper and lower limbs perform dynamic movements. Prolonged sitting in a static posture can put constant pressure on certain muscle groups in the back and neck, leading to fatigue. The repetitive performance of technological tasks that require coordinated movements and the use of certain muscle groups places considerable strain on the upper limbs (arms, hands, fingers). This strain is mainly caused by the one-sided dynamic work required in these activities. Lack of time for muscle recovery can lead to fatigue, but this can be avoided by taking breaks or changing the type of work [8].

During the execution of the work process, fatigue occurs, which can be divided into physical (muscle activity in the form of dynamic and static work) and mental (overstrained attention, monotony) depending on the type of workload.

The analysis of fatigue from a physiological, psychological and production point of view includes three interrelated phenomena: a decrease in work performance due to changes in work activity, changes in the physiological state of the organism and the complex experience of fatigue with feelings of discomfort, boredom and the need to rest.

Fatigue is evident in production processes, as indicated by [9]:

- decline in qualitative and quantitative productivity levels,
- the work activity can be interrupted spontaneously and breaks are planned according to the workload of the worker,
- the speed of work is subject to fluctuations with phases of slowing down and speeding up, which leads to noticeable fluctuations in work performance. In addition, the accuracy, precision and quality of technological operations are reduced,
- changes in the function of various organs (accelerated heartbeat, breathing, blood changes, impaired visual acuity, etc.),
- lack of psychomotor dexterity, which leads to a deterioration in coordination and the occurrence of unnecessary movements when performing technical tasks.

Quickly carrying out of technological operations with the regular repetition of specific suboperations and movements during working hours can lead to emotional and psychological tension and monotony. Workers' fatigue may be due to a mismatch between the physical, mental and health capabilities of workers and the demands of the work, as well as poor work organization and unfavorable microclimatic conditions. Workers often suffer from musculoskeletal disorders due to long-term mental and physical stress in the technological process [10].

Effective prevention strategies in the workplace include appropriate workplace redesign, updating work methods for certain technological tasks, investing in ergonomic equipment such as chairs, adjustable tables and sewing machines, and introducing new forms of organization such as modular organization. These strategies, if implemented correctly, can significantly reduce workload, fatigue, the incidence of injuries and occupational illnesses.

3. EXPERIMENTAL PART

The workload of workers in the technological process of manufacturing a children's T-shirt was assessed by analysing the sewing of the shoulder seam at a workplace equipped with a special overlock sewing machine. To analyse the workload, the OWAS method was used, in which a video recording was used to capture 95 repetition of technological operations of sewing the shoulder seam. A total of 885 observations were made in which the positions of all body parts involved were precisely documented.

The video analysis was used to evaluate the angle of curvature of the spine and the head posture of the worker at the workplace when sewing the shoulder seam. A total of 25 consecutive executions of the technological operation were examined. The video recording provided a valuable source for the analysis of individual static images representing borderline work postures. These individual images were carefully selected based on the sequence of technological operations. A total of 175 images were examined at the workplace, which enabled the measurement of curvature angles for the spine and head.

4. RESULTS AND DISCUSSION

The OWAS method was used to determine the values for worker workload, which are shown in Table 1. This table also provides information on the necessary redesign of the workplace in order to be representative of the individual work posture.

Table 1: Workload according to the OWAS method at the shoulder seam sewing workplace

Designation of working posture	Number of notes	Percentage [%]	Duration of individual work posture [min]	Redesign of the workplace
1.1	250	28.2	126.9	unnecessary
1.2	430	48.6	218.7	required in the near future
1.3	205	23.2	104.4	required in the near future
2.1	60	6.8	30.6	unnecessary
2.2	660	74.6	335.7	required soon
2.3	105	11.8	53.1	unnecessary
2.4	60	6.8	30.6	unnecessary
3.1	710	80.2	360.9	required immediately.

3.3	175	19.8	89.1	unnecessary
4.1	855	96.6	434.7	required in the near future
4.2	30	3.4	15.3	unnecessary
5.1	160	18.1	81.5	unnecessary
5.2	465	52.5	236.3	required in the near future
5.3	260	29.4	132.3	required in the near future

The data obtained using the OWAS method show that the worker spends 48.6% of his working time (equivalent to 218.7 minutes) in an anterior flexion of the spine with an angle of more than 15° (position 1.2) and 23.2% of his working time (equivalent to 104.4 minutes) in a spinal position with a twist of more than 30°. During 52.5% of working time (236.6 minutes), the worker's head is in a forward flexion position with an angle of more than 30°, while during 29.4 of working time (132.3 minutes) it is tilted to the side by more than 30° (position 5.3).

When working at the sewing machine, the worker holds her upper arms away from her body (position 2.2) for 74.6% of the working time (335.7 minutes), which leads to considerable strain on her hands. The careful positioning and guiding of the workpiece during sewing causes considerable strain on the fingers and hands of the worker (position 3.1), who spends 80.2% of the working time (360.9 minutes) on this task. Table 2 shows the technological operation in relation to the technological sub-operations.

Table 2: Technological sub-operations of the technological operation of sewing the shoulder seam

No. of the technological suboperation	Description of the technological suboperation	Type of the technological suboperation
1. 1a	taking the front part of the T-shirt positioning	$(tp)_r$
2. 2a 2b	taking the back part of the T-shirt positioning together positioning	$(tp)_r$
3.	machine-hand sewing of segment A	$(tt)_{ar}$
4. 4a	cutting off the thread laying off the T-shirt	$(tp)_r$

Figure 1 shows the average angle of curvature of the spine and head, with the technological operation divided into sub-operations, as shown in the schematic diagram in Table 2. When analysing the angle of curvature of the spine and head, the technological sub-process of laying off the workpiece was not taken into account.

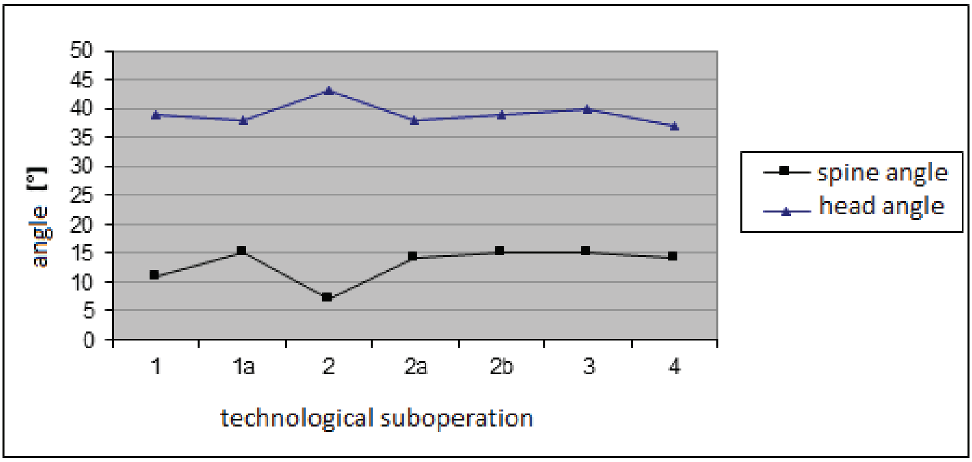


Figure 1: Presentation of the curvature of the spine and head angle while sewing the shoulder seam during the technological process.

When analysing the mean angle of curvature of the spine, it was found that the worker consistently adopts a posture with increased forward flexion of the spine. When performing the technological sub-operation of positioning and the technological sub-operation of machine-hand sewing, the average angle of curvature of the spine is 15°. When performing the technological sub-operation of taking the back part of the shirt, the worker adjusts his posture to keep the spine upright while turning the upper body and head. In the technological sub-operations of positioning together and thread cutting, the average value of the spine bending angle is 14°, which is on the edge of a comfortable posture. The average head bending angle indicates that the worker is constantly working at an angle of more than 30° and also turns her head sideways. The angle of curvature of the head is between 37 and 43°.

Fig. 2 illustrates the working posture of the worker when sewing the shoulder seam, including the angles of the kinematic chains.

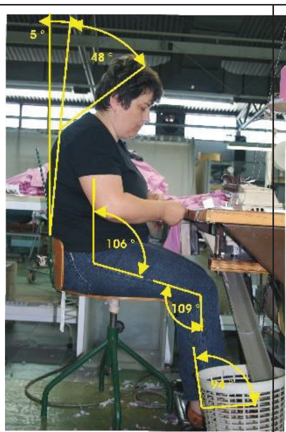
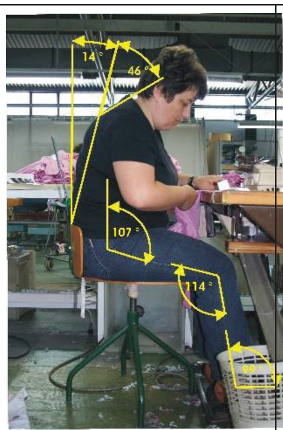
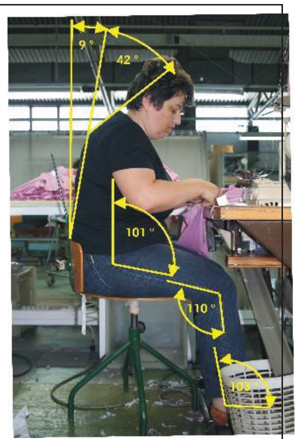
<table>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>aligning the workpiece</td>
<td>machine-hand sewing the workpiece</td>
<td>cutting off the thread</td>
</tr>
</table>

Figure 2: Boundary working postures found at the shoulder seam sewing workplace, along with the corresponding kinematic chains.

After analysing the existing workplace for sewing shoulder seams, a more favourable working method and a redesign of the workplace are proposed. To be able to work effectively with large-sized workpieces, it is essential to add an extension to the work surface on the left-hand side. It was recommended that a new overlock sewing machine with an automatic thread cutter and a tool for cutting the edge of the fabric should be launched on the market. To ensure an ergonomically correct work posture, it is important to adjust the height of the work surface and seat to the anthropometric measurements of the worker.

5. CONCLUSION

The constant sitting posture while operating a sewing machine can lead to progressive pathological changes in the muscles of the upper back and neck in workers as a result of the constant strain on certain muscle groups. The joints, ligaments and tendons are at risk due to the combined effort of arms, hands and fingers, which results in considerable strain. Health problems resulting from the workload and fatigue of workers over a long period of time are often related to inadequately designed workplaces and unfavorable work methods. The physical dimensions of the workplace are crucial, as even small changes can have a significant impact on worker performance and health and safety in the workplace.

Proper workplace design and appropriate sewing methods in the technological sewing process include adjusting the size and height of the work surface, seat and pedals to the worker's height. The result is a comfortable and efficient workplace that minimizes the worker's fatigue and enables a functional posture that ensures excellent mobility of the limbs, an advantageous arrangement of the work and viewing area and a stable balance. A favorable posture of the worker at the workplace and an efficiently planned way of work lead to top performance with minimal strain and fatigue and to a satisfied and healthy worker.

REFERENCES

[1] Singh, G., Vasudev, H.: Human Factor Considerations in Sewing Machine for Workstation Desing, International Journal of Advance Research, Ideas and Innovations in Technology **1**, (2014), 1, 10-15, ISSN 2249-8958

[2] Mehta, R.: Major Health Risk Factor prevailing in Garment Manufacturing Units of Jaipur, Journal of Ergonomics **2**, (2012), 2, 1-3, ISSN 2168-7556

[3] Dragčević, Z., Firšt Rogale, S.: Metode određivanja vremena strojno – ručnih tehnoloških zahvata šivanja, Tekstil **51**, (2002.) 2, 51-63, ISSN 0492-5882

[4] Polajnar, A., Verhovnik, V.: Oblikovanje dela in delovnih mest, Udžbenik Univerze v Mariboru, Fakulteta za strojništvo, Maribor, 2000, ISBN 86-435-0341-X

[5] Polajnar, A., Verhovnik, V., Sabadin A., Hrašovec B: Ergonomija, Udžbenik Univerze v Mariboru, Maribor, 2003, ISBN 86-435-0550-1

[6] Muhundhan, M.: Improved Work Station Desing of Impoved Productivity, International Journal of Scentific Engineering and Technology **2** (2013), 3, 225-227, ISSN 2277-1581

[7] Čolović, G.: Ergonomics in the garment industry, Woodhead Publishing India, Pvt Ltd, New Delhi, 2014, ISBN 978-93-80308-26-5

[8] Dragčević Z., Firšt Rogale S.: Investigation of Dynamic Working Zones and Movements in Garment Engineering, International Journal of Clothing Science and Technology **13,** (2001), 3/4, 264-279

[9] Dragčević Z., Zavec D., Rogale D., Geršak J.: Workloads and Standard Time Norms in Garment Engineering, Journal of Textile and Apparel Technology and Management 2, (2002), 2, 1-6

[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

OCCUPATIONAL MUSCULOSKELETAL DISORDERS AMONG DENTISTS

Karla Kovačević Čorak[1], Marina Milaković[1], Dominik Oroz[1], Petra Kovačević Totić[2], Marija Bubaš[3], Krunoslav Capak[4]

[1] Croatian Institute of Public Health, Division for Occupational Health, Radoslava Cimermana 64a, 10020 Zagreb, CROATIA, karla.kovacevic@hzjz.hr

[1] Croatian Institute of Public Health, Division for Occupational Health, Radoslava Cimermana 64a, 10020 Zagreb, CROATIA, marina.milakovic@hzjz.hr

[1] Croatian Institute of Public Health, Division for Occupational Health, Radoslava Cimermana 64a, 10020 Zagreb, CROATIA, dominik.oroz@hzjz.hr

[2] Clinical Hospital Centre "Sisters of mercy", Clinic for rheumatology, physical medicine and rehabilitation, Vinogradska cesta 29, 10000 Zagreb, CROATIA, petrakova13@gmail.com

[3] Ministry of Health, Ksaver 200a, 10000 Zagreb, CROATIA

[4] Croatian Institute of Public Health, Rockfellerova 7, 10000 Zagreb, CROATIA

Abstract: *Dentistry is a high-risk profession for the development of occupational and work-related diseases. Musculoskeletal disorders (MSDs) are one of the most common occupational health issues amongst dentists. Physical loads in terms of prolonged static non-physiological posture and repetitive movements during work lead to the occurrence of work-related musculoskeletal disorders (WMSDs) in dentists. The etiology of WMSDs is multifactorial and includes, in addition to aforementioned physical loads, individual and psychosocial factors. The most common areas of complaints are neck, shoulders, lower back, elbows and hands. MSDs may result in pain, stiffness, discomfort and loss of function. In literature dentists report decreased work ability and productivity which results in more frequent sick leaves and forces early retirement. Both workplace and individual preventative measures should be adopted.*

Keywords: *musculoskeletal disorders, dentists, work-related, preventative measures*

1. INTRODUCTION

Dental professionals are exposed to a wide range of occupational hazards. These include biological, physical, chemical and mechanical hazards, as well as psychosocial and physical strains [1]. Biological hazards comprise microorganisms such as bacteria, viruses, fungi, and prions. Dentists face an elevated risk of infection transmission, including hepatitis B, C, and HIV, due to their direct exposure to infected patient's saliva and blood during oral cavity work [2]. Ionizing and non-ionizing radiation, intense noise, vibrations, artificial lighting and polymerization light are categorized as physical occupational hazards in dentistry [3]. Furthermore, occupational contact dermatitis in dentists can be caused by chemical hazards such as disinfectants, dental materials, medicines, and latex-containing gloves [4]. Within the working environment of dentists, one also encounters psychosocial stressors like heavy workloads and schedule time constraints, which may lead to the onset of work-related stress [5]. Dentistry is a high-risk profession for the development of occupational and work-related diseases. Physical strains such as prolonged static positions, monotonous repetitive movements, and poor ergonomic features of devices and instruments used by dentists are known to precipitate or aggravate musculoskeletal disorders (MSDs) in dentists [4]. MSDs are one of the most common occupational health issues amongst dentists. These disorders refer to a group of diverse conditions affecting nerves, muscles, tendons, bones, joints, ligaments, blood vessels, and supporting structures such as intervertebral discs resulting in pain (often persistent) and impairments in mobility and dexterity thus reducing workers' ability to work and engage in society. When the work environment and task performance are among several contributing factors to the development of musculoskeletal conditions, they are classified as work-related MSDs (WMSDs). Conversely, if MSDs arise solely from working conditions, then they are categorized as occupational diseases (e.g. some overstrain syndromes).

The World Health Organization (WHO) estimates that approximately 1.71 billion people globally are affected by musculoskeletal conditions [6]. Numerous studies have investigated the prevalence of musculoskeletal disorders among dentists. The Standardized Nordic Questionnaire is the most commonly utilized method for analyzing musculoskeletal pain symptoms. In a meta-analysis conducted by Chenna et al., the prevalence of musculoskeletal disorders among dentists in Europe ranged from 54.07% to 97.91% [7]. A systematic review carried out by Soo et al. also reported a high prevalence of MSD's among dentists (between 68% and 100%). The most predominant regions for MSD's were the lower back (29% to 94.6%), shoulder (25% to 92.7%) and, neck (26% to 92%) [8]. In 2016, Vodanović et al. conducted a national survey on professional health problems among dentists in Croatia, revealing MSD's as the most common issue with a prevalence range from 55.8% (pain in legs and feet) to 78.3% (pain in the upper back) [9]. However, data on the incidence of musculoskeletal disorders categorized as occupational diseases in dentists are scarce. According to the Registry of Occupational Diseases of the Croatian Institute of Public Health, in the 15-year long period that the Registry is being conducted (2009. - 2023.) and after excluding the COVID-19 pandemic-related occupational diseases, occupational overuse syndromes make up for the majority of recognized cases of occupational diseases in Croatian dentists. Carpal tunnel syndrome is reported to be the most prevalent, occurring at an average of 57.5 years of age and after an average of 23.5 years of exposure to dentistry-related occupational static and dynamic strains. Stenosing tenosynovitis (trigger finger) has been reported to be the second most prevalent. All cases of recognized occupational diseases were observed in either self-employed or private practice female dentists suggesting the need for further research of organizational, as well as individual factors that may contribute to the development and/or onset of overuse syndromes and musculoskeletal pain in dentists.

2. ETIOLOGY

The development of WMSDs is caused by a variety of complex factors. *Individual factors* include age, weight, height, gender, and genetic predisposition. Younis et al. reported that dentists with higher age and weight were more likely to have WMSDs [10]. Consistent with these findings, the meta-analysis conducted by Shiri et al. highlighted a strong correlation between increased weight and back pain [11]. A Korean study demonstrated a correlation between height and musculoskeletal pain (MSP), identifying height as a risk factor for MSP among dental practitioners. Specifically, individuals in the ≥160 cm height group exhibited a 42% lower pain level compared to those in the <160 cm group [12]. This can be attributed to the fact that dental practitioners in the <160 cm group have to excessively raise their arms while working alongside a dental unit chair. Research findings regarding the prevalence of WMSDs among female dentists are contradictory. Some studies suggest a higher prevalence of WMSDs among female dentists [13–15], while others report there is no significant disparity between male and female dentists in the prevalence of WMSDs [16, 17]. Younis et al. even documented a lower occurrence of these disorders in women [10].

Another crucial aspect influencing the development of WMSDs in dentists is the presence of *physical work factors,* which include prolonged static non-physiological posture and repetitive movements. Dentists frequently maintain prolonged static non-physiological positions, engaging over 50 percent of the body's muscles [18]. The static forces generated by these postures are far more strenuous than dynamic forces [19]. Awkward postures, including forward bending and repetitive rotation of the head, neck, and trunk, can lead to muscle imbalances over time. The muscles responsible for rotation may become shorter and stronger, while opposing muscles weaken and elongate. Consequently, this asymmetry of uneven forces on the spine can lead to spinal misalignment and restricted movement in one direction over the other [18]. Another common working position adopted by dentists is leaning the head forward with rounded shoulders. In this case, the “stabilizer” muscles of the shoulder blades (middle and lower trapezius, rhomboids, and serratus anterior) may progressively weaken. Consequently, shoulder blades drift away from the spine, contributing to a rounded shoulder posture. Simultaneously, anterior "mover" muscles such as the scalene, sternocleidomastoid, and pectoralis become shortened and tightened, drawing the head forward [18]. This non-physiological posture increases forces on the upper neck muscles (upper trapezius and levator scapulae) and vertebral disks which can lead to pain in the overworked muscles and degenerative changes in cervical vertebral disks [18]. Another example of the muscle imbalance that tends to develop in dentists is between the abdominal and low back muscles. Repeatedly bending toward a patient can lead to strain and overuse of the lower back muscles, while the deep stabilizing abdominal muscle (transversus abdominis) tends to weaken [18]. It's important to highlight that over time, the body adapts to the abnormal posture resulting from these muscle imbalances. Thus, individuals may maintain this unbalanced posture not only during work but also during leisure activities. During extended periods of sitting, prolonged static contractions of the low back extensor muscles (lumbar erector spinae) lead to a decrease in oxygenation levels within the muscle. Ischemic areas of muscles are prone to the development of trigger points, which can cause pain, stiffness, and limited range of motion [18]. Furthermore, prolonged static postures result in joint hypomobility so dentists who consistently lean forward toward patients may have excellent spinal flexion, but eventually, the ability of the spine to extend is diminished. As previously mentioned, dentists frequently assume a forward flexion and rotation posture, which increases the pressure in lumbar spinal discs by 400 percent compared to the pressure experienced in the upright standing position [20]. Hence, repeated forward flexing can lead to bulging or herniation of intervertebral discs in dentists. Dentists often adopt a raised-arm working position during procedures and this posture leads to muscle fatigue in the neck and shoulders over time. Repetitive work activities, on the other hand, lead to the overuse of specific muscles. As a result of repetitive movements and the simultaneous application of force, the development of various overstrain syndromes of the musculoskeletal system may occur. As mentioned above, overstrain syndromes caused solely as a result of working conditions are considered occupational diseases.

In addition to individual and physical factors, *psychosocial factors* such as organization of the job, job demands (high workload, time pressure), job control, low job variety (repetitive tasks), style of supervision, and support amongst co-workers play a significant role in the etiology of WMSDs [21]. Mental stress leads to muscle tension, contributing to the development of WMSDs, particularly in the upper extremities [22]. Furthermore, elevated stress levels can result in 'burnout' and further contribute to musculoskeletal problems in dental practitioners.

3. WMSDs IN DENTISTS

Among the most prevalent WMSDs resulting from prolonged static posture in dentistry are chronic low back pain, tension neck syndrome, and trapezius myalgia. In the literature, the lower part of the spine is frequently identified as the most common site for musculoskeletal disorders among dentists [8, 10, 16, 23, 24]. Newell et al. indicate that orthodontists frequently suffer from low back pain as a result of the repetitive forward positioning of the head and bending of the lower back during clinical procedures [25]. Furthermore, general dental practitioners are prone to neck and low back MSD's because of their prolonged static postures and fewer repetitive motions involved in their work [26]. Degeneration of intervertebral discs in the lumbar or lumbosacral region of the spine (known as lumbar and lumbosacral discopathy) can result in pain in the loins and lower back, which often radiates to the lower extremities. A higher incidence of this pain in the right leg can be explained by the greater strain placed on the right side of the body when working with seated patients [27]. Tension neck syndrome (TNS) is a condition characterized by myofascial pain localized in the neck and shoulder regions. Symptoms include pain, stiffness, tenderness, and fatigue in the cervical musculature, along with headaches that radiate from the neck. These symptoms occur without a history of injury, degenerative processes, or herniated cervical disk [28]. Additionally, there is often referred pain between the shoulder blades or in the occiput and sometimes tingling or loss of sensation in one arm or hand can be present [18]. TNS primarily results from keeping the forward head posture [18]. Trapezius myalgia is characterized by pain, stiffness, tenderness, and muscle spasms of the upper trapezius muscle. The main predisposing factor for the development of trapezius myalgia is prolonged work with elevated arms. It's frequently observed in the trapezius muscle on the side where the dentist holds the mirror [18].

4. OCCUPATIONAL MUSCULOSKELETAL DISEASES IN DENTISTS

Dentistry involves complex procedures with repetitive, monotonous movements and simultaneous application of force, which causes stress on the wrist and elbow joints. Additionally, frequent use of hand tools in dental work can lead to chronic external compression of the nerves in the hand, potentially resulting in the entrapment of digital nerves [29]. Consequently, median nerve entrapment and ulnar nerve entrapment are common among dentists. Carpal tunnel syndrome (CTS) is caused by compression of the median nerve in the carpal tunnel. Symptoms include pain, numbness, and paresthesia in the palmar distribution of the median nerve in the hand. This specifically affects the thumb, index finger, middle finger, and the radial half of the ring finger. Similarly, the aforementioned symptoms can be experienced in the dorsal distribution of the median nerve in the hand, specifically affecting the dorsum of the distal halves of the same lateral three-and-a-half fingers. Additionally, individuals with CTS may experience weakness of the hand, diminished grip strength, and reduced fine motor coordination. Also, atrophy of the thenar muscles can occur. At first, symptoms are commonly experienced at night, yet, as the disorder advances, they become increasingly constant. Therefore, CTS can profoundly affect an individual's quality of life, resulting in functional limitations, difficulties with daily tasks, decreased productivity and potentially forcing them to consider leaving their dental profession [30]. In a systematic review conducted by Chena et al. the overall pooled prevalence of CTS among dental healthcare personnel was 15% and was higher among dentists than dental auxiliaries [30]. They also concluded that dental healthcare personnel have a higher risk of CTS than the general population because of frequent repetitive activity and firm gripping [30]. Prolonged wrist flexion and finger bending movements, along with the use of ambidextrous gloves, increases the risk of developing CTS among dentists[31]. For instance, some dental procedures like root planing, require dentists to apply high force. During these procedures, dentists must firmly grip small instruments and continuously flex and extend their wrists, which increases their vulnerability to CTS [31]. A study conducted by Maghsoudipour et al. also revealed a significant relationship between CTS prevalence and exposure to vibrating equipment (e.g. micro-motors and angle turbines), indicating that vibration exposure may be a risk factor for developing CTS among dentists as well as physical strains [32]. In addition to the aforementioned work-related risk factors, several other individual factors and medical conditions are associated with an increased risk of developing CTS. These include genetic predisposition, injury or trauma of the wrist, pregnancy, menopause, breast cancer, female sex, individuals with diabetes, rheumatoid arthritis, lupus, hypothyroidism, and obesity.

Trigger finger, also known as stenosing tenosynovitis, is a disorder characterized by snapping, catching, or locking of the involved finger in full or near full flexion. The trigger finger most frequently affects the dominant hand, with the thumb and ring finger being the most commonly involved digits. Symptoms include pain in the palm that radiates along the finger when moving the affected digit. This condition results from thickening of the flexor tendon in the distal aspect of the palm, leading to abnormal gliding and locking of the tendon within the tendon sheath. The tendon typically gets trapped at the edge of the first annular (A1) pulley. Studies have correlated trigger finger with occupations that involve prolonged gripping and repetitive hand flexion, such as those involving the use of shears or handheld tools [33].

5. AFFECTS OF MSDs

As emphasized by the World Health Organization, MSDs are a major cause of disability worldwide due to their significant impact on restricting mobility and dexterity [6]. The effect of MSDs on individuals' health varies, ranging from intermittent pain and stiffness that may not necessarily affect job performance or efficacy to severe conditions where pain significantly interferes with daily tasks. Certainly, with prolonged exposure to workplace hazards, dentists exhibit more severe symptoms like generalized pain, loss of muscle strength, hypersensitivity, loss of balance, etc. [34]. Research conducted among healthcare providers, including dentists, revealed that experiencing musculoskeletal pain across multiple sites was linked to decreased work ability. Moreover, this association was likely to strengthen with a higher number of pain sites [35]. Likewise, Marklund et al. noted that approximately 20% of dentists reported reduced work productivity as a result of pain and discomfort, while more than 6% reported having poor-to-moderate work ability [36]. A study conducted in Pakistan revealed that 95.4% of dentists sought medical treatment for musculoskeletal pain and 69% of dentists took sick leave due to WMSDs during their life [10]. In severe cases, WMSDs can result not only in frequent absences from work, but can ultimately lead to early retirement. Burke et al. reported that nearly one third of the dentists who retired early were forced to do so due to MSDs [37].

6. CONCLUSION

Dentistry is a highly demanding profession which exposes dental professionals to numerous occupational hazards and strains. MSDs represent a significant health burden for dentists. Therefore, effective workplace and individual preventative measures should be adopted. Optimal ergonomic design of the dental workplace is important to reduce awkward working postures. Furthermore, incorporating frequent short stretch breaks between patient appointments and integrating regular strengthening exercises as part of leisure activities are crucial for preventing occupational MSDs among dentists.

REFERENCES

[1] Moodley, R.; Naidoo, S.; van Wyk, J.: The prevalence of occupational health-related problems in dentistry: A review of the literature, *Journal of Occupational Health*, (2018), Vol. *60*, pp. 111–125.

[2] Khandelwal, P.; Hajira, N.: Prevention of transmission of HIV & hepatitis during dental procedures, *International Journal of Applied Dental Sciences*, (2015), Vol. *1*, pp. 163–165.

[3] Anjum, A.; Akram Butt, S.; Abidi, F.: Hazards in dentistry - a review, *Pakistan Journal of Medicine and Dentistry*, (2019), Vol. *8*.

[4] Firić, I.; Krstić Vukelja, E.; Firić, M.; Mustajbegović, J.: Profesionalni rizici u dentalnoj medicini, *Sigurnost*, (2016), Vol. *58*, pp. 145–153.

[5] Moore, R.; Brødsgaard, I.: Dentists' perceived stress and its relation to perceptions about anxious patients, *Community Dentistry and Oral Epidemiology*, (2001), Vol. *29*, pp. 73–80.

[6] WHO: Musculoskeletal health, (2022).

[7] Chenna, D.; Pentapati, K.C.; Kumar, M.; Madi, M.; et al.: Prevalence of musculoskeletal disorders among dental healthcare providers: A systematic review and meta-analysis, *F1000Research*, (2022), Vol. *11*, pp. 1062.

[8] Soo, S.Y.; Ang, W.S.; Chong, C.H.; Tew, I.M.; et al.: Occupational ergonomics and related musculoskeletal disorders among dentists: A systematic review, *Work*, (2023), Vol. *74*, pp. 469–476.

[9] Vodanović, M.; Sović, S.; Galić, I.: Profesionalni zdravstveni problemi medu stomatolozima u Hrvatskoj, *Acta Stomatologica Croatica*, (2016), Vol. *50*, pp. 310–320.

[10] Younis, U.; Shakoor, A.; Chaudhary, F.A.; Din, S.U.; et al.: Work-Related Musculoskeletal Disorders and Their Associated Risk Factors among Pakistani Dental Practitioners: A Cross-Sectional Study, *BioMed Research International*, (2022), Vol. *2022*.

[11] Shiri, R.; Karppinen, J.; Leino-Arjas, P.; Solovieva, S.; et al.: The association between obesity and low back pain: A meta-analysis, *American Journal of Epidemiology*, (2010), Vol. *171*, pp. 135–154.

[12] Cho, K.; Cho, H.-Y.; Han, G.-S.:Risk factors associated with musculoskeletal symptoms in Korean dental practitioners, n.d.

[13] Puriene, A.; Aleksejuniene, J.; Petrauskiene, J.; Balciuniene, I.; et al.: Self-Reported Occupational Health Issues among Lithuanian Dentists, *Industrial Health*, (2008), Vol. *46*, pp. 369–374.

[14] Ayers, K.M.S.; Thomson, W.M.; Newton, J.T.; Morgaine, K.C.; et al.: Self-

reported occupational health of general dental practitioners, *Occupational Medicine*, (2009), Vol. *59*, pp. 142–148.

[15] Harutunian, K.; Gargallo-Albiol, J.; Figueiredo, R.; Gay-Escoda, C.: Ergonomics and musculoskeletal pain among postgraduate students and faculty members of the School of Dentistry of the University of Barcelona (Spain). A cross-sectional study, *Medicina Oral, Patologia Oral y Cirugia Bucal*, (2011), Vol. *16*, pp. 425–429.

[16] Aljanakh, M.; Shaikh, S.; Siddiqui, A.A.; Al-Mansour, M.; et al.: Prevalence of musculoskeletal disorders among dentists in the Ha'il Region of Saudi Arabia, *Annals of Saudi Medicine*, (2015), Vol. *35*, pp. 456–461.

[17] Muralidharan, D.; Fareed, N.; Shanthi, M.: Musculoskeletal Disorders among Dental Practitioners: Does It Affect Practice?, *Epidemiology Research International*, (2013), Vol. *2013*, pp. 1–6.

[18] Valachi, B.; Valachi, K.: Mechanisms leading to musculoskeletal disorders in dentistry, *Journal of the American Dental Association*, (2003), Vol. *134*, pp. 1344–1350.

[19] Ratzon, N.Z.; Yaros, T.; Mizlik, A.; Kanner, T.: Musculoskeletal symptoms among dentists in relation to work posture, *Work*, (2000), Vol. *15*, pp. 153–158.

[20] Nachemson, A.L.: Disc pressure measurements, *The Spine Journal*, (1981), Vol. *6*, pp. 93–97.

[21] Morse, T.; Bruneau, H.; Dussetschleger, J.: Musculoskeletal disorders of the neck and shoulder in the dental professions, *Work*, (2010), Vol. *35*, pp. 419–429.

[22] Melin, B.; Lundberg, U.: A biopsychosocial approach to work-stress and musculosketal disorders, *Journal of Psychophysiology*, (1997), Vol. *11*, pp. 238–247.

[23] Hayes, M.J.; Cockrell, D.; Smith, D.R.: A systematic review of musculoskeletal disorders among dental professionals, *International Journal of Dental Hygiene*, (2009), Vol. *7*, pp. 159–165.

[24] Szymańska, J.: Disordes of the musculoskeletal system among dentists from the aspect of ergonomics and prophylaxis, *Annals of Agricultural and Environmental Medicine*, (2002), Vol. *9*, pp. 169–173.

[25] Newell, T.M.; Kumar, S.: Prevalence of musculoskeletal disorders among orthodontists in Alberta, *International Journal of Industrial Ergonomics*, (2004), Vol. *33*, pp. 99–107.

[26] Valachi, B.; Valachi, K.: Preventing musculoskeletal disorders in clinical dentistry: Strategies to address the mechanisms leading to musculoskeletal disorders, *Journal of the American Dental Association*, (2003), Vol. *134*, pp. 1604–1612.

[27] Szymanska, J.: Occupational hazards of dentistry, *Annals of Agricultural and Environmental Medicine*, (1999), Vol. *6*, pp. 13–19.

[28] França, D.L.M.; Senna-Fernandes, V.; Cortez, C.M.; Jackson, M.N.; et al.: Tension neck syndrome treated by acupuncture combined with physiotherapy: A comparative clinical trial (pilot study), *Complementary Therapies in Medicine*, (2008), Vol. *16*, pp. 268–277.

[29] Milerad, E.; Ekenvall, L.: Symptoms of the neck and upper extremities in

dentists, *Scandinavian Journal of Work, Environment and Health*, (1990), Vol. *16*, pp. 129–134.

[30] Chenna, D.; Madi, M.; Kumar, M.; Kumar, V.; et al.: Worldwide prevalence of carpal tunnel syndrome among dental health care personnel - A systematic review and meta-analysis, *F1000Research*, (2023), Vol. *12*, pp. 251.

[31] Powell, B.J.; Winkley, G.P.; Brown, J.O.; Etersque, S.: Evaluating the fit of ambidextrous and fitted gloves: implications for hand discomfort., *Journal of the American Dental Association (1939)*, (1994), Vol. *125*, pp. 1235–1236.

[32] Maghsoudipour, M.; Hosseini, F.; Coh, P.; Garib, S.: Evaluation of occupational and non-occupational risk factors associated with carpal tunnel syndrome in dentists, *Work*, (2021), Vol. *69*, pp. 181–186.

[33] Makkouk, A.H.; Oetgen, M.E.; Swigart, C.R.; Dodds, S.D.: Trigger finger: etiology, evaluation, and treatment, *Current Reviews in Musculoskeletal Medicine*, (2008), Vol. *1*, pp. 92–96.

[34] Kawtharani, A.A.; Chemeisani, A.; Salman, F.; Haj Younes, A.; et al.: Neck and Musculoskeletal Pain Among Dentists: A Review of the Literature, *Cureus*, (2023).

[35] Phongamwong, C.; Deema, H.: The impact of multi-site musculoskeletal pain on work ability among health care providers, *Journal of Occupational Medicine and Toxicology*, (2015), Vol. *10*.

[36] Marklund, S.; Mienna, C.S.; Wahlström, J.; Englund, E.; et al.: Work ability and productivity among dentists: associations with musculoskeletal pain, stress, and sleep, *International Archives of Occupational and Environmental Health*, (2020), Vol. *93*, pp. 271–278.

[37] Burke, F.J.; Main, J.R.; Freeman, R.: The practice of dentistry: an assessment of reasons for premature retirement, *British Dental Journal*, (1997), Vol. *182*, pp. 250–254.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

MEETING THE "TEKSERGO" PROJECT

Damir Kralj[1], Snježana Kirin[1], Marinela Vulić[1]

[1] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, CROATIA-47000 Karlovac,

damir.kralj@vuka.hr, snjezana.kirin@vuka.hr & marinela.vulic@vuka.hr

Abstract: *Unfavorable working conditions are the reality of all forms of industrial production processes, including the textile industry. This paper aims to provide a preliminary statement and basic insight into the beginning of the project, the subject of which is the analysis of the main indicators of occupational safety and the assessment of the current situation, measurement of the parameters of the working environment, determination of working ability, evaluation of the work method, along with the analysis of the psychophysiological and postural load of workers by applying program support for measuring these indicators and 3D simulation and improvement of the work scene and scenario. The basics of activities planned to organize, implement, and shape the expected results of the project are described. In addition to the contribution in terms of improving working conditions, the project is expected to classify and present the acquired experiences in the form of a manual for achieving pleasant working environment conditions, as well as the improvement of the higher education program in the field of workplace ergonomics and safety at work.*

Keywords: *Ergonomics, measurements, program support, improvement of working conditions, safety at work.*

1. INTRODUCTION

In the textile industry, there are unfavorable working conditions, high workloads, and the use of machines and other work equipment, which makes the work extremely psychophysically and statodynamically intensive, and the worker is susceptible to occupational diseases. The necessary improvements can be achieved through the development and adoption of a safety culture that influences the attitudes and behavior of workers, provides a framework for their actions and thinking, affects stress reduction, and thus affects the level of safety. This paper will briefly describe the initial project in which research and analysis of the main indicators of occupational safety and assessment of the existing condition, measurement of parameters of the working environment, determination of working ability, assessment of work methods, and analysis of psychophysiological and postural load of workers will be carried out. The official name of the mentioned project is TeksErgo. In addition to the already established procedures for measuring workplace parameters, the project's methodology will be supplemented by recording work scenarios using computer equipment and specialized software support. The research will be conducted in real production processes of textile industries. The expected results are the determination of the frequency and level of musculoskeletal disorders, the determination of the workload and fatigue of workers, and the proposal of a suitable design of workplaces in the textile industry, as well as the creation of a manual for working in a safe manner. The significance of the proposed research is based on finding the optimal working conditions when working in the textile industry, which, among other things, significantly reduces the current percentage of sick leave of workers, which is a significant contribution to the ergonomic improvement of working conditions and the reduction of costs associated with worker illnesses. [1, 2, 3]

The research within this project aims to optimize work movements when operating machines with a significant reduction in the current number of work injuries and sick leave in the textile industry. To achieve this, selected indicators of the working ability of employees will be analyzed and compared, and recommendations for further improvement of the workplace safety management system will be made. One of the main contributions is the creation of a manual for working in a pleasant and safe way. The use of program support for recording and calculation of workload indicators, as well as programs for 3D work simulation, will certainly significantly contribute to the improvement of work methods, reduce the workload and fatigue of workers, and reduce the total psychophysiological efforts of workers. An additional very important goal of the project is to implement the application of the mentioned modern program support in the higher education curriculum of security and protection studies so that students acquire the necessary digital competencies in their professional domain as early as possible, necessary for the improvement of job security within Industry 4.0 and Industry 5.0. [4, 5, 6, 7, 8]

2. METHODOLOGY AND RESOURCES OF RESEARCH

In the period preceding the project, work methods were investigated using MTM (Method Time Measurement), methods and worker workload using OWAS (Ovaco Working Analyzing System), RULA (Rapid Upper Limb Assessment), REBA (Rapid Entire Body Assessment) and SMART (Scoring Method for Assessment of Repetitive Tasks) methods. The ErgoFellow program was used for REBA and RULA research at that time. Based on these studies, a significant workload of workers in the textile and clothing industry was observed, as well as an expressed need for redesigning workplaces and determining a suitable work method to reduce workload and increase work productivity. In this way, the number of sick days and occupational diseases would be reduced. [8, 9, 10, 11]

The research methodology of the TeksErgo project can be summarized in the following nine steps:

- Searching for relevant domestic and foreign scientific and professional works in the field of occupational safety and workload and fatigue of workers in production processes;
- Measurement of working environment parameters;
- Analysis of the basic indicators of safety at work;
- Analysis of the working capacity index;
- Analysis of the presence of musculoskeletal disorders;
- Analysis of work methods;
- Workload analysis using software;
- Simulation of a redesigned workplace using a computer;

- Creation of a manual for working in a safe manner.

As additional features of the methodology, the use of specialized computer equipment and software support used for recording the work scenario, measurement of load parameters through a network of inertial sensors, calculation of statistical indicators and analysis, simulation, and improvement of the work scene and work scenario should be highlighted. The next important feature of the methodology is that the applied means and methods are introduced into the curriculum of the professional study of security and protection, and thus the students become essential factors in the modernization of the workload assessment procedures and the improvement of workplaces.

The purpose and justification of the research can be summarized through the following contributions:

- The application of program support and the results of the analysis of psychophysiological and statodynamic efforts create a working environment with less workload and a suitable work method;
- The improved working environment contributes to the reduction of musculoskeletal disorders, which affects the lower prevalence of occupational diseases;
- Until now, in the textile industry in the Republic of Croatia, no research has been conducted on psychophysical and statodynamic efforts using software support for the analysis and 3D simulation of workplaces, which is an important contribution to the innovation of the project;
- New knowledge is gathered about the psychophysical and statodynamic effort and workload of employees in the textile industry;
- Until now, students of the Karlovac University of Applied Sciences have not had the opportunity to use program support for analysis and 3D simulation of the work process, which is additional innovation and gives students new competencies for work on the labor market;
- From the previous contribution, the improvement of the teaching process follows the application of software support for the analysis and 3D simulation of the work process;
- Creation of a manual for working in a safe manner, which could educate workers and employers about a more pleasant and safer workplace;
- New knowledge about the transformation of work methods and work environment.

The results of the project in the form of tables, diagrams, and video presentations will be stored in electronic form, and important results will be available in written form and can be used in the further teaching process. The application of specialized program support will contribute to the improvement of the teaching process in the courses Applied Ergonomics and Computer Ergonomics. The results of the research will be included in the preparation of the final and graduate theses. Creating a safe work manual would be used in industry and the teaching process.

3. COMPUTER AND PROGRAM SUPPORT

When choosing specialized program support, the financial and functional sustainability of the project and its ultimate goals had to be taken into account. Financial sustainability is the basis of functional sustainability. The financial resources that we invest in electronic equipment (computer equipment, sensors, etc.) are one-time over a relatively long period. However, program licenses must be renewed every year, and in order to raise the quality of teaching in the future, it is necessary to plan to increase the number of workstations, which increases the number of required licenses per year. In short, an excessive amount of the price of software licenses could make up an excessive share of the price of the performance of the professional study, which calls into question its sustainability. Based on the set criteria and a comparison of the prices and functionality of software solutions available on the market, the final choice fell on the product of the French company HRV Simulation called NAWO Solutions [12]. This software package is compact and portable enough for the intended application scenarios. It consists of three program modules. NAWO Live is an application with an annual license. It allows recording of working movements only with a video camera with digital processing of the video footage (less accurate) or recording with a video camera and inertial sensors (high precision with tracking of joint rotation with an accuracy of 1°). Software support for calibration, communication, and receiving data from the sensors is included in the price of the sensor kit and has a permanent license on a USB dongle. Thus, NAWO Live is a key application for recording work sequences and subsequent analysis of collected data (Figure 1). A detailed report on the total load within the work scenario can be exported for later detailed analysis in Excel format (Figure 2). For a quick review and control (screening) of work sequences, you can use NAWO Smart, which is free and can be installed on a mobile device. It is suitable for ergonomic checking of the work sequence during work, where workers in the plant can record each other for control, and by uploading the recording to NAWO Live, make a quick analysis of the situation. This approach is also suitable for student applications during field exercises or professional practice. It is enough to take a good recording position with good lighting and avoid physical obstacles between the recorded worker and the camera of the mobile device, so that the digital character (avatar) covers the entire body of the recorded worker, records the video and transfer it to the computer in the NAWO Live application. The NAWO Studio application has an annual license like NAWO Live and serves the VR simulation of work sequences in a real (previously digitized) or newly designed work environment. Using VR glasses, it is possible to "enter" the digital scene and analyze its settings. To see the capabilities of the NAWO Live application, the manufacturer gave us a test license for two periods of one week each, during which we analyzed the functional capabilities of the NAWO Live and NAWO Smart applications and determined the limit properties of the computer equipment on which this program support works satisfactorily. The manufacturer was always available for help and advice. In the test period, we made a dozen test measurements by recording videos, based on which we made reports on workloads and thus gained our first experience in the digital analysis of work scenarios using this kind of specialized software support. Assessment methods functionally supported by the selected software are RULA, REBA, OCRA, NIOSH, EAWS (EN1005 and ISO 11228), and BORG. [11, 12]

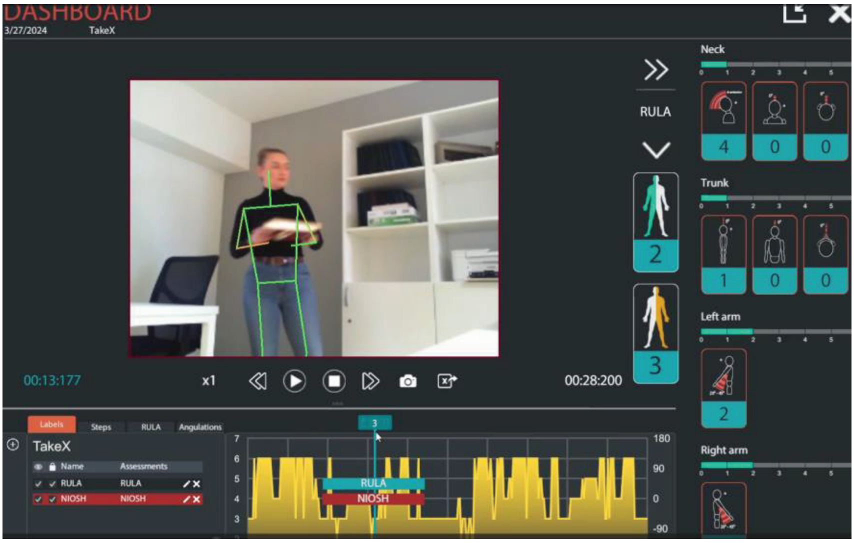


Figure 1: Analysis of the work scenario in the NAWO Live program (source: author)

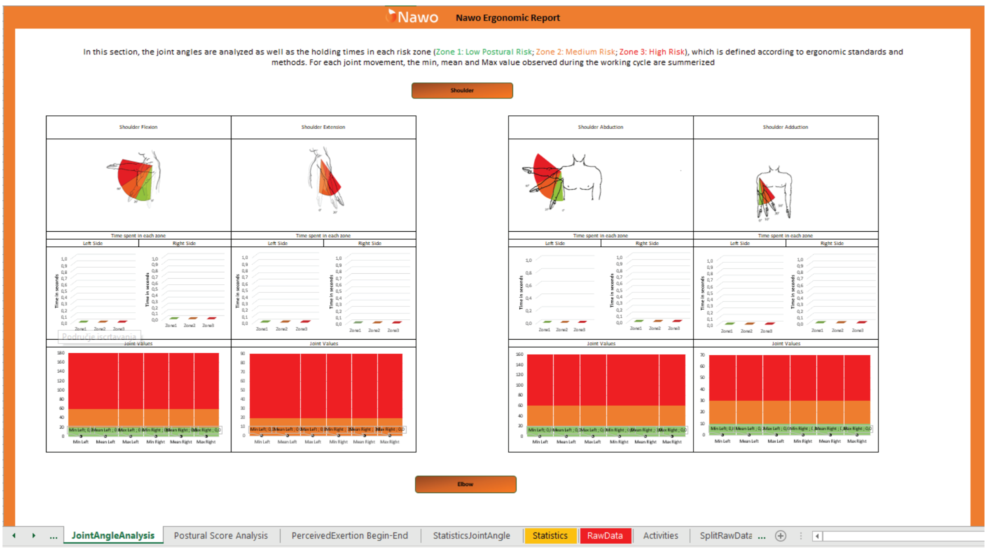


Figure 2: Part of the load report exported from NAWO Live (source: author)

Based on the experience gained during the testing of the software support, a decision was made on the general configuration of the computer equipment on which this software support will be installed. In any case, for the sake of portability, the computer must be a mobile workstation with an advanced processor (Intel i7 or higher), at least 32 GB of RAM, a fast SSD, advanced graphics (for CAD drawing and VR), a minimum screen size of 17" and with an external monitor of at least 27" for comfortable work in stationary conditions.

4. CONCLUSION

In this summary overview of the research methodology, applied means, and expected contributions of the TeksErgo project, only a basic insight into the course and goals of this two-year project is given. The project will certainly result in a set of measurable and non-measurable indicators.

The measurable ones will be expressed through: the development of proposals for measures to reduce the statodynamic load and fatigue of workers, the development of proposals for reducing the psychophysiological effort of workers, the implementation of specialized program support in the teaching process, the development of proposals for measures to improve workplace safety within Industry 4.0 and Industry 5.0, creation of manuals for working safely and publication of the results through the foreseen number of papers in journals and professional-scientific conferences.

The immeasurable indicators first of all derive from the purpose of these researches, which is to achieve a culture of safety in the performance of workers' jobs during technological procedures and to propose measures to reduce psychophysical and statodynamic efforts in the textile industry, which can enable the reduction of sick leave of workers. Furthermore, there are programmatic indicators of the proposed research that will certainly result in the strengthening of human potential for scientific work at the Karlovac University of Applied Sciences, improvement of research infrastructure, and cooperation between the Karlovac University of Applied Sciences and textile industry factories, strengthening of the interdisciplinary nature of scientific work and connection with other scientific institutions in the same scientific field and the popularization of science by holding of seminars for industry.

REFERENCES

[1] Heiser, J., Render, B.: *Production and Operations Management*, New Jersey, Prentice Hall, (1996), ISBN 0471-51293

[2] Meyers F. E., Stewart J. R.; *Motion and Time Study, 3rd edition*, Prentice Hall, New Jersey/ Columbus / Ohio, (2002), ISBN 0-13-03061670-9

[3] Verhovnik, V., Polajnar, A.: *Oblikovanje dela in delovnih mest, II izdanje*, Univerza v Maribor Fakulteta za strojništvo, Maribor, (2007), ISBN 86-435-0341-X

[4] Balantič, Z., Polajnar, A., Jevšnik, S.: *Ergonomija v teoriji in praksi*, Nacionalni inštitut za javno zdravje, Ljubljana, (2016), ISBN 978-961-6911-91-7

[5] Hursa Šajatović, A., Kirin, S.: Ergonomska analiza statodinamičkog opterećenja radnika u tehnološkom procesu šivanja odjeće, *Sigurnost* **64** (2022) 3, pp. 223-235

[6] Jurčević Luić, T., Runjak, M.: Procjena opterećenja radnika pri podizanju tereta, *Sigurnost* **55** (2013) 2, pp. 125-131.

[7] Kirin, S., Hursa Šajatović, A.: Karakteristike rada i istraživanje radnog opterećenja u odjevnoj industriji, *Sigurnost* **65** (2023) 3, pp. 269-282

[8] Kirin, S.:Ergonomska istraživanja opterećenja radnika u procesu šivanja odjeće, *Sigurnost*, **62** (2020) 3, pp. 239-249, ISSN 0350-6886 (original scientific work)

[9] Kirin, S.: Ergonomska procjena opterećenja radnika u tehnološkom procesu šivanja REBA metodom, *12th International Scietific Conference on Production Engineering, RIM 2019.-Development and moderenization of production*, Hodžić, A.; Islamović, F.; Mijović, B. (Ed.), pp. 372-377 Univerzitet u Bihaću Tehnički fakultet, (2019)

[10] Kirin, S.; Dragčević, Z.: Investigation of Workload in the Technological Sewing Process Using the RULA Method, *Book of Proceedings of the 9th International Textile, Clothing&Desing Conference - Magic World of Textiles*, Dragčević Z. (Ed.), pp.197-202, ISSN 1847-7275, Dubrovnik, Croatia, October 7th-10th, 2018

[11] Kirin, S., Dragčević, Z., Firšt Rogale, S: Workplace redesing in the computer-aided technological sewing process, *Tekstil* **63** (2014.) 1-2, PP. 14-26, ISSN 0492-5882

[12] Nawo Solution: „Ergonomic analysis solution to indentify MSDs − Nawo Solution", *Available from*: https://nawo-solution.com/home/ *Accessed:* 2024-05-25

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

STRESS AT WORK CAUSED BY BURNOUT SYNDROME

Bojan Latić
Kemigal,Tehnička ispitivanja i analiza, Juranovo brdo 3, Duga Resa, Hrvatska
bojan.latic47250@gmail.com

Abstract

Burnout syndrome is a state of emotional, mental, and physical exhaustion caused by prolonged and excessive stress at the workplace. Some common symptoms include emotional exhaustion, cynicism towards work, reduced efficiency, sleep problems, physical symptoms, anxiety, and depression.

Employers can help prevent burnout syndrome by creating a healthy work environment, supporting work-life balance, providing stress management training, and encouraging open communication. Preventing burnout syndrome requires ongoing engagement and attention to the emotional, mental and physical health of employees.

Key words: *Burnout sindrome, mental exhaustion, depression, work-life balance, employee health*

1. Introduction

Work-related stress can have serious health consequences for employees and, in some cases, can lead to occupational diseases. This is often referred to as "burnout syndrome."

Prolonged work-related stress can become an occupational disease triggered by burnout or mobbing, both of which represent serious conditions characterized by physical and emotional symptoms. Additionally, various factors such as lack of support, continuous pressure, job insecurity, and lack of control can contribute to work-related stress and the development of occupational diseases. To reduce the risk of such conditions, the importance of stress prevention, risk management, and providing support to employees in managing work-related stress is emphasized. This indicates the need for a holistic approach involving organizations, employees, medical professionals, and regulatory bodies to ensure a healthier and more productive work environment.

Work-related stress can have serious consequences on the physical and mental health of employees, including increased anxiety, depression, sleep problems, and headaches. Professional losses, such as loss of motivation and reduced productivity, are also highlighted as possible consequences of prolonged stress.

To address this complex issue, it is important to educate people about mental health, reduce the stigma associated with seeking help, and promote cooperation between employees and employers. These additional steps can contribute to creating a work culture that supports employee well-being and reduces the risk of occupational diseases caused by work-related stress.

2. Psychological Aspects of Work-Related Stress

Prolonged work-related stress can lead to serious health consequences for employees, and burnout can be recognized as an occupational disease. Organizations and employees should work together to create working conditions that support employee well-being to reduce the risk of such conditions.

Proving that stress causes occupational disease can be challenging, as stress is often subjective and difficult to directly link to specific physical symptoms or diseases. However, there are certain steps and strategies that employees and their doctors can take to try to prove the connection between work-related stress and occupational disease: [1]

It is important for organizations to recognize the significance of managing work-related stress to preserve the health of their employees and create a work environment that supports well-being. This includes providing resources for stress prevention, mental health education, and properly addressing situations that can lead to occupational disease.

Factors of work-related stress can vary depending on the type of job, work environment, and personal characteristics of employees. Here are some additional aspects that contribute to how work-related stress can become an occupational disease. [2]

3. Stress Management

Constant pressure, work overload, poor relationships in the workplace, or unrealistic expectations can lead to prolonged stress. If these factors are not addressed or managed, employees are at risk of developing an occupational disease.

Continuous stress can cause various physical symptoms such as headaches, sleep problems, appetite changes, and other health issues. Emotional symptoms may include anxiety, depression, loss of motivation, and a sense of exhaustion.

People suffering from work-related stress often show decreased productivity. Difficulties in concentration, increased mistakes, and loss of interest in work can result from stress, further hindering work efficiency. [3]

Work-related stress can change employees' attitudes towards their jobs. People who have suffered prolonged stress may become cynical, lose a sense of achievement, or develop a negative attitude towards work.

When work-related stress is not addressed or managed appropriately, it can lead to professional burnout. This is a state of complete physical, emotional, and mental exhaustion. People suffering from burnout are often unable to effectively perform their work tasks.[4]

4. Recognizing Stress as an Occupational Disease

In some cases, work-related stress can be recognized as an occupational disease, especially if the symptoms are severe enough to affect a person's ability to work. Laws and regulations on recognizing such conditions can vary between different jurisdictions.

Lack of support from superiors, colleagues, or the organization can significantly increase work-related stress. The absence of support can make it difficult to cope with demanding situations.

Setting unrealistic deadlines, the constant need to achieve high performance, and lack of recognition for effort can create continuous pressure, leading to stress.

Fear of job loss or uncertainty about future employment can create significant stress. This can be particularly pronounced during periods of economic instability.

When employees fail to balance job demands with personal obligations and needs, it can lead to additional stress.

Feelings of helplessness or lack of control over work tasks can also contribute to work-related stress. People who feel they have no control over their work environment are often more susceptible to stress.

Working without adequate time for rest and recovery can lead to chronic fatigue and increase the risk of professional burnout.

Lack of recognition or adequate rewards for good work can negatively impact employee motivation, leading to feelings of alienation and low self-confidence.

Overall, preventing and managing work-related stress requires a holistic approach that includes organizational support, employee education, proper task management, and the promotion of a healthy work culture. This can reduce the risk of occupational diseases and improve employee well-being.[5]

5. Example of an Occupational Disease: Burnout Syndrome

An employee works in an environment where they are constantly exposed to high levels of stress, excessive working hours, pressures from superiors, and unrealistic expectations, experiencing prolonged stress resulting from constant work pressure, workplace conflicts, or lack of support from colleagues and superiors.

Due to prolonged stress, the employee begins to show symptoms of burnout, such as emotional exhaustion, loss of interest in work, reduced productivity, depersonalization (developing cynicism towards work and colleagues), and feelings of inefficacy.

Burnout can have serious physical and mental consequences, including increased anxiety, depression, sleep problems, headaches, increased risk of heart disease, and other health issues.

As symptoms become more severe, the employee may start to be absent from work due to health problems. This can lead to reduced productivity and increased costs for the organization.

In the most severe cases, burnout can lead to complete loss of professional capacity. The employee may be forced to leave the job or face a reduced ability to perform work tasks.

People suffering from burnout often require professional help, including therapy, counseling, or medical intervention, to cope with stress and restore their mental health.

The first step is to seek professional medical advice. A doctor can diagnose based on symptoms and medical examinations. If the symptoms are related to stress, the doctor can document this connection in the medical records.

Mental health professionals, such as psychologists or psychiatrists, can provide an assessment of the employee's mental health. This assessment may include an interview, psychological tests, and observation of stress-related symptoms.

It is important to gather documentation that illustrates stressful working conditions, including work schedules, pressures from superiors, work tasks, and other factors that could contribute to work-related stress. This can include emails, meeting notes, and other written records.

If there is support from colleagues or other witnesses, their testimonies can be helpful. This can include statements about working conditions, behavior of superiors, or any other aspects that may affect the employee's stress.

If the occupational disease is related to certain business changes, such as restructuring or downsizing, notes on these changes can help connect stress to work conditions. Sometimes expert analysis by professionals, such as labor law experts or medical experts, is needed.

They can provide additional expertise and confirm the connection between work-related stress and occupational disease.

It is important to note that legal proceedings related to occupational diseases can vary according to the laws in a specific area. If an employee suspects that work-related stress is causing an occupational disease, it is recommended to consult a lawyer specialized in labor law to obtain legal support and advice on proving such a case.[6]

6. Conclusion

The conclusion regarding work-related stress and occupational diseases as a consequence emphasizes the seriousness of the problem and the need for a comprehensive approach to protect the health of employees. Here are some key points:

Prolonged work-related stress can have serious consequences on the physical and mental health of employees. This can lead to various occupational diseases, including burnout syndrome, anxiety, depression, and other health issues.

One of the common consequences of prolonged work-related stress is professional burnout. This syndrome is characterized by severe exhaustion, loss of motivation, and reduced work efficiency, which can lead to significant consequences for quality of life and the ability to perform the job.

Organizations should recognize the importance of preventing work-related stress and managing risks to protect the well-being of their employees. This includes creating a supportive work environment, managing work tasks, providing resources for coping with stress, and promoting healthy work practices.

Recognition of occupational diseases, including those caused by work-related stress, by organizations and legal protection for employees play a crucial role in preserving the rights and well-being of the workforce. Laws and regulations should provide appropriate protection and mechanisms for employees suffering from occupational diseases.

Education and awareness-raising about mental health are important steps in the fight against work-related stress. Open communication about mental health, educating employees on stress management techniques, and reducing the stigma around seeking help can contribute to a healthier work environment.

The key to successfully combating work-related stress lies in the cooperation between employees and employers. Understanding the needs and concerns of employees and joint efforts in creating a work environment that promotes well-being are crucial factors in reducing work-related stress.

Ultimately, addressing the issue of work-related stress and occupational diseases requires a holistic approach, involving organizations, employees, medical professionals, and regulatory bodies in achieving a healthier and more productive work environment.

7. REFERENCES

[1] Psychological Aspects of Work-Related Stress:"The Effects of Stress on Job Functioning: A Review from the Challenge-Hindrance Stressor Framework" - Podsakoff, LePine, & LePine (2007),"Occupational stress in the 21st century" - Cooper, Dewe, & O'Driscoll (2001)

[2] Professional Burnout:"Maslach Burnout Inventory Manual" - Maslach, Schaufeli, & Leiter (1996),"Burnout and health: A review of the evidence and its implications" - Maslach, Schaufeli, & Leiter (2001)

[3] Stress Management and Prevention:"Stress and the Art of Biofeedback" - Morrow (2004),"Occupational Stress and Its Management" - Rayner, Cooper, & Goldenberg (2002)

[4] Legal Aspects of Occupational Diseases:"Occupational Health Law" - Blum & Connell (2009),"Occupational Health and Safety Law" - Stellman (2011)

[5] Organizational Culture and Stress:"Organizational Stress: A Review and Critique of Theory, Research, and Applications" - Beehr, Jex, Stacy, & Murray (2000),"Organizational Stress: What It Is and What to Do About It" - Cooper, Sloan, & Williams (1988)

[6] Interventions and Employee Support:"Worksite Stress Management Interventions: Their Effectiveness and Conceptualisation" - Nielsen & Randall (2013),"Employee Assistance Programs: Wellness/Enhancement Programming in the Workplace" - Roman, Blum, & Lyness (2004)

PSYHOSOCIAL RISKS AT THE WORKPLACE CAUSES, CONSEQUENCES, PREVENTION

Gorana Lipnjak
Croatian Association for Healthy Work Place, Kornatska 1d, Zagreb, Croatia,
glipnjak@gmail.com

Abstract: *Psychosocial risks (PSRs) are a set of occupational risks that affect the physical or mental health of an employee. These psychosocial risks have a real impact on the company and its operations, because employees are in no condition to do their jobs effectively. Many factors have influence on psychosocial risks: Work Organization. Management and supervisory practices that influence work processes, production, and performance, Shiftwork, Long Work Hours, Remote work, Fatigue, Violence, Bullying, Incivility, etc. Knowing how to identify the main signs of PSRs is essential for good prevention of psychosocial risks. The paper presents the main causes of psychosocial risks in the workplace, the consequences for the health of employees, as well as the negative impact on the success of the organization's operations. Recommendations for the prevention of psychosocial risks and examples of good practice are also given.*

Key words*: psychosocial risk, mental health, workplace, health protection*

1. INTRODUCTION

Psychosocial risks are **occupational risks** that can affect any employee and are increasing in the current context. Indeed, new psychosocial risks are emerging with the remote working mode, often imposed since the beginning of the Covid-19 crisis. **37% of those** recently interviewed point to isolation and admit to suffering psychologically from the current situation. It also appears that for 83% of employee representatives, the crisis has aggravated **psychosocial risks**. [1].

Psychosocial risks affect the **physical or mental health** of an employee. These psychological or physical concerns have a real impact on the company and its operations, since they can put employees in no condition to do their jobs effectively. They are one of the recently discovered **occupational diseases** affecting mental health and present many risks to physical and mental health. There are many forms of psychosocial risks:

Burn-out: also known as burnout, burn-out is a serious depressive disorder. The employee suffering from it no longer finds meaning in his or her work, is physically and morally exhausted and cannot achieve the desired results. He or she loses complete control over his or her professional life, which almost always has an impact on his or her personal life.

Depression: This mental disorder is characterised by a loss of interest in one's usual activities, great sadness, low self-esteem and is often accompanied by feelings of guilt. Depression also causes fatigue and difficulty concentrating.

Harassment: there are several types of harassment: sexual harassment, physical harassment and mobbing. Bullying can be direct, indirect, collective or individual. Harassment can contribute to burn-out, depression and stress. In the most serious cases, it can lead to suicide.

Attacks: isolated or repeated moral or physical attacks are part of psychosocial disorders.

2. CAUSES

Each risk can interact with and add to the others. It is important to understand the causes of psychosocial risks at work in order to anticipate and combat them. [2]. These include:

Insecurity of the job, of the work situation.

Lack of autonomy: an employee who feels oppressed, restricted, monitored and judged is likely to develop PSR.

Poor relations within the company: tensions with the hierarchy or team members are difficult to manage on a daily basis. In the long run, they can create anxiety and contribute to burn-out. These conflicts can also be a source of harassment.

High demands at work: intense or complex assignments can affect the quality of working life. Good organisation at work and assignments that are adapted to the talents and skills of employees are essential to ensure that everyone can flourish in their jobs and avoid unhappiness at work.

Too many emotional demands: our emotions are sometimes put to the test at work. Strained relationships with clients, having to hide our emotions, or being subjected to verbal or physical abuse can cause PSR.

Conflicts of values: having values that differ from those of the company or one's colleagues is a factor in psychosocial risks. The employee may feel isolated, left out, judged or out of step with the company. One thing leading to another, they generally lose the meaning of their work and develop PSR.

Stress: acute or chronic stress can be aggravated by assignments, a work environment or an unsuitable job. If it persists over time, stress can have an irreversible psychological effect, on a person.

3. CONSEQUENCES

What physical, psychopathological, psychosomatic and behavioral reactions will occur in a certain person exposed depends on the duration and intensity of psyhosocial risks at the workplace, sociodemographic characteristics of the victim, his skills and life experience. The consequences of psychosocial risks can be psychosomatic as well as behavioral. [3,4].

3.1. Psychosomatic consequences

Asthma attacks, Dermatitis, High blood pressure, Headache, Migraine, Abdominal pains, Stomach ulcer, Problems with balance, Heart diseases [5].

3.2. Behavioral consequences

Increased addiction – nicotine, coffee, alcohol, drugs, Eating disorders – anorexia, overeating, Isolation – alienation, Sexual dysfunction

3.2. Consequences of stress on employees

Stressor is any negative stimulus that can cause stress. [6].
Physical stressors - cause distraction and discomfort: loud noise, extreme heat or cold, too little or too much physical activity
Psychological stressors - disagreements with colleagues and friends, personal or business failures, a feeling of frustration due to an event...
Social stressors - caused by economic and social events
Symptoms of stress are:
Physical symptoms – headache, fatigue, tension, stiffness or pain in the muscles, problems
with digestion, cold
Cognitive symptoms - forgetting, difficulty making decisions, the need to escape from above all, disturbance in concentration, loss of will for any activity
Emotional symptoms - anxiety, depression, nervousness, irritability, worry, mood swings, fear, loss of self-esteem, feeling overwhelmed
Behavioral reactions - destruction, reaction, self-destruction

4. PREVENTION

There are numerous standardized tools for assessing psychosocial risks that are easy to use on a large number of workers and provide useful information about the levels of expression of psychosocial risks in the workplace. [7].

4.1. Questionnaire for psychosocial risk assessment

There are a lot of Questionnaire for psychosocial risk assessment. For example: Questionnaire for psychosocial risk assessment [8] or ILO Stress Prevention at Work Checkpoints. [9].

4.2. An example of good practice

Research on the presence of stress among Ericsson Nikola Tesla d.d. company employees gave good results. [10]. The research was organized by the Occupational Health and Safety Department and the company's Trade Union with the support of the company's management and the engagement of external experts – psychologists. Interviews of psychologists were conducted with several employees from different organizational units who were selected by the union commissioners. Based on the collected data, a questionnaire was created with 78 statements, which had to be evaluated as to how much they relate to the specific situation at work, and then how important it is to the employee. Questionnaires were submitted for each organizational unit, the application was anonymous.

Factor analysis of the results revealed seven possible stressors: Work overload, Bad management, Problems in doing work, Bad working conditions, Fear and insecurity, Problems with colleagues, Bad situation in the restaurant

Conclusion: Regardless of the identified possible stressors, the situation in the company is satisfactory in some units, corrective activities have been determined.

4.3. Aplication of robots and cobots

Using **robots** is very useful because they could work instead of employees. They can replace them in dangerous and stressful jobs (guards, at the reception).

Cobots (collaborative robots) are designed to work alongside human employees. The main goal of the MindBot project are: determine methods and solutions that positively affect the mental health of workers in Industry 4.0, especially in small and medium-sized enterprises, design workplaces where the level of challenge and the difficulty of work tasks match the abilities and skills of workers in order to promote and support motivation.

Kobot MindBot is a new type of collaborative robot. Mindbot communicates with the worker through an avatar, telling him to take a break, speed up or slow down, so that the difficulty of work tasks is consistent with the current abilities of the worker caused, for example, by fatigue due to overload or boredom due to lack of work challenges. [11].

4.4. Implementation of ISO 45001:2018 and ISO 45003:2021 standards

In order to reduce psychosocial risks, it is useful to implement ISO standards.
ISO 45001:2018 Occupational Health and Safety Management Systems [12].
ISO 45003:2021 Psychological health and safety at work management system [13].

4.5. Counseling on promoting mental health

In the Counseling Center for the Promotion of Mental Health, you can receive services that are by their nature of shorter duration (up to 10 meetings), such as psychoeducation, psychological first aid and initial professional support for mental health, short counseling interventions and psychological counseling, risk assessment and the need for referral to further treatment, as well as information about mental health care services offered in the community. Users of the Counseling Center remain anonymous, all services are free and no referral is required. [14].

4.6. Education, awareness raising

Education and raising awareness give importance to preventing psyhosocial risks. Training on decent behavior must be an integral part of general familiarization with the workplace so that workers are aware of all forms of harassing behavior and the long-term consequences. Workers must be aware of the policy against abuse, mobbing, threats and violence and should comply with the prescribed requirements and clearly communicate it to everyone. Workers should be trained to spot abusive behavior and rewarded for notifying the appropriate person when such behavior occurs. Training and raising awareness of decent behavior at work can also have a positive impact on behavior outside of work, for example in the family and neighborhood. [6].

4.6 The role of the employer

The role of the employer is extremely important. "The days of the imperial CEO are gone". The employer must adopt standards for inclusive behavior with lots of empathy according to different groups of workers. A friendly environment should be created and better infrastructure to help and support for families. Employers should be asking their workers what they want. They would be amazed at how people work when they a stake in the place. [15].

5. CONCLUSION

The organization of the workplace must be in accordance with all prescribed requirements of the Occupational Safety and Health Act and related rules (ergonomics, noise, microclimate conditions). Regular risk assessments of each workplace should be carried out and regular sessions of the Occupational Safety Committee with occupational health reports should be done. The organization of the workplace should take into account the risks specific to the workplace. Groups of workers with a high risk of violence and psyhosocial risks are health workers in psychiatric and emergency departments, police officers, bus and taxi drivers, doormen, principals, teachers, etc. Each worker should have, if necessary, an escape route, easy access to the alarm system, video surveillance, separation from the client. Safety measures at the workplace should be discussed with the relevant experts. All employees, including visitors, part-time workers and temporary workers, should be well informed about the psyhosocial risks and violence and the use of safety measures.

A workplace where employees at all levels treat the organization with respect will: give a good reputation in the community, facilitate employment, avoid high fluctuation, reduce absenteeism from work.

REFERENCES

[1] EU-OSHA, Psychosocial risks and mental health at work, *Available from* https://osha.europa.eu/en/themes/psychosocial-risks-and-mental-health
[2] IPAG, What are psychosocial risks (PSR)?, 14. Februar 2022., *Available from* https://www.ipag.edu/en/blog/risques-psychosociaux
[3] Havelka, M. i Havelka-Meštrović, A.: *Zdravstvena psihologija: psihosocijalne osnove zdravlja*. Jastrebarsko: Naklada Slap, 2020
[4] Vuković, S., Psihološki stress i tjelesne bolesti, završni rad, Visoka škola Ivanić-Grad, 2024-05-21, *Available from* https://urn.nsk.hr/urn:nbn:hr:258:292169
[5] Ćehić, M., Statistika fizičkog i psihičkog nasilja na radnim mjestima, međunarodni seminar: Rizici i zaštita od fizičkog i psihičkog nasilja na radnom mjestu, Novi Sad, October, 2023
[6] Lipnjak, G., Aktivnosti na smanjenju stresa i nasilja na radnom mjestu, međunarodni seminar: Rizici i zaštita od fizičkog i psihičkog nasilja na radnom mjestu, Novi Sad, listopad, 2023
[7] HZJZ, Preporuke za upravljanje stresom na radu, HZJZ, Služba za medicine rada, prosinac 2022.
[8] Kako procjenjivati psihosocijalne rizike?, *Available from* http://www.hzzzsr.hr/index.php/psihosocijalni-rizici/procjena-psihosocijalnih-rizika/
[9] ILO, Stress prevention at work checkpoints, *Available from* https://www.google.com/search?client=firefox-b-d&q=ILO+%E2%80%93+%C4%8Dek+lista+Stress+prevention+at+work+checkpoints
[10] Lipnjak, G., Istraživanje uzroka stresa zaposlenih, časopis,Sigurnost 53(3)219-226 (2011)
[11] Štefok, S., Prezentacija rezultata projekta Mental Health promotion of cobot Workers in Industry 4.0 – MindBot, Stručni skup HUZRM, ožujak 2024.
[12] ISO 45001:2018, Occupational Health and Safety Management Systems, International Organisation for Standardisation (ISO)
[13] ISO 45003:2021, Psychological health and safety at work management system, International Organisation for Standardisation (ISO)
[14] HZJZ, Savjetovalište za mentalno zdravlje, *Available from* https://www.hzjz.hr/savjetovaliste-za-mentalno-zdravlje/
[15] Temelkuran, E., Put trust in human beings, Think:Act Magazine, March 2023, ISSN 2628-2895

PRE-WORK WARM-UP ROUTINE FOR CHAINSAW WORKERS

Josipa Nakić[1], Matija Landekić[2]

[1] Faculty of Kinesiology, University of Zagreb, Horvaćanski zavoj 15, 10000 Zagreb, CROATIA, josipa.nakic@kif.unizg.hr

[2] Faculty of Forestry and Wood Technology, University of Zagreb, Svetošimunska cesta 23, 10000 Zagreb, CROATIA, mlandekic@sumfak.unizg.hr

***Acknowledgments:** 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.

Abstract

Chainsaw workers' job is physically extremely demanding. Often requires significant musculoskeletal strains in conditions of large movement amplitudes of the joint systems. That is why, to make the work of the chainsaw worker as safe as possible, and to reduce the probability of sprains and other muscle and tendons injuries to a minimum, before starting work it is necessary to raise the working capacity through raising body temperature and warming the joint systems. The above is very similar to preparing an athlete for training or competition. According to a similar principle, chainsaw workers' body should be prepared for work. An integral part of the worm up is walking to the place of cutting and processing trees, i.e. to the felling line. After that, it is suggested to conduct a few dynamic pre-work warm-up exercises. Within this paper, through QR code and photos, a possible complex of exercises that chainsaw workers can perform before starting work is presented.

***Keywords:** Chainsaw workers, pre-work warm-up routine, dynamic warm-up exercises, prevention of muscle and tendon strains, working capacity.*

1. INTRODUCTION

Chainsaw workers' job is a physically extremely demanding. Numerous studies conducted among forest workers have detected musculoskeletal problems in different anatomical regions of the body such as hands, elbows, shoulders, neck [1, 2, 3], with pain in the lower back that occurs constantly from 38% [2]to almost 71% [3]of sampled forest workers.

Some of the work tasks of the chainsaw worker are checking the direction of tree felling, cleaning the working area, starting the chainsaw, making a sink cut, making the final cut, tamping the wedge using an axe, etc. Previously mentioned elements of work technique often require significant musculoskeletal strains in conditions of large movement amplitudes of the joint systems. That is why, to make the work of the chainsaw worker as safe as possible, and to reduce the probability of sprains and other muscle and tendons injuries to a minimum, before starting work it is necessary to raise the working capacity through raising body temperature and warming the joint systems.

The above is very similar to preparing an athlete for training or competition. Let us remember, every training session in a sport as well as every hour of physical education classes began (and begins) with the implementation of an appropriate warm-up and preparation of muscles and tendons for eccentric and concentric contractions when performing work tasks. According to a similar principle, chainsaw workers body should be prepared for work.

An integral part of the worm up is walking to the place of cutting and processing trees, i.e. to the felling line. After that, it is suggested to conduct a few dynamic pre-work warm-up exercises. The short-term effect of exercise on articular cartilage is thickening that occurs due to the absorption of synovial fluid into the cartilage, the delivery of nutrients and the elimination of metabolic byproducts [4]. Due to this short-term thickening effect, articular cartilage performs better the function of distributing force during dynamic activities such as the work tasks of the cleaver worker. Warm-up exercises should respect the principles of stability-mobility approach [5]. More details on this principle in the next chapter. Within this paper, through text, QR code and photos, a possible complex of exercises that chainsaw workers can perform before starting work is presented.

2. STABILITY-MOBILITY APPROACH

Stability-mobility approach is presented in the book *Athletic Body in Balance* [5]. This approach speaks of how some joint systems most often lack stability, and some joint systems most often lack mobility. The mobility of joint systems can be defined as ability of a joint to move through its natural, effective range of motion and is further characterized as the balance of strength and flexibility regulating contrasting motions around a joint [6]. The joint systems that most often lack mobility are ankles, hips, thoracic part of the spine and shoulders. The joint systems that most often lack stability are knees, lumbar spine, shoulder blades and cervical part of the spine.

Occupational kinesiology is an area that takes special care of how the worker's job and his specific work tasks affect the stability and mobility of his articular system. Proper postural-movement habits in the workplace, but also in everyday life, are an important prerequisite for optimal mobility and stability of joint systems.

Pre-work warm-up routine for chainsaw workers should ensure optimal mobility of the ankles in the sagittal plane, hips, thoracic part of the spine in the sagittal (extension) and transverse plane, and mobility of the shoulders. Also, pre-work warm-up routine for chainsaw workers should affect the establishment and preservation of stability of the knee, lumbar spine, shoulder blades and cervical part of the spine. For more details on the preservation of stability and optimization of mobility of specific articular systems, see the next chapter.

Explained stability-mobility approach is very important to respect not only in warm-up but also when performing work tasks such as starting chainsaws, making notches, making the final cut, etc.

3. PRE-WORK WARM-UP ROUTINE FOR CHAINSAW WORKERS

<table>
<tr>
<td>
Figure 1: Military marching</td>
<td>1. **Military marching**
The exercise is an imitation of soldiers' marching. It is performed simultaneously lifting the opposite arm and the opposite leg. The amplitudes of movement are individual.
Number of repetitions: 10 x alternating.
According to stability-mobility approach this exercise contributes to ankle mobility, knee stability, hip mobility, stability of the lumbar spine, mobility of the thoracic part of the spine in the sagittal and transverse plane, scapular stability, shoulder mobility and cervical stability.</td>
</tr>
</table>

<table>
<tr>
<td>
Figure 2: Side circles shoulders backwards</td>
<td>2. **Shoulder rotations**
From the position of standing, the palms on the shoulders, simultaneous rotations of the shoulders to the back are performed. During the exercise, gently squeeze the abdominal muscles and slightly bend the knees.
Number of repetitions: 10 x
According to stability-mobility approach this exercise contributes to shoulder mobility and thoracic mobility in the sagittal plane. It also contributes to the scapular stability.</td>
</tr>
</table>

Figure 3: Dead lift – hip hinge

3. Dead lift – hip hinge

From a position where the feet are shoulder-width apart, push your hips backwards. The trunk leans forward at the same time, and the knees bend slightly. The back should be straight i.e. in a neutral position, and the main axis of rotation is in the joints of the hips. It's a movement known as hip hinge.

Number of repetitions: 10 x

According to stability-mobility approach this exercise contributes to knee stability, hip mobility, stability of the lumbar spine, mobility of the thoracic part of the spine in the sagittal plane.

Figure 4: Dynamic stretching of the pectoral muscles

4. Dynamic stretching of the pectoral muscles

From the position of standing, stretches of the pectoral muscles with the palms open forward are performed. During the exercise, gently contract the abdominal muscles and slightly bend the knees.

Number of repetitions: 10 x alternating

According to stability-mobility approach this exercise contributes to mobility of the thoracic part of the spine in the transverse plane and shoulder mobility.

Figure 5: Squat

5. Squat

In the starting position of the feet are shoulder-width apart, the toes of the legs slightly turned outwards. From the starting position, a squat is performed. The weight of the body is on full feet, the back as upright and straight as possible.

Number of repetitions: 10 x

According to stability-mobility approach this exercise contributes to ankle mobility, knee stability, hip mobility, stability of the lumbar spine, mobility of the thoracic part of the spine in the sagittal plane, scapular stability, shoulder mobility and cervical stability.

Figure 6: Stretching the lateral sides of the trunk

6. Stretching the lateral sides of the trunk

From the starting position in which the feet are shoulder-width apart, alternating lateral tiltings of the upper part of the trunk are made. During the exercise, gently contract the abdominal muscles to ensure the stability of the lower back.

Number of repetitions: 10 x alternating

According to stability-mobility approach this exercise contributes to shoulder mobility.

Figure 7: Deadlift stepping back

7. Deadlift stepping back

From the starting position of standing, a small step forward is made with the simultaneous tilting of the hull forward. The movement is performed from the hip joints - hip hinge, the back is straight, i.e. in a neutral position, and the knees are slightly bent.

Number of repetitions: 5 + 5

According to stability-mobility approach this exercise contributes to knee stability, hip mobility, stability of the lumbar spine, mobility of the thoracic part of the spine in the sagittal plane and scapular stability.

Figure 8: Military marching

8. Military marching

The last warm-up exercise is the same as the first exercise. The exercise is an imitation of soldiers' marching. It is performed simultaneously lifting the opposite arm and the opposite leg. The amplitudes of movement are individual.

Number of repetitions: 10 x alternating

According to stability-mobility approach this exercise contributes to ankle mobility, knee stability, hip mobility, stability of the lumbar spine, mobility of the thoracic part of the spine in the sagittal and transverse plane, scapular stability, shoulder mobility and cervical stability.

The first and last exercises are complex and warm-up the whole body at the same time. Exercise simultaneously warms the muscles and joints of almost the entire body and is easy to perform. It contributes to the optimization of joint stability and mobility, but also to balance as an important motor skill for workers. A video of all exercises can be viewed by activating the link and/or scanning the QR code (QR code and link number 1).

https://www.youtube.com/watch?v=QetGJV7u7ko

QR code and link number 1: Educational video clip Pre-work warm-up routine for chainsaw workers

3. CONCLUSION

The preservation of the working capacity of chainsaw worker has a long-term impact and significance for the worker himself to preserve his health, active life and extend his working life, but also for the company and society as a whole in order to provide the necessary labor force in the labor market and reduce labor costs due to sick leave and early retirement.

Prework warm-up routine, along with a correct occupational posture and movement habits, can significantly contribute to preserving the health of the musculoskeletal system and maintaining the working capacity of workers over time.

The paper presents some exercises that can be applied by forest workers, with the aim of warm-up and preparation for work.

REFERENCES

[1] Grzywinski, W., Wandycz, A., Tomczak, A., Jelonek, T.: The prevalence of self-reported musculoskeletal symptoms among loggers in Poland. *Int. J. Ind. Ergon*., 52, 12–17, doi: 10.1016/j.ergon.2015.07.003 (2016).

[2] Lagerstrom, E., Magzamen, S., Brazile, W., Rosecrance, J.: Active surveillance of musculoskeletal disorder symptoms in the development of safety interventions for professional loggers. *Safety*, 5 (2) (2019).

[3] Landekić, M., Šporčić, M., Bačić, M., Pandur, Z., Bakarić, M. *Workability and Physical Wellbeing Among Chainsaw Operators in Croatia*. Croat. J. For. Eng 44(1), 83-94, doi: 10.5552/crojfe.2023.2073 (2023).

[4] Abernethy, B., Hanrahan, S.J., Kippers, V., Mackinnon, L.T., Pandy, M.G. *Biofizičke osnove ljudskog pokreta*. Dana status, Beograd (2012).

[5] Cook, G.: *Athletic body in balance*. Human Kinetics, Champaign, IL. (2003)

[6] Clark, M. A. i Lucett, S. C.: *NASM essentials of corrective exercise training* (1st ed.). National Academy of Sports Medicine, (2011).

APPLICATION OF OCCUPATIONAL EXOSKELETONS

Zlatko Šarić, Sonja Damjanović Dešić, Tina Mudrovčić

Croatian Institute for Public Health, Zagreb, zlatko.saric@hzjz.hr

Abstract:

An exoskeleton is a hard covering that supports the body shape and protects the internal organs of insects, arachnids, and crustaceans. Humans doesn't have exoskeleton but only endoskeletons which is enclosed underneath soft tissues. Humans have limited physical abilities that can be enhanced through technologysuch as exoskeletons which are wearable structures that support and assist movement in order to augmentthe capabilities of the human body.

Several types of exoskeletons have been developed so far, which are used for different purposes. Exoskeletons can be used for facilitating recovery during the rehabilitation in order to help maintain balance and improves mobility, in military activities for improving weapon skills, during the training to enhance muscle work while performing gyms etc. In this paper we will be focus on exoskeletons that canbe used at work so called Industrial or occupational exoskeletons.

Key words: *occupational exoskeleton*

1. INTRODUCTION:

Occupational exoskeletons are wearable devices designed to augment human performance in various work environment. The development of exoskeletons already began in early 1970s with projects undertaken for military purposes. The first exoskeletons was large full-body exoskeleton designed to increase the user's strength to be able to lift heavy objects. From this time up to nowadays, the main objective of industrial exoskeletons is to support workers with or prevent them from getting musculoskeletal disorders because work-related musculoskeletal disorders are a leading cause to workplace injuries. Although exoskeletons have more potential in static activities than in dynamic tasks at work, the key factors influencing the worker experience are comfort, ease of use and management and safety.

2. OCCUPATIONAL EXOSKELETONS

2.1. Types of occupational exoskeletons

There are different types of exoskeletons according to the body part focused (for whole body,for upper extremities, for lower extremities and for specific limbs (leg, hand, arm)), kinematic structure (soft and rigid), action category (passive, semi-active and active), technology (mechanisms driven by human strength, hydraulic actuators, pneumatic actuators and electricalenergy) [1]; [2].

The full-body exoskeletons assist all the limbs. The upper body exoskeletons are made for chest, head, back, and/or shoulders. The lower body exoskeletons are made for thighs, lower legs, and/or hips. Exoskeleton for specific limbs and specific joints are designed for the knee, ankle, hand, arm, foot, etc. [3]. Soft exoskeleton that has soft kinematic structure uses flexibleelements that adapt to the structure of the worker's body while the rigid exoskeleton type consists of additional elements (kinematic joints, as actuators), that allow the user's mobility.Active exoskeletons usually use actuators driven by pneumatic and hydraulic actuators. Semi- active are using mechanisms based on springs and the elastic recovery properties of materials.Passive exoskeletons do not have power sources and the users perform the movement to work.[4].

2.2. Application of occupational exoskeletons

The use occupational exoskeletons are wide. For example, in automotive industry where workers often engage in repetitive tasks and awkward postures, use of exoskeletons can help in reducing muscle fatigue and prevent musculoskeletal disorders. In electronics assembly where fine motor skills and precision tasks are common, exoskeletons can provide support without hindering dexterity.

In construction, exoskeletons can assist workers in lifting heavy materials, thereby reducing the risk of back injuries but also devices that support the arms and shoulders help in tasks thatrequire prolonged periods of working above the head.

In healthcare system nurses and caregivers can benefit from exoskeletons that assist in lifting and moving patients, reducing the risk of back injuries Also, surgeons can wear exoskeletons to reduce fatigue during long procedures, improving precision and endurance.

In logistics and warehousing where workers have material handling and repetitive tasks, exoskeletons can be used as support in loading and unloading goods, minimizing physical strain and for reduce the cumulative impact of repetitive motions, such as picking and packing.

We can give example of companies which use different types of occupational exoskeletons. Some automobile industries have implemented exoskeletons that are wearable over workers uniform and multiple spring levels on this device allow for complete customization ofassistance and no batteries are needed. Structure of this device supports workers arms for full range of motion because left and right sides are independent which allow natural movement. At the same time, open back prevents overheating of workers body. This exoskeleton reduces worker fatigue and the risk of injuries during tasks that require overhead [5]; [6].

On the market, there are different types of exoskeletons. For example, passive hip exoskeleton is designed to protect the spine during bending while working or holding/lifting heavy tools and parts [7].

There is also a good example of using exoskeletons for slaughterhouse workers because for reduced muscle activity, especially for tasks that involve prolonged standing and repetitive arm movements [8]; [9].

In Croatia, the adoption of advanced technologies like exoskeletons is growing, especially in industrial sectors to improve worker safety and productivity. However, specific Croatian companies' names utilizing these technologies are not prominently mentioned in available resources. There are companies on the Croatian market that sell passive exoskeleton to lighten the load on the shoulders and arms during work in the overhead area and wearable exoskeleton which can be used construction site to help relieve shoulder and neck fatigue when working above shoulder level [10].

What will potentially turn off employers who want to invest in the purchase of an exoskeletonis its price.

2.3. Benefits, challenges and future prospects of exosceletons

The benefits of using occupational exoskeletons are injuries prevention, enhanced productivity, worker wellbeing and cost savings. As we mention before, there are some benefits when using occupational exoskeletons. First of all, it is injury prevention because exoskeletons reduce the risk of work-related musculoskeletal disorders (WMSDs) by offloading weight and supporting the body in strenuous activities. By reducing fatigue, workers can maintain higher levels of productivity over longer periods so enhanced productivity is another benefit. We can also emphasize worker wellbeing because by reducing fatigue, workers can maintain higher levels of productivity over longer periods.

Anyway, there are lots of challenges in application of industrial exoskeletons. Workers may be hesitant to adopt new technologies due to comfort issues, perceived stigmatization, or fear of job displacement. The initial investment in exoskeletons can be high, which may be a barrier for small and medium-sized enterprises. There are also some challenges in ergonomics and comfort because it has to be ensured that exoskeletons are comfortable for long-term wear and do not restrict movement is crucial for user acceptance. And at the end all exoskeletons have technical limitations regarding battery life, weight, and adaptability to different tasks and bodytypes.

Ongoing research of exoskeleton development is focused on improving the power sources, reducing weight, and enhancing the adaptability of exoskeletons to different tasks. It is necessary to integrate exoskeleton with smart technologies. Future exoskeletons may incorporate sensors and artificial intelligence to provide real-time feedback and adjustments, further improving their efficiency and usability. Comprehensive training programs for workers and management can improve acceptance and maximize the benefits of exoskeletons.

3. CONCLUSION

Occupational exoskeletons represent a promising advancement in workplace ergonomics and safety. While challenges remain, particularly in terms of cost and user acceptance, the potential benefits in injury prevention, productivity and worker's wellbeing make them a valuable investment for many industries. Continued technological improvements and supportive policies will be a key to their successful integration into the workforce.

REFERENCES

[1] Omar Flor-Unda, Bregith Casa, Mauricio Fuentes, Santiago Solorzano, Fabián Narvaez-Espinoza, and Patricia Acosta-Vargas: Exoskeletons: Contribution to Occupational Health and Safety, *Available from* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10647659/, *Accessed:*2024-6-24.

[2] Simona Crea, Philipp Beckerle, Michiel De Looze, Kevin De Pauw, Lorenzo Grazi, Tjaša Kermavnar, Jawad Masood, Leonard W. O'Sullivan, Ilaria Pacifico, Carlos Rodriguez- Guerrero, Nicola Vitiello, Danijela Ristić-Durrant, and Jan Veneman: Occupationalexoskeletons: A roadmap toward large-scale adoption. Methodology and challenges of bringing exoskeletons to workplaces, *Available from* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10936259/, *Accessed:*2024-6-24.

[3] Javier A. de la Tejera, Rogelio Bustamante-Bello, Ricardo A. Ramirez-Mendoza andJavier Izquierdo-Reyes: Systematic Review of Exoskeletons towards a General Categorization Model Proposal, *Available from* https://www.mdpi.com/2076- 3417/11/1/76, *Accessed:*2024-6-24.

[4] Omar Flor-Unda, Bregith Casa, Mauricio Fuentes, Santiago Solorzano, Fabián Narvaez- Espinoza and Patricia Acosta-Vargas: Exoskeletons: Contribution to Occupational Health and Safety, *Available from* (PDF) bioengineering Exoskeletons: Contribution to Occupational Health and Safety (researchgate.net), *Accessed:*2024-6-24.

[5] *EksoBIONICS*, Ekso EVO is designed to provide power without the pain, *Availablefrom* https://eksobionics.com/ekso-evo/, *Accessed:*2024-6-24.

[6] *MIT Technology Review*, Ford is deploying exoskeletons in 15 of its factories around the world, *Available from* Ford is deploying exoskeletons in 15 of its factories around theworld | MIT Technology Review, *Accessed:*2024-6-24.

[7] *Laevo exoskeletons*, Laevo V2, *Available from* Laevo V2 — Laevo Exoskeletons (laevo-exoskeletons.com), *Accessed:*2024-6-24.

[8] Annett Dalbøge, Jeppe Frost, Regine Grytnes, Jean-Sebastian Roy, Afshin Samani, DavidHøyrup Christiansen: Effects of a passive shoulder exoskeleton on muscle activity amongDanish slaughterhouse workers, *Available from* Effects of a passive shoulder exoskeleton on muscle activity among Danish slaughterhouse workers - ScienceDirect, *Accessed:*2024-6-24.

[9] Sander De Bock , Jo Ghillebert , Renée Govaerts , Shirley A. Elprama, Uros Marusic, BenSerrien ,An Jacobs, Joost Geeroms, Romain Meeusen, and Kevin De Pauw: PassiveShoulder Exoskeletons: More Effective in the Lab Than in the Field?, *Available from* https://www.researchgate.net/publication/349684329_Passive_Shoulder_Exoskeletons_ More_Effective_in_the_Lab_Than_in_the_Field), *Accessed:*2024-6-24.

[10] HILTI, *Available from* https://www.hilti.hr/c/CLS_EXOSKELETON_HUMAN_AUGMENTATION/CLS_UP PERBODY_EXOSKELETON, *Accessed:*2024-6-24.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

IMPACT OF SEXUAL HARASSMENT IN THE WORKPLACE: CONSEQUENCES ON WORK ENVIRONMENT AND PRODUCTIVITY

Maja Trečić[1], Željka Potočnjak[1]

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA

Abstract: Sexual harassment in the workplace is a serious problem with profound consequences for the work environment and productivity. This paper investigates the impact of sexual harassment on the work environment with special emphasis on employee productivity. Sexual harassment can create a hostile, toxic and unpleasant work environment, resulting in increased stress, fear and discomfort among employees. Such an environment can lead to reduced productivity, poorer quality of work and higher employee turnover. Employers face legal and financial costs due to lawsuits and damages related to sexual harassment. This paper provides insight into the seriousness and importance of combating sexual harassment in the workplace to ensure a safe and supportive environment for all employees. The paper suggests directions for further research and the implementation of preventive measures to prevent sexual harassment in the workplace and ensure a safe, supportive and productive environment for all employees

Keyword: *sexual harassment, work environment, productivity, stress, prevention, safety*

1. INTRODUCTION

Sexual harassment is one of the most common forms of sexual violence, which strips individuals of their personality and individuality, reducing them to mere physical attributes. [1] At the workplace, sexual harassment can be defined as unwanted sexual behavior that undermines a person's dignity, creating a hostile, intimidating, degrading, or offensive environment. Legally, it includes various behaviors, such as verbal, non-verbal, and physical actions, ranging from sexual comments and unwanted touching to demands for sexual favors and the distribution of sexually explicit materials.

Research indicates that sexual harassment significantly negatively impacts victims' mental and physical health, leading to symptoms of anxiety, depression, and PTSD. Additionally, it is associated with higher employee turnover, reduced job engagement, lower productivity, and increased absenteeism. Organizations failing to address sexual harassment face reputational damage and higher financial costs due to compensation claims and legal proceedings. [1]

2. SEXUAL HARASSMENT IN THE WORKPLACE IN CROATIA

In Croatia, data on sexual harassment are available through reports from the Office of the Ombudsperson for Gender Equality, which tracks indicators of sexual harassment and has noted a continuous increase in complaints related to employment and education since 2021. The Ministry of the Interior also reports an increase in complaints, with 98 recorded in 2021. However, despite the rising number of complaints, the number of prosecuted cases and convictions remains low, averaging in the single digits annually.

The Frida project, focused on workplace sexual harassment in Croatia, revealed that 71% of 448 respondents experienced some form of sexual harassment at work. Supervisors harassed 61% of respondents, and one-third reported harassment by multiple perpetrators. Among respondents, men, though fewer in number (32), also reported harassment, with half experiencing it.

Forms of harassment reported include:

- Unwanted sexual comments: 90.1%
- Leering at body parts: 63.8%
- Unwanted touching, hugging, kissing: 52.6%
- Unwanted sexual calls: 40.3%
- Sending explicit sexual content electronically: 14.2%
- Displaying obscene images at the workplace: 14.2%
- Sexual coercion: 10.2%
- Sexual gestures or exposure: 8.1%

These findings highlight the widespread and varied nature of workplace sexual harassment in Croatia, emphasizing the need for more effective preventive measures and support for victims. [2]

3. LEGAL FRAMEWORK IN CROATIA

Sexual harassment in Croatia can be classified as either a misdemeanor or a criminal offense.

As a misdemeanor, sexual harassment is defined by the Anti-Discrimination Act (Article 3) and the Gender Equality Act (Article 8).

When it constitutes a criminal offense, it is addressed by the Criminal Code of the Republic of Croatia (Article 156) and is prosecuted ex officio.

Article 156

1. Anyone who sexually harasses or severely harasses a person subordinate to them or dependent on them will be punished by imprisonment of up to two years.
2. If the offense from paragraph 1 is committed against a close person or a person particularly vulnerable due to age, illness, disability, dependency, pregnancy, severe physical or mental disability, the punishment is imprisonment of up to three years.
3. Sexual harassment is any verbal, non-verbal, or physical unwanted behavior of a sexual nature that aims to or actually violates a person's dignity, causing fear, a hostile, humiliating, or offensive environment. [3]

4. IMPACT ON THE WORKPLACE AND PRODUCTIVITY

Sexual harassment in the workplace is a significant issue that adversely affects employee health, the work environment, and overall organizational productivity.

Impact on Employee Health

Mental and Physical Health: Employees experiencing sexual harassment often suffer from severe psychological and physical issues, including anxiety, depression, PTSD, sleep disturbances, and general health problems. These issues reduce work capability and increase absenteeism, directly impacting their efficiency and engagement.

Emotional and Psychological State: Sexual harassment can lead to deep emotional and psychological consequences. Employees may feel insecure, uncomfortable, and lack confidence, which undermines their motivation and ability to form healthy relationships with colleagues. This further diminishes employee engagement and their sense of belonging to the organization.

Impact on the Work Environment

Work Atmosphere: A work environment marred by sexual harassment becomes hostile and toxic. This can result in decreased morale among employees, impaired teamwork, and a generally negative impact on workplace culture. Consequently, such an atmosphere can cause conflicts and reduce mutual trust, further lowering team effectiveness.

Employee Turnover: A hostile work environment stemming from sexual harassment often leads to high employee turnover. Employee insecurity and dissatisfaction increase the number of departures, resulting in the loss of qualified personnel and higher costs for recruitment and training.

Impact on the Organization

Legal and Financial Consequences: Organizations that neglect to address sexual harassment face serious legal and financial repercussions. These include costs associated with legal proceedings, compensations, and fines, which can significantly burden the organization. Additionally, the company's reputation can be severely damaged, negatively impacting relationships with clients and business partners.

Reduced Productivity: The combination of decreased morale, frequent absenteeism, and employee turnover leads to a reduction in overall productivity. Employees in a hostile environment are often less engaged, less creative, and less efficient, which can result in delays and lower quality of work or products.

Sexual harassment in the workplace has far-reaching and serious consequences that manifest through compromised mental and physical health of employees, a negative work environment, and decreased organizational productivity. Prevention and effective resolution of this issue are crucial for creating a safe, fair, and productive workplace that fosters positive work relationships and organizational success. [4]

5. PREVENTION OF SEXUAL HARASSMENT AT WORK

To prevent sexual harassment in the workplace, it is crucial to develop an inclusive and supportive work environment where it is clearly defined that sexual harassment will not be tolerated. It is also necessary to eliminate cultural, gender, and social norms that enable or justify violence and sexual harassment. Creating a work culture based on mutual respect and dignity requires employers to take responsibility and appropriate measures according to their level of control to prevent violence and harassment.

Introducing preventive policies or measures can include providing information and training on sexual harassment to employees and other relevant parties, as well as establishing a code of conduct that explicitly prohibits sexual harassment. Dunja Bonacci Skenderović, in her research "At Work, I Want to Be Perceived Professionally," conducted as part of the "Frida" project, presents several recommendations for the prevention of sexual harassment and violence in the workplace:

- Implement the legal obligation to protect workers' dignity through company internal acts, defining procedures for establishing the circumstances and facts necessary for decision-making on complaints and measures to prevent further harassment.
- Adopt the position of a commissioner for the protection of workers' dignity.
- Ensure regular training for all employees on sexual harassment in the workplace.
- Regularly educate commissioners for the protection of workers' dignity.
- Develop internal forms for reporting sexual harassment in the workplace.

These measures are essential for creating a safe and supportive work environment that respects the dignity of all employees. [5]

6. CONCLUSION

Sexual harassment in the workplace is a pervasive issue that profoundly affects individuals and organizations. It undermines the dignity of employees, leading to severe mental and physical health problems such as anxiety, depression, and PTSD. These effects extend to the work environment, creating a hostile and toxic atmosphere that lowers morale, impairs teamwork, and increases employee turnover. The resulting decrease in productivity and legal and financial repercussions further burden organizations.

In Croatia, despite increasing complaints, the number of prosecuted cases remains low. Effective prevention requires comprehensive strategies, including clear policies, regular training, and dedicated roles for protecting workers' dignity. Organizations must foster a culture of respect and take proactive measures to prevent harassment. Implementing these steps can help create a safe, supportive, and productive workplace, enhancing employee well-being and organizational success.

REFERENCES:

[1] Anđelić, H: Seksualno uznemiravanje, objektificiranje i catcalling - što potiče ljude da se upuste u uznemiravanje drugih?, Filozofski fakultet u Zagrebu, odjel za psihologiju; orcid: 0000-0003-1771-984x, *Available from* https://hrcak.srce.hr/file/438063 , *Acessed*: 2024.04.24.

[2] Bonacci Skenderović, D.: "Na poslu želim da me se doživljava profesionalno!", Istraživački izvještaj o spolnom uznemiravanju na radnome mjestu u Hrvatskoj, Bonacci j.d.o.o., Zagreb 2021. *Available from* https://bonacci.hr/wp-content/uploads/2023/01/Spolno-uznemiravanje-na-radnom-mjestu.pdf, *Acessed*: 2024.04.23.

[3] Ženska soba: Oblici seksualnog nasilja, *Available from* https://zenskasoba.hr/seksualno-nasilje/oblici-seksualnog-nasilja/ *Acessed:* 2024.04.23.

[4] SIOP (Society for Industrial and Organizational Psychology): Addressing Sexual Harassment in the Workplace. A White Paper. 2018. *Available from* *https://www.infocoponline.es/pdf/ACOSOSEXUALLABORAL.pdf* *Acessed:* 2024.04.25.

[5] Sertić, A.: Spolno uznemiravanje na random mjestu, Diplomski rad, / Sveučilište u Zagrebu, Pravni fakultet, Zagreb 2022. *Available from* https://repozitorij.pravo.unizg.hr/islandora/object/pravo%3A4576/datastream/PDF/view Acessed: 2024.04.24.

STRESS AND CONSEQUENCES OF STRESS OF HEALTHCARE WORKERS IN ONCOLOGY DEPARTMENTS

Maja Ulemek[1]; Željko Jovanović[2]

[1] General hospital Karlovac, Andrije Štampara 3, Karlovac, CROATIA, majaulemek0@gmail.com

[2] Faculty of Health Studies, Viktora Cara Emina 5, Rijeka, CROATIA, zeljko.jovanovic@uniri.hr

Abstract

We have investigated the presence and intensity of professional stress and burnout syndrome among employees of the oncology departments of the General Hospital (OB) Karlovac and the Tumor Clinic (KZT) Zagreb. The research was conducted as an observational and cross-sectional study on a convenient sample. A higher level of stress among the employees of OB Karlovac and KZT Zagreb was shown by respondents from OB Karlovac (t=2.09; P=0.039). Also, the level of burnout at work is statistically significant among respondents OB Karlovac (t=2.09; P=0.039). No positive correlation was found between gender, age, level of education, as opposed to the length of work experience, on the total experience of stress and the incidence of burnout syndrome. An increase in length of service by a year leads to an expected increase in burnout at work by an average of 2.79. The parameter is statistically significant (t=2.04; P=0.022). It was found that a statistically significant majority of medical personnel do not take anxiolytics to help them perform their duties normally (χ2=51.56; df=1; P<0.001). Respondents from the oncology departments of OB Karlovac show a higher presence of professional stress and burnout syndrome than their colleagues at KZT Zagreb. Respondents do not use anxiolytics as an aid in performing their duties, but the help of a psychologist in their team is welcome. They describe satisfaction with their life with a high rating.

Keywords: *anxiolytics, burnout syndrom, oncology, stress*

1. INTRODUCTION

Stress is a condition caused by a mismatch between the demands placed on the individual by the environment and the individual's ability to respond to these demands (1). Among the more stressful occupations are those that are centred on working with people. People who work with people in need or with traumatised people are often referred to as helpers. Helping professions are stressful not only because of the direct communication with people in need of help, but also because this communication requires empathising with the person's emotional state. It is important to distinguish whether the reaction to stress leads to a better adaptation of the organism or to maladaptation and illness. In both cases, there are changes in the brain, bodily functions, behaviour and mood. When stress has a negative sign, we speak of distress, while positive stress or eustress brings a positive environment and enables the growth and development of the individual to overcome new challenges. People working in the healthcare sector are exposed to various stressors in the workplace on a daily basis, especially those working in emergency medical care, intensive care units, psychiatry and oncology departments. The risk of field work, shift and night work, the responsibility of decision- making, the uncertainty of the outcome of diagnostic and therapeutic measures, the communication of a difficult diagnosis to a patient with a malignant disease and his family, and the emotional exhaustion of healthcare workers all contribute to increased morbidity due to mental disorders and psychosomatic illnesses (2,3). Workplace stress or critical events faced by oncologists can cause symptoms of post-traumatic stress, anxiety, depression and burnout syndrome. Workplace stress increases sickness absence, reduces productivity and encourages staff retraining (3). For all these reasons, one in four healthcare professionals surveyed occasionally take anxiolytics to function normally at work (2,4). Studies carried out in Europe show that around 30% of employees feel tired and emotionally exhausted. Oncologists from North America report higher levels of burnout in the workplace than their European counterparts (5). In Greece, 44% of employees are dissatisfied with their work, while in Germany only 4.2% experience emotional exhaustion. The literature states that 80% of oncologists and oncology nurses feel that they have little self-actualisation (6). In a study conducted by the Oncology Clinic of the Clinical Hospital Centre in Zagreb, it was found that 70% of respondents have a sense of low personal accomplishment and there is a significant correlation between burnout syndrome and male gender, as well as the correlation between emotional exhaustion and depersonalisation in relation to the profession (7). The aim of this work is to describe stress, causes and aspects of stress and their consequences for the health of employees in oncological workplaces, so that preventive measures can be taken to avoid significant effects on the quality of work and life of these people in general. The main objective of this work was to investigate the differences in the effects of stress and its consequences on the quality of work and life of nurses and doctors in the oncology departments of the General Hospital Karlovac and the Hospital for Tumors, Sestre milosrdnice University Hospital Centre, Zagreb.

2. SUBJECTS AND METHODS

The research was conducted as an observational and cross-sectional study on an appropriate sample consisting of medical staff from the oncology departments of the General Hospital Karlovac and the Hospital for Tumors, Sestre milosrdnice University Hospital Centre, Zagreb of both genders. The sample size was 118 persons. The study was conducted from March 2023 to June 2023. A questionnaire was created for the purposes of this study and consisted of 4 parts with a total of 55 questions. The first part of the questionnaire provides socio-demographic data and consists of 17 questions designed for conducting the research (gender, age, marital status, household, education level, occupation, job, seniority, working hours, type of employment, use of sick leave, contact with cytostatic drugs). The second part of the questionnaire "Stress in the workplace of healthcare workers in hospitals" (8) was taken from the official website of the School of Public Health "Andrija Štampar" of the Faculty of Medicine of the University of Zagreb. The author's prior consent was obtained for the aforementioned questionnaire. Respondents were offered 17 work stressors related to work organisation, communication with superiors and patients, work overload and job demands.

Respondents rated their experience of a particular stressor on a Likert scale from 1 (not at all stressful) to 5 (extremely stressful). Each category comprises 5 questions and the total number per category can range from 17 to 85 points. Higher scores indicate a more stressful experience. All scores above 60 indicate a high level of stress. The third part of the questionnaire deals with the "intensity of the burnout syndrome at work" (9). It consists of 15 questions relating to the intensity of burnout syndrome according to the Freundenberger Burnout Scale. Respondents indicate the strength of their feelings on a Likert scale from 1 to 5, with 1 being the weakest feeling and 5 being the strongest feeling. The fourth part of the questionnaire contains five questions on the consumption of anxiolytics with multiple-choice answers and a final question on life satisfaction, in which the number that best describes life satisfaction must be ticked on scale from 1 to 10.

Statistical data processing

The data obtained are described by descriptive statistics for each variable and each scale. All variables (categorical and numerical) are presented with absolute and relative frequency. Central tendencies are represented for categorical variables by the mode and for numerical variables by the arithmetic mean and the standard deviation as an indicator of dispersion. The normality of the distribution of the numerical data was analysed using the Shapiro-Wilk test, and the homogeneity test was carried out using the Levene test. Categorical variables were analysed using Fisher's exact test, Pearson's chi-squared test ($\chi 2$ test) and the Wilcoxon test, while numerical variables were analysed using the Kruskal-Wallis non-parametric test and one-way analysis of variance. The variables stress and burnout were used as dependent variables in the study, while socio-demographic characteristics (gender, age, length of service and educational level) were used as independent variables, as well as variables related to working conditions (working hours, weekly working hours) and working environment (exposure to cytostatic drugs). The chi-square test was used to analyse the difference in the structure of employees according to socio-demographic data, working conditions, working environment and information on the use of anxiolytics. The significance level for all analyses performed was set at $p = 0.05$. The data collected in this study was processed using the TIBCO Statistica Version 14.0 December 2020.

Ethical aspects of the research

The ethical committee of the General Hospital Karlovac and the Hospital for Tumors, Sestre milosrdnice University Hospital Centre, Zagreb (KZT Zagreb) approved the research. The research was anonymous and voluntary. The consent form states the purpose of the research and the methods to be used. There was no conflict of interest of any of the parties involved in the preparation of the work.

3. RESULTS

Socio-demographic and general data

The majority of respondents were female (96), while 22 were male, i.e. a statistically significant difference was found in the representation of medical staff by gender ($\chi 2=46.41$; df=1, $P<0.001$). A larger number of respondents are employed at KZT Zagreb (n=82; 69.49%) than respondents working at OB Karlovac (n=36; 30.51%). In terms of age, the 30 to 39-year-olds are the most strongly represented (n=37; 31.36%), while the 60 to 65-year-olds are the least represented (n=6; 5.08%). The median age is 39 years (IQR=31.00-47.00). The most common marital status of respondents is married (n=81; 68.64%). The majority of respondents have two children (n=44; 37.29%). Respondents who work only one shift are the most common (n=40; 33.93%), while the smallest number of respondents work two shifts (morning, afternoon) (n=3; 2.54%), and the survey revealed the presence of statistically significant differences in the representation of medical staff in terms of working hours ($\chi2$=59.66; df=5; P<0.001). The data on the working hours of the respondents are shown in Table 1.

Table 1: The working hours of the respondents

Working hourse	n	%	χ2	P
Only in one shift	40	33,90		
In two shifts (morning, afternoon)	3	2,54		
In 3 shifts (mornings, afternoons, nights)	32	27,12	59,66	<0,001
Morning shift + on-call duty 24 hours	26	22,03		
12-24-12-48	13	11,02		

The majority of respondents are employed on a permanent basis (n=106; 89.83%). The average working week is 40.0 hours (IQR=40.00-48.00), ranging from 20 to 80 hours. The average length of service is 17 years (IQR=6.25-26.00), ranging from 6 months (0.50 years) to 48 years. The average length of service at the current workplace is 9.25 years (IQR=4.00-17.00) and ranges from 3 months (0.25 years) to 45 years. The data on education shows that most respondents have a high school diploma (n=39; 33.05%), the fewest respondents have completed postgraduate studies (n=6; 5.09%), and a statistically significant difference was found in the representation of medical staff by education level ($\chi2$=25.20; df=3; P<0.001). The data on educational level and by occupation are shown in Table 2 and 3.

Table 2: Respondents by education level

	n	%	χ2
High school	39	33,05	
Undergraduate professional/university studies	36	30,51	25,20
Graduate professional university study	37	31,36	
Ph D	6	5,09	

Table 3: Respondents by occupation

Occupation	**n**	**%**	**$\chi 2$**	**P**
MD/oncology specialist	28	23,73		
registered nurse /technician	42	35,59	17,19	0,001
bachelor's degree	36	30,51		
master's degree in nursing	12	10,17		

Perception of the level of stress at work

Most respondents had not taken sick leave in the last year (n=64; 54.24 %). The average number of sick days was 10 days (IQR=7.00-30.00) and ranged from 2 to 365 days. The average stress level (Table 4) was 55.61 points (SD=11.93). The lowest stress level was found for the item "threat of legal action", where the average stress level was 2.54, while the highest stress level was found for the item "work overload", where the average stress level was 4.06 (SD=0.99).

The presence of stress in the examinees is determined if they score above 60 on the occupational stress scale. The number of examined healthcare professionals who do not experience stress (n=73; 61.86%) is 1.62 times higher than the representation of examinees diagnosed with stress (n=45; 38.14%), and the survey revealed that a statistically significant majority of healthcare professionals do not diagnose stress ($\chi 2=6.64$; df=1; P=0.010). However, when comparing the Karlovac OB and KZT Zagreb workplaces, a statistically significant difference (t=2.09; P=0.039) was found at the Karlovac OB workplace, higher than that of employees at Zagreb, and the study revealed a statistically significant difference (t=2.09; P=0.0039).

Burnout syndrome in the workplace

Another aim of the study was to analyse burnout syndrome in the workplace, using Freudenberg's burnout scale from 1 to 5, with 1 being the lowest intensity of this feeling and 5 being the highest. Workplace burnout syndrome was assessed using a series of 15 items (Table 5), and the average stress level was found to be 40.94 points (SD=14.08). The lowest stress level was found for the item "Are you unable to make fun of yourself?", where an average stress level of 2.02 (SD=1.19) was found on a scale of 1 - 5, while the highest stress level was found for the item "Do you get tired easily and feel exhausted?", where an average stress level of 3.49 (SD=1.18) was found on a scale of 1 - 5.

Table 4: Respondents according to their perception of stress at the workplace

	1		2		3		4		5		
	N	%	N	%	N	%	N	%	N	%	AS
1. Insufficient personal income	9	7,63	15	12,71	43	36,44	31	26,27	20	16,95	3,32
2. Financial restrictions	7	5,93	25	21,19	53	44,92	23	19,49	10	8,47	3,03
3. Insufficient working space	17	14,41	22	18,64	38	32,20	24	20,34	17	14,41	3,02
4. Few opportunities for promotion	23	19,49	29	24,58	33	27,97	21	17,80	12	10,17	**2,75**
5. Poor communication with superiors	21	17,80	32	27,12	35	29,66	18	15,25	12	10,17	**2,73**
6. Insufficient number of employees	4	3,39	5	4,24	29	24,58	29	24,58	51	43,22	**4,00**
7. Poor work organisation	11	9,32	23	19,49	36	30,51	25	21,19	23	19,49	3,22
8. Unforeseen events	7	5,93	8	6,78	43	36,44	35	29,66	25	21,19	3,53
9. Administrative issues	10	8,47	13	11,02	24	20,34	31	26,27	40	33,90	**3,66**
10. Work overload	4	3,39	3	2,54	21	17,80	44	37,29	46	38,98	**4,06**
11. Threat of legal action	34	28,81	28	23,73	27	22,88	16	13,56	13	11,02	**2,54**
12. Unreasonable expectations on the part of the patient	5	4,24	26	22,03	36	30,51	28	23,73	23	19,49	3,32
13. Exposure to public criticism	6	5,08	21	17,80	38	32,20	23	19,49	30	25,42	3,42
14. Misinformation of patients by the media	7	5,93	14	11,86	37	31.36	23	19,49	37	31,36	3,58
15. Conflicts with patients/family members	12	10,17	31	26,27	43	36,44	19	16,10	13	11,02	2,92
16. Inability to separate professional and private life	20	16,95	24	20,34	29	24,58	26	22,03	19	16,10	3,00
17. 24 years of liability	12	10,17	13	11,02	34	28,81	22	18,64	37	31,36	3,50
Stres level											

Table 5: Respondents according to burnout at work

	1		2		3		4		5		AS	SD
	n	%	n	%	n	%	n	%	n	%		
1**. Do you get tired easily and feel exhausted?**	**9**	**7,63**	**11**	**9,32**	**41**	**34,75**	**27**	**22,88**	**30**	**25,42**	**3,49**	**1,18**
2. Do you get angry when someone tells you that you don't look good?	30	25,64	26	22,22	29	24,79	22	18,80	10	8,55	2,60	1,30
3. Do you always do more and feel like you've done nothing?	19	16,10	7	5,93	42	35,59	22	18,64	28	23,73	3,28	1,33
4. **Are you more disappointed with the world around you?**	**23**	**19,49**	**14**	**11,86**	**31**	**26,27**	**27**	**22,88**	**23**	**19,49**	**3,11**	**1,38**
5. Are you sad and don't know why?	34	28,81	24	20,34	32	27,12	18	15,25	10	8,47	2,54	1,28
6. Are you forgetful?	33	27,97	21	17,80	35	29,66	16	13,56	13	11,02	2,62	1,31
7. Are you grumpy and short-tempered?	23	19,49	17	14,41	38	32,20	25	21,19	15	12,71	2,93	1,28
8. Are you spending less time with friends and family?	**24**	**20,34**	**17**	**14,41**	**35**	**29,66**	**19**	**16,10**	**23**	**19,49**	**3,00**	1,38
9. Are you too busy for your usual needs?	28	23,73	18	15,25	31	26,27	22	18,64	19	16,10	2,88	1,38
10. Do you always feel bad or are you constantly ill?	44	37,29	25	21,19	33	27,97	10	8,47	6	5,08	2,23	1,18
11. Do you feel unfocussed at the end of the day?	19	16,10	27	22,88	38	32,20	22	18,64	12	10,17	2,84	1,20
12. Do you struggle to achieve feelings of happiness and contentment?	31	26,27	23	19,49	31	26,27	22	18,64	11	9,32	2,65	1,30
13. Can you make fun of yourself or crack jokes?	55	46,61	28	23,73	19	16,10	10	8,47	6	5,08	**2,02**	*1,19*
14. Is sex stressing you out more than usual?	55	46,61	18	15,25	25	21,19	12	10,17	8	6,78	**2,15**	*1,29*
15. Do you feel that you have little to say to people?	33	27,97	22	18,64	35	29,66	16	13,56	12	10,17	2,59	1,30
Burnout at work											40,94	14,08

The presence of burnout syndrome is divided into 5 categories (absence of the syndrome, candidate for the development of the syndrome, risk area, affected by the syndrome and the person is considered burnt out). Burnout syndrome was present in 26 people

(22.03%), while 92 people (77.97%) were not diagnosed with burnout syndrome. After the study, it was found that a statistically significant majority of medical staff were not diagnosed with burnout syndrome (χ2=36.92; df=1; P<0.001).

Table 6: Respondents according to the presence of burnout syndrome

Burnout syndrome	n	%	n	%	χ2
Absence of the syndrome	19	16,10			
Candidate for the development of the syndrome	21	17,80	92	77,97	
Risk area	52	44,07			36,9 p<0,001
Affected by sydrome	**19**	**16,10**			
The affected person is considered burnt out	**7**	**5,93**	**26**	**22,03**	

The average level of burnout at work is 5.88 points higher among OB Karlovac employees than among KZT Zagreb employees, and the study revealed a statistically significant difference (t=2.09; P=0.0039). Regarding the use of anxiolytics, 102 people declare that they do not use anxiolytics (86.44%), compared to respondents who use anxiolytics (n=16; 13.56%), and the research found that the majority of medical staff do not use anxiolytics (χ2 =62.68; df=1; P<0.001). Of the respondents who do use anxiolytics, most take them occasionally (n=8; 50.00%), namely alprozalam. Most respondents work in a setting that does not contribute to the need to take anxiolytics (n=73, 61.86%), and the survey found that a statistically significant majority of medical staff do not work in a setting that contributes to the need to take anxiolytics (χ2=6.64; df=1; P<0.001). According to the structure of the observed responses, the number of respondents who do not take anxiolytics as an aid to the normal performance of their duties (n=98; 83.05%) is 4.90 times greater than the number of respondents who take anxiolytics as an aid to the normal performance of their duties (n= 20; 16.95%), and the survey found that a statistically significant majority of medical staff do not take anxiolytics to perform their duties normally (χ2=51.56; df=1; P<0.001). When asked about the need for a psychologist in the workplace to conduct psychological assessments, be available and support staff in the collective, the number of respondents who need a psychologist as part of the work collective is 5.94 times higher (n=101; 85.59%) than the number of respondents who do not require a psychologist as part of the work team, and the survey found that a statistically significant majority of medical staff require a psychologist as part of the work team (χ2=59.80; df=1; P<0.001). The final question asked respondents about satisfaction with their lives (the answer is given on a scale of 1 -10, with 1 being not at all satisfied and 10 being completely satisfied (Table 7).

Table 7: Respondents according to life satisfaction

Likert scale	n	%	Me	IQR	Rx
4	7	5,93			
5	6	5,09			
6	16	13,56			
7	17	14,41	8,00	(7,00-9,00)	(4,00-10,00)
8	27	22,88			
9	24	20,34			
10	21	17,80			

4. DISCUSSION

Physician and nurses burnout has reached epidemic levels, as documented in national studies of both health workers in training and practising physician and nurses. The consequences are negative effects on patient care, professionalism, physicians' and nurses' own care and safety, and the viability of health-care systems (10). The medical professions most at risk are oncologists, paramedics, obstetricians, psychiatrists, anaesthetists and surgeons. Burnout syndrome is more common in helping professions, which is due to the ambitious goals set in daily work and the daily workload that exceeds the actual resilience (11,12). Medical professionals are exposed to higher levels of stress at work compared to the general population and are also at higher risk of psychosomatic illness The daily confrontation with other people's misfortune and difficult diagnoses challenges healthcare workers' own appropriate control over their lives as they are confronted with other people's harrowing experiences. Research has shown that 27.5% of oncologists suffer from some form of sleep disturbance, 26% from anxiety, 16% from unhappiness, anger, disgust and irritability and 13% from depression and low self-esteem (5).

The main aim of this work was to investigate the differences in the effects of stress and its consequences on the quality of work and life of nurses and doctors in the oncology departments of the Karlovac General Hospital Karlovac and the KZT Zagreb. This research included 118 respondents, most of whom are female (81.36%), which shows that this is the so-called "feminisation" of the growing proportion of women in this profession. If we look at the respondents according to their age, we see that the majority of respondents are young and middle-aged, while only 5.08% of respondents are close to retirement. These data show us that predominantly younger employees work in oncology, suggesting that older age and longer tenure are greater predictors of burnout syndrome. Similar results were found in the oncology departments of Pula and Slavonski Brod (2,13). Most of the respondents work only one shift, which is usually the morning shift. This has an impact on the quality of life, as the organisation of work and working hours in shifts strongly affect the quality of work and employee satisfaction. Indeed, shift work is the most common form of work in the healthcare sector, with afternoon work taking up free time, while night work disrupts the natural biorhythm. Frequent and long-term changes in rhythm and functioning can have lasting effects on health. The average length of service of respondents is 17 years, and the average length of service at the current job is 9.25 years, suggesting that length of service increases the level of burnout in the workplace. Research conducted at KBC Rijeka and KBC Osijek shows a correlation between length of service and burnout in the workplace (14,15).

As far as the level of education is concerned, higher education slightly predominates (33.05%). A higher percentage of respondents with a higher level of education could have a lower burnout rate due to the security that higher education brings. However, there are contradictory results in the literature that suggest an increased risk of additional stress and burnout syndrome with a higher level of education (specialisations, doctorates) (16). A large percentage of respondents are employed on a permanent basis, which would argue for a lower rate of burnout syndrome due to the security that permanent employment brings, especially today in a time of uncertain economic crisis. The lack of employees has a clear impact on the quality of work and employee satisfaction. The sick leave variable is not statistically significant among the respondents, and among those who took sick leave, their average was 10 days, which also corresponds to the cause of the most common sick leave last year, namely the coronavirus pandemic. As for the results on stress at work, the lowest level of stress was found for the question about harassment due to a court case, where the average stress level was 2.54, followed by poor communication with the supervisor - 2.73 points and low promotion opportunities - 2.75. The highest level of stress was found in the question of work overload, where the average stress level was 4.06, followed by insufficient number of employees - 4.00 and administrative tasks - 3.66, which is also confirmed by the KBC Zagreb survey, where 75.6% of respondents said they feel they were working too much. In addition, one European says that around 30% of respondents feel tired and emotionally exhausted. The main trigger for emotional exhaustion is work overload (7.29). A similar study found that the majority of respondents complained about an insufficient number of employees, work overload, poor work organisation, insufficient material resources for work and night work (17,18).

This is exactly what was shown in this study when comparing the subjects of the oncology departments of OB Karlovac and KZT Zagreb, as the study showed that statistically significant differences were found in the subjects of OB Karlovac in terms of both the presence of stress and burnout at work. It can be concluded that the reason for this is the large volume of work with very few employees, fewer opportunities for promotion, fewer opportunities for diagnosis and treatment, non-recognition of professional qualifications after graduation (this is especially true for nurses) and the proximity of clinics in Zagreb, which is specific to Karlovac. a problem that has both advantages and disadvantages. As for the results of the questionnaire on burnout at work, respondents gave the highest score of 3.49 for the statement "Do you get tired easily and feel exhausted?", followed by "Do you tend to be caustic and disappointed with the world around you?" (3.11) "Do you spend less and less time with friends and family?" (3.00).

When categorising by 5 categories of influence (absence of the syndrome, candidate for the development of the syndrome, risk area, affected by the syndrome and the subject is considered "burnt out"), it was found that the burnout syndrome is present in 22.03%, but the research showed that we have candidates for the development of the syndrome and the vast majority of them are in the risk area, that is, there are 61.87% of respondents who are potential candidates for the category of burnout syndrome. In this sense, the results of previous research conducted using questionnaires on burnout syndrome among the staff of the Emergency Department and Vrapče Hospital show that 31.7% of respondents do not have burnout syndrome, 42.1% have initial burnout and 26.2% have high-level burnout (18). Research at KBC Zagreb shows that 49% of respondents have burnout syndrome, 32% have initial burnout and 19% have severe burnout (19). From this it can be concluded that most of the available research shows that burnout syndrome exists in healthcare, respondents recognise it, it is only crucial how we investigate and assess it, so perhaps it would be of greater statistical significance if all investigators used an identical measurement instrument set to the same mode for the same test variable. All of this has immense implications for prevention procedures, the protection of mental and general health of healthcare workers. The study of the relationship between increased stress levels and the use of anxiolytics shows that 13.56% of respondents use anxiolytics, occasionally, with the most common anxiolytic being alprazolam. 38.14% of the respondents stated that they work in conditions that require anxiolytics, while 16.95% of them believe that anxiolytics help them to fulfil their tasks normally. The results are similar in the research in Pula, where 15% of respondents take anxiolytics and 17.3% of them believe that they help them do their work, while the results differ significantly among respondents in Pula, where 66.4% of them believe that their working conditions significantly influence the need to take anxiolytics. In contrast to anxiolytics, 85.59% of respondents see the need for psychological support in the form of a psychologist as part of the collective (13).

In order to prevent burnout in work in good time, one of the best methods is to improve communication both within the team and in the relationship with patients. Adequate mutual communication contributes significantly to better co-operation within the collective, with patients and their families (20-23). Since it has already been mentioned that stress can cause psychophysical problems for the health of the individual, the care of professionals in the helping professions should not be a luxury, but a must for every organisation in which an employee works. The results point to the need to continue this study and involve a larger number of respondents in order to develop a strategy for the prevention of stress and burnout at work among healthcare workers based on quality data. the main elements of this strategy are better work organisation, recognition and expansion of professional competences, recognition of professional qualifications, promotion of excellence, better financial conditions, mutual constructive communication, thematic training, the possibility of attending congresses, taking all annual leave as required by the employee, recognising symptoms of burnout, employee fatigue, changing jobs for a certain period of time if necessary.

5. CONCLUSION

Respondents from the oncology departments in Karlovac show a higher level of occupational stress and burnout syndrome than their colleagues in Zagreb. The influence of socio-demographic characteristics such as gender, age and educational level is not related to the overall experience of stress and the occurrence of burnout syndrome in this study, with the exception of the duration of work experience. Respondents do not often take anxiolytics as an aid to fulfil their tasks, but consider the help of a psychologist in their team to be very necessary, although they describe their life satisfaction as high. In view of the dangerous consequences that burnout at work can have for the individual and the community, help in the form of a psychological team in the collective is still an under-utilised option, and the need for it is indeed there. Even if this study has not confirmed the expectations and examples from daily practise, this does not alter the fact that occupational stress and burnout at work exist among healthcare professionals and the need to promote and protect mental health. The shortcoming of this study is the uneven distribution by gender and profession, and a larger number of respondents from oncology departments would be desirable, and it would be interesting to see personality traits as a predictor of burnout. Employment, work organisation and workplace are important factors for mental health. It is crucial to create a healthy and productive working environment that supports employees both psychologically and socially, has a positive impact on promoting mental health and prevents negative stress factors in the working environment.

6. REFERENCES

[1] Nedić O, Jocić N, Filipović D. *A sense of responsibility in health personnel as a cause of work-related stress.* Pub Med. 2002. p. 55(3-4): 97-103. Available from:
https://pubmed.nebi.nlm.nih.gov/12070938/

[2] Jovanović, Ž.; Pešut, S.; Miletić, B.: *Comparison of perception of stress and consumption of anxiolytics in hospital and out-hospital conditions: a cross-sectional study.* Front. Public Health. 2024; 12:1339246. doi: 10.3389/fpubh.2024.1339246

[3] Gil-Monte, PR.: *Factorial validity of the Maslach Burnout Inventory (MBI-HSS) among Spanish professionals.* Revista de saude publica. 2005; 39 1 1-8.

[4] Matuzić, S.; Kosić, R.: *Zastupljenost sindroma izgaranja kod medicinskih sestara i tehničara na primarnoj i sekundarnoj razini zdravstvene zaštite.* SG/NJ. 2020; 25:116-23 DOI: 10.11608/sgnj.25.2.4 https://hrcak.srce.hr/file/361369

[5] Ramirez, AJ.; Graham, J.; Richards, MA.; Cull, A.; Gregory, WM.: *Mental health of hospital consultants: The effect of stress and satisfaction at work*. Lancet. 1996;347: 724-8.

[6] Molassiotis, A.; Van den Akker, OB.; Boughton, BJ.: *Psychological stress in nursing and medical staff on bone marrow transplant units.* Bone Marrow Transplant. 1995; 15:449-54.

[7] Demšer, M.: *Prevalencija sindroma sagorijevanja u djelatnika zaposlenih na onkološkim odjelima.* [diplomski rad]. [Zagreb]: Medicinski fakultet Sveučilište u Zagrebu; 2017.

[8] Milošević, M.: *Izrada mjernog instrumenta stresa na radnom mjestu bolničkih zdravstvenih djelatnika i procjena njegove uporabne vrijednosti. [disertacija]. [Zagreb]: Medicinski fakultet Sveučilišta u Zagrebu; 2010.*

[9] Mazzi, B.; Ferlin, D.: *Sindrom sagorjelosti na poslu – naš profesionalni problem. Hrvatsko društvo obiteljskih doktora.* Zagreb; 2009. Available at: https://www.hdod.net/rad_drustva/RAD%20-%20Burnout%20syndro%20-%202004.pdf-upitnik C

[10] West, CP.; Dyrbye, LN.; Erwin, P.; Shanafelt, TD.: *Interventions to prevent and reduce physician burnout: a systematic review and meta-analysis.* Lancet. 2016;388(10057):2272-2281. doi:10.1016/S0140-6736(16)31279-X

[11] Hulsman at all.: *How stressful is doctor-patient communication? Physiological and psychological stress of medical students in simulated history taking and bad-news consultations*. International Journal of Psychophysiology. 2010; (77) 26-34.
[12] Isikhan, V.; Comez, T.; Danis,MZ.: *Job stress and coping strategies in health care Professionals working with cancer patients.* European Journal of Oncology Nursing Nursing.2004; 8:234-244
[13] Mikić, M.: *Istraživanje potrošnje anksiolitika u bolničkim i izvanbolničkim uvjetima* [diplomski rad]. [Pula]: Sveučilište Jurja Dobrile u Puli; 2023.
[14] 14.Katarinčić, D.: *Usporedba sindroma izgaranja medicinskih sestara i tehničara na odjelu opservacije i odjelima dugoležećih pacijenata* [diplomski rad]. [Rijeka]: Sveučilište u Rijeci; 2021.
[15] Barać, I.; Plužarić, J.; Kanisek. S.; Dubac Nemet, L.: *Job satisfaction of nurses in relation to workplace*. Sestrinski Glas. 2015; 20(1): 27-3220.
[16] Fred Herbert, L.; Mark, S.: *Scheid. Physician Burnout: Causes, Consequences, and (?) Cures.* Texas Heart Institute journal. 2018; (45) 4: 198-202.
[17] Strapajević, D.: *Procjena utjecaja rada u integriranoj bolničkoj hitnoj službi na zdravlje i radnu sposobnost djelatnika* [diplomski rad]. [Zagreb]: Medicinski fakultet Sveučilišta u Zagrebu; 2014.
[18] Debogovi,ć S.: *Profesionalni stres i sindrom sagorijevanja u djelatnika intenzivne psihijatrijske skrbi i hitne medicine* [diplomski rad]. [Zagreb]: Medicinski fakultet Sveučilišta u Zagrebu.; 2018.
[19] Šmaguc, I.: Sindrom izgaranja medicinskih sestara u jedinicama intenzivnog liječenja u KBC Zagreb [diplomski rad]. [Zagreb]: Medicinski fakultet Sveučilišta u Zagrebu; 2016.
[20] Fallowfield, L.; Jenkins, V.: *Communicating sad, bad, and difficult news in medicine.* The Lancet.2004; 363: 312-319
[21] Farber, N.J.; Urban, S.Y.; Collie, V.U.; Weiner, J.; Poriberg, D.: *The good news about giving bad news to patients.* General Internal Medicin.2002; (17) 914-922.
[22] Adam, D.; Berschick, J.; Schiele, JK.: *Interventions to reduce stress and prevent burnout in healthcare professionals supported by digital applications: a scoping review*. Front Public Health. 2023; 11:1231266. Published 2023 Oct 25. doi:10.3389/fpubh.2023.1231266
[23] Ulemek, M.: *Stres i posljedice stresa kod zdravstvenih djelatnika na onkološkim odjelima [diplomski rad].* [Rijeka]: Fakultet zdravstvenih studija Sveučilišta u Rijeci; 2023.

THE PROCESS OF INTEGRATION OF LIGHTING FIXTURES IN THE WORK SPACE, MEASUREMENT AND SIMULATION OF LIGHTING

Eric Žgela[1]; Filip Žugčić[1]; Anamarija Kirin[1]
[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac,
eric.zgela@student.vuka.hr
filip.zugcic@vuka.hr
anamarija.kirin@vuka.hr

Abstract: *The specifications of lighting fixtures, their effects on the people at their workplace, and the design optimal lighting are covered in this article. It is vital to design the workstation in order to select the appropriate lighting that satisfies the requirements for specific workspaces as well as the visual shape according to the kind and purpose of the space. DIALux software was used to design the optimal lighting by today's standards.*

Keywords: *lighting fixtures, workplace, DIALux software*

1. INTRODUCTION

We need to illuminate objects in order to see and recognize them. If we cannot illuminate objects with natural light, i.e., sunlight, they must be illuminated with artificial light sources. The eye receives about 80% of information through vision, and proper and properly directed lighting is of great importance not only for the proper execution of business tasks but also for the mood itself. [1] With adequate lighting in the workplace, employees, in addition to achieving a higher level of efficiency, also achieve better work results than those who work in poorly lit workplaces. When designing the lighting, it is necessary to comply with the Ordinance on Occupational Safety for Workplaces [2] and the associated norms (HRN EN 12464-1:2021). Lighting of workplaces, Part 1: Internal Work Spaces. [3]

2. THE IMPACT OF LIGHTING ON HEALTH AND PRODUCTIVITY

Good light inspires, conveys corporate culture, and creates favorable working conditions. Nothing else has the same psychological and mental effects as light. Regarding the health and well-being of employees, lighting - both artificial and daylight is crucial. An organization's productivity can be greatly increased by having well-lit workspaces, which also foster the best possible conditions for collaboration and focus. One of the most striking factors influencing how we work is the color temperature (Fig.1). Better lighting conditions encourage focus and facilitate visual performance that needs to be done at a desk, such as during presentations or customer interactions. Pleasant lighting brings emotion to the workplace and motivates. On the other hand, inadequate lighting detracts from productivity because it raises the likelihood of mistakes. Weak lighting contributes to headaches, exhaustion, and disease. For instance, headaches, shoulder, back, and neck pain, and vision issues are among the causes of absence. Health issues can be greatly decreased, and vision issues can be reduced by more than 50%, with optimum lighting solutions that fulfill all visual activities and consider individual needs. [4]

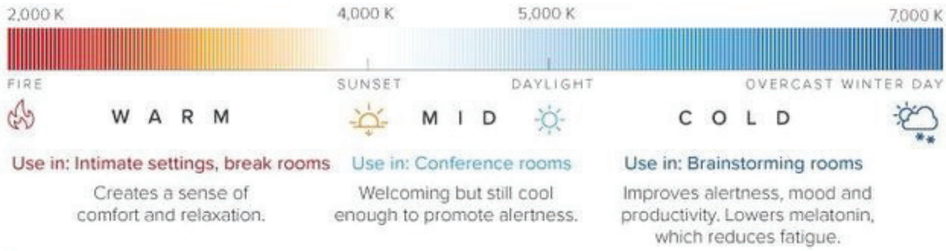


Figure 1: Light sources we are exposed to on a regular basis [5]

3. OFFICE LIGHTING SIMULATION IN DIALUX

DIALux is software designed to create, analyze and visualize lighting plans. Steps to create a lighting plan are:

1. Space creation - One of the first steps in designing a lighting plan is to create the space itself. The space can be created manually or by importing an already-designed space from another program, e.g., AutoCAD.

2. Installing fixtures - The program offers an extensive library of lighting fixtures ranging from classic lamps to advanced LED technology. This allows designers to select appropriate fixtures and place them in desired locations in the virtual space.

3. Lighting parameters - Lighting is not only the presence of light, but also its quality. DIALux makes it possible to set detailed lighting parameters, such as brightness, color temperature and light distribution, to achieve the desired atmosphere and functionality.

4. Simulation and analysis – one of the most powerful features of the program is the ability to run lighting simulations. This allows designers to visualize and analyze the effects of different lighting scenarios before they are implemented in the real world. [6]

3.1. Space creation of office

We measured the office space and entered the measurements into DIALux to create the initial layout of our office. The space's dimensions are as follows: length - 7,5 m, width - 3,45 m, height - 3,51 m. Measuring the window's dimensions was the next stage. The furniture was positioned in the room to get as near to the actual arrangement as possible after all the dimensions were entered into the DIALux application. Figure 2 shows the office 221 furniture layout at Karlovac University of Applied Sciences. [7]

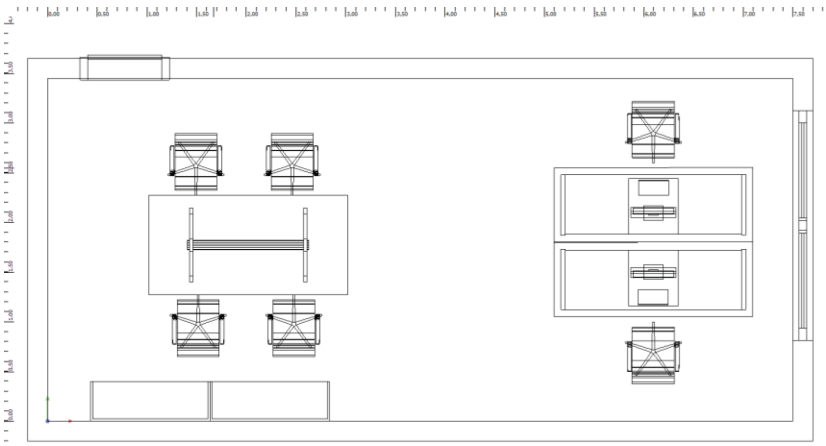


Figure 2: Office designed in DIALux

The office woodwork and furniture's reflections have a significant role in lighting design. Users of the application can choose the materials for each of the office's reflecting surfaces. The selection of the reflecting coating and reflection factor, both stated in percentages, is possible for each reflective surface. This is crucial knowledge because we don't want the carpentry to be reflecting because the worker will be distracted by the "flashing" light and find it harder to do his responsibilities.

For the carpentry, a material with a 24% reflection factor and a 4% reflective coating was selected. The parquet floor is the largest reflective surface in the office, with a reflective coating of 27% and a reflection factor of 7%. The office door's specifications, a 2% reflective coating, and a 48% reflection factor are displayed in Figure 3. [7]

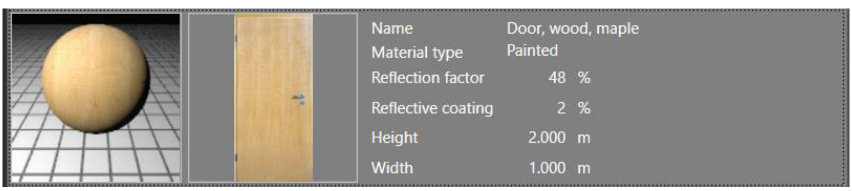


Figure 3: Selection of door material

3.2. Selection of measuring surfaces

After the office is designed, surfaces that are important for measuring illumination must be selected. One side table and two desks were our choices. The standard distance between the measurement surfaces and the floor is 0.85 meters. The surfaces that have been chosen for illuminance measurement are shown in Figure 4. [7] It is important to note that DIALux uses a single measuring surface to conduct numerous smaller measurements. A measurement is represented at each location on the workbench.

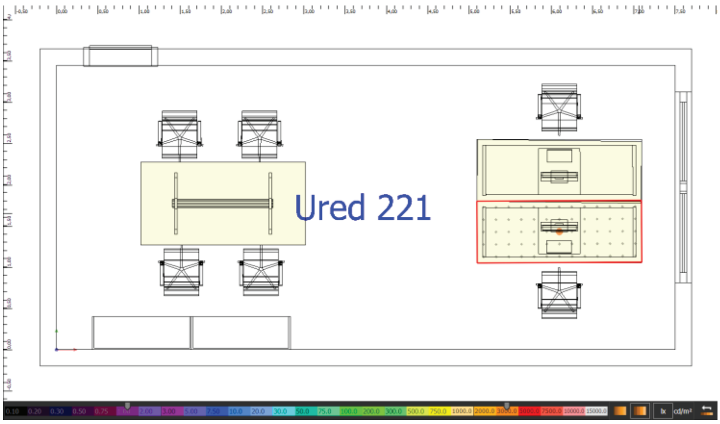


Figure 4: Display of measuring surfaces in 2D

3.3. Selecting a lighting fixture

DIALux provides a vast database of various lighting kinds. It is also feasible to incorporate the database of specific lighting fixture manufacturers into the application. In this instance, a Philips LED lighting fixture was chosen, and we also have a sheet with all the fixture's details. Figure 5 displays the specifications for the lighting fixture, including its size, type, power, color temperature, photometric curve, mounting technique, and other details. [7]

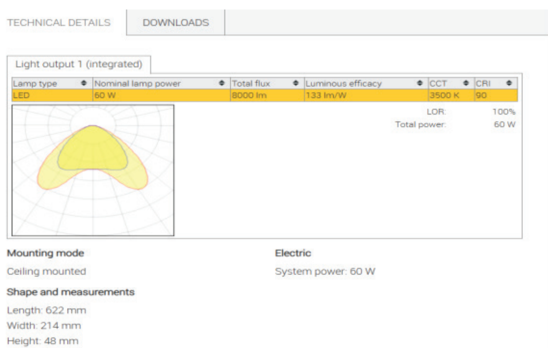


Figure 5: Specifications of the selected lighting fixture

4. MEASUREMENT RESULTS

It's time to calculate the lighting after creating the office layout and adding the lighting fixtures. Prior to delving into the lighting calculations, it is imperative to underscore that the chosen LED lighting fixture has a 100% light output ratio. This can be adjusted to your preference to avoid having an excessively high number of lux at any one measurement location. While meeting the requirements is crucial, caution must also be used to avoid overdoing the light's intensity when it is not required. Everything is dependent upon the difficulty of the work that the employee is performing, as the text has previously stated.

We complied with the specifications for the side table, requiring a minimum of 503 lx and a maximum of 724 lx. A minimum of 574 lx and a maximum of 977 lx are sufficient for the left desk. The right desk, with a minimum of 685 lx and a maximum of 905 lx, likewise satisfies the specifications. With an average of 589 lx, the total office space satisfied the requirement of at least 500 lx. It should be noted that the average we found cannot be considered reliable data because DIALux, a tool used to measure artificial light sources, was given a minimum value of 0.88 lx in this computation because natural lighting's contribution was not considered. Figure 6 shows the lighting calculation for individual work surfaces. [7]

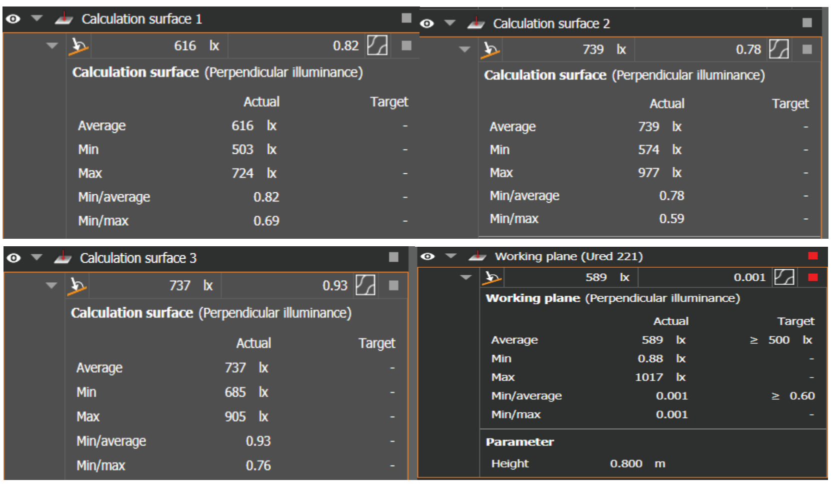


Figure 6: Lighting calculation for individual work surfaces

5. CONCLUSION

Because it significantly lowers the likelihood of headaches, weariness, and blurred vision and increases worker productivity and attention, lighting is crucial for both the individual and the workspace. It is quite simple to build a work area with the DIALux application in order to select a suitable light fixture that offers the right amount of illumination for the area in accordance with current laws and standards.

REFERENCES

[1] Lider/Hina, Available from https://lidermedia.hr/aktualno/preporucena-osvijetljenost-radnog-prostora-u-uredima-je-500-luxa-33230 Accessed 2024-06-07.

[2] Pravilnik o zaštiti na radu za mjesta rada, Available from https://narodne-novine.nn.hr/clanci/sluzbeni/2020_09_105_1965.html Accessed 2024-06-07.

[3] HRN EN 12464-1:2021: Svjetlo i rasvjeta - Rasvjeta radnih mjesta - 1. dio: Unutrašnji radni prostori, http://www.hzn.hr/, Accessed 2024-06-07.

[4] licht.de ; Lichtlexikon Available from https://www.licht.de/de/grundlagen/licht-und-arbeit Accessed 2024-06-07.

[5] Mount lighting : How lighting can affect workplace productivity, Available from https://mountlighting.co.uk/lighting-affects-workplace-productivity/ Accessed 2024-06-07.

[6] Lixero : DIALux Available from https://lixero.eu/en/kennisbank/bericht/what-is-dialux/ Accessed 2024-06-08.

[7] Žgela E.: Proces integriranja rasvjetnih tijela u radni prostor, mjerenje i simulacija osvjetljenja, Karlovac: Veleučilište u Karlovcu, 2023, urn:nbn:hr:128:007527, Završni rad, Accessed 2024-06-08.

6

ENVIRONMENTAL PROTECTION

ENVIRONMENTAL DAMAGE - CHOICE OF APPLICABLE LAW

Asmira Bećiraj
University of Bihać, Faculty of Law, Džanića mahala 68, 77000 Bihać,
Bosnia and Herzegovina, asmira_beciraj@yahoo.com

Abstract: *With the aim of maintaining and developing the area of freedom, security and justice, within the European Union the Rome II Regulation established the rules governing the applicable law for environmental damage. To respect the principle of party autonomy and to enhance legal certainty, the parties should be allowed to make a choice as to the law applicable to a non-contractual obligation. This choice should be expressed or demonstrated with reasonable certainty by the circumstances of the case. Where establishing the existence of the agreement, the court has to respect the intentions of the parties. Protection should be given to weaker parties by imposing certain conditions on the choice. This paper, after the field of application and the answer to the question of what environmental damage entails, will analyze the provisions of the Rome II Regulation, which governs the issue of the choice of the applicable law for environmental damage.*

Keywords: *environmental damage, applicable law, choice, Rome II*

1. INTRODUCTION

The legal framework for environmental protection derives from the Treaty on the Functioning of the European Union, Union policy on the environment shall contribute to pursuit of the following objectives: preserving, protecting and improving the quality of the environment, protecting human health, prudent and rational utilisation of natural resources, promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change (Article 191) [1]. One of the measures adopted within the framework of the European Union is Regulation (EC) No 864/2007 of the European Parliament and of the Council of 11 July 2007 on the law applicable to non-contractual obligations – Rome II [2].

The Community has set itself the objective of maintaining and developing an area of freedom, security and justice. For the progressive establishment of such an area, the Community is to adopt measures relating to judicial cooperation in civil matters with a cross-border impact to the extent necessary for the proper functioning of the internal market (Preamble 1 Rome II). Of course, many issues had to be thoroughly discussed, for example, first of all, an answer had to be given to the basic question related to the legal nature of autonomy, then to possible restrictions and various conditions that must be fulfilled in order for the contracting parties to be able to realize the freedom of choice of the applicable law [3]. The Rome II Regulation aims to optimize predictability and legal certainty [4].

The subject of this work is the autonomy of the will, that is, the possibility for the parties to choose the applicable law themselves. After answering the question of what environmental damage is, the paper analyzes the provisions of the Rome II Regulation that regulate the applicable law for environmental damage.

2. ROME II – *ratione materiae, territorii, temporis*

This Regulation shall apply, in situations involving a conflict of laws, to non-contractual obligations in civil and commercial matters. It shall not apply, in particular, to revenue, customs or administrative matters or to the liability of the State for acts and omissions in the exercise of State authority (acta iure imperii) (Article 1 (1) Rome II).

The following shall be excluded from the scope of this Regulation: (a) non-contractual obligations arising out of family relationships and relationships deemed by the law applicable to such relationships to have comparable effects including maintenance obligations; (b) non-contractual obligations arising out of matrimonial property regimes, property regimes of relationships deemed by the law applicable to such relationships to have comparable effects to marriage, and wills and succession; (c) non-contractual obligations arising under bills of exchange, cheques and promissory notes and other negotiable instruments to the extent that the obligations under such other negotiable instruments arise out of their negotiable character; (d) non-contractual obligations arising out of the law of companies and other bodies corporate or unincorporated regarding matters such as the creation, by registration or otherwise, legal capacity, internal organisation or winding-up of companies and other bodies corporate or unincorporated, the personal liability of officers and members as such for the obligations of the company or body and the personal liability of auditors to a company or to its members in the statutory audits of accounting documents; (e) non-contractual obligations arising out of the relations between the settlors, trustees and beneficiaries of a trust created voluntarily; (f) non-contractual obligations arising out of nuclear damage; (g) non-contractual obligations arising out of violations of privacy and rights relating to personality, including defamation (Articel 1 (2)).

This Regulation shall be binding in its entirety and directly applicable in the Member States in accordance with the Treaty establishing the European Community.This Regulation shall apply from 11 January 2009, except for Article 29, which shall apply from 11 July 2008 (Article 32 Rome II).

3. ENVIRONMENTAL DAMAGE

In its provisions, the Rome II Regulation also defines the concept of damage to the environment. ‘Environmental damage’ should be understood as meaning adverse change in a natural resource, such as water, land or air, impairment of a function performed by that resource for the benefit of another natural resource or the public, or impairment of the variability among living organisms (Preamble 24 Rome II). Regarding environmental damage, Article 174 of the Treaty, which provides that there should be a high level of protection based on the precautionary principle and the principle that preventive action should be taken, the principle of priority for corrective action at source and the principle that the polluter pays, fully justifies the use of the principle of discriminating in favour of the person sustaining the damage. The question of when the person seeking compensation can make the choice of the law applicable should be determined in accordance with the law of the Member State in which the court is seised (Preamble 25 Rome II).

4. APPLICABLE LAW

The law applicable to a non-contractual obligation arising out of environmental damage or damage sustained by persons or property as a result of such damage shall be the law determined pursuant to Article 4(1), unless the person seeking compensation for damage chooses to base his or her claim on the law of the country in which the event giving rise to the damage occurred (Article 7 Rome II).

Unless otherwise provided for in this Regulation, the law applicable to a non-contractual obligation arising out of a tort/delict shall be the law of the country in which the damage occurs irrespective of the country in which the event giving rise to the damage occurred and irrespective of the country or countries in which the indirect consequences of that event occur (Article 4 (1) Rome II). However, where the person claimed to be liable and the person sustaining damage both have their habitual residence in the same country at the time when the damage occurs, the law of that country shall apply (Article 4 (2) Rome II). Where it is clear from all the circumstances of the case that the tort/delict is manifestly more closely connected with a country other than that indicated in paragraphs 1 or 2, the law of that other country shall apply. A manifestly closer connection with another country might be based in particular on a preexisting relationship between the parties, such as a contract, that is closely connected with the tort/delict in question (Article 4 (3) Rome II).

5. CHOICE OF THE APPLICABLE LAW

The Rome II Regulation is a regulation that also contains conflict of laws rules. Namely, the basic setting from which the decisions of the Rome II Regulation are based is based on the choice of the applicable law. The parties are enabled to choose the applicable law under conditions that primarily strengthen the position of the weaker party [5]. Considering the growing number of damages in the environment, this shows that they consider these issues to be an essential part of European integration. Party autonomy is today perceived as a natural right of the individual, which exists with certain limitations in the modern multi-jurisdictional world in the system of conflict rules [6].

The introduction of the autonomy of the will means, in a certain sense, a departure from blind collision justice, which makes the choice of the applicable law predictable, and giving a certain priority to material justice, which implies that the parties choose the law that best suits their interests [7], justified primarily by the general need to grant the parties the freedom to regulate their contractual relationship [8].

To respect the principle of party autonomy and to enhance legal certainty, the parties should be allowed to make a choice as to the law applicable to a non-contractual obligation. This choice should be expressed or demonstrated with reasonable certainty by the circumstances of the case. Where establishing the existence of the agreement, the court has to respect the intentions of the parties. Protection should be given to weaker parties by imposing certain conditions on the choice (Preamble 31 Rome II).

The parties may agree to submit non-contractual obligations to the law of their choice: (a) by an agreement entered into after the event giving rise to the damage occurred; or (b) where all the parties are pursuing a commercial activity, also by an agreement freely negotiated before the event giving rise to the damage occurred. The choice shall be expressed or demonstrated with reasonable certainty by the circumstances of the case and shall not prejudice the rights of third parties (Article 14 (1) Rome II). Therefore, the court is not allowed to construct the hypothetical will of the parties, but it must be real, whether it is explicit or tacit [9]. Where all the elements relevant to the situation at the time when the event giving rise to the damage occurs are located in a country other than the country whose law has been chosen, the choice of the parties shall not prejudice the application of provisions of the law of that other country which cannot be derogated from by agreement (Article 14 (2) Rome II).

Where all the elements relevant to the situation at the time when the event giving rise to the damage occurs are located in one or more of the Member States, the parties' choice of the law applicable other than that of a Member State shall not prejudice the application of provisions of Community law, where appropriate as implemented in the Member State of the forum, which cannot be derogated from by agreement (Article 14 (3) Rome II).

6. SCOPE OF THE LAW APPLICABLE

The law applicable to non-contractual obligations under this Regulation shall govern in particular: (a) the basis and extent of liability, including the determination of persons who may be held liable for acts performed by them; (b) the grounds for exemption from liability, any limitation of liability and any division of liability; (c) the existence, the nature and the assessment of damage or the remedy claimed; (d) within the limits of powers conferred on the court by its procedural law, the measures which a court may take to prevent or terminate injury or damage or to ensure the provision of compensation; (e) the question whether a right to claim damages or a remedy may be transferred, including by inheritance; (f) persons entitled to compensation for damage sustained personally; (g) liability for the acts of another person; (h) the manner in which an obligation may be extinguished and rules of prescription and limitation, including rules relating to the commencement, interruption and suspension of a period of prescription or limitation.

7. CONCLUSION

One of the fundamental principles on which the European Union is based refers to freedom, security and justice. In order for such a thing to happen, it is necessary to pass regulations that make it possible. Determining the applicable law for environmental damage is one of the most important issues. The law of which country will be applied also depends on the answer to this question. The Rome II Regulation offers a positive solution in its provisions, and it refers to the possibility of choosing the applicable law, that is, for the parties themselves to choose the applicable law.

In order to ensure one of the fundamental rights, the right to a healthy and ecologically acceptable environment, unique rules have been defined within the European Union that regulate the applicable law for environmental damage. One of the numerous issues regulated by European Union regulations in the field of environmental protection is the question of which law is applicable for environmental damage. Considering the growing number of cases of environmental pollution with an international character, it is of particular importance to determine the rules that determine the applicable law. This means that an important part of European integration is the question of which country's law applies to environmental damage. In order to achieve these goals, the solutions of the Rome II Regulation, when determining the applicable law for environmental damage, are based on the autonomy of the will, that is, the freedom of contract. This means that the parties are allowed to choose the applicable law. How much importance is attached to this principle is already clear from the very introductory provisions of the Rome II Regulation. In view of the advantages provided by such specific solutions contained in the Rome II Regulation, they are aimed at achieving legal certainty and predictability.

REFERENCES

[1] Treaty on the Functioning of the European Union,OJ C 202, 7.6.2016.
[2] Regulation (EC) No 864/2007 of the European Parliament and of the Council of 11 July 2007 on the law applicable to non-contractual obligations, OJ L 199/40, 11. 7. 2007.
[3] Klasiček, D.; *Autonomija u međunarodnom privatnom pravu – novije tendencije*, Zbornik PFZ, 56 (2-3) 687-715 (2006), 687-715.; 691.
[4] Bouček, V.; *Uredba Rim II - Komunitarizacija europskog međunarodnog deliktnog prava – drugi dio: opće poveznice deliktnog statuta Uredbe Rim II i harmonizacija hrvatskog mpp-a,* Zbornik radova Pravnog fakulteta u Splitu, 45, 3/2008., 487-504.; 502.
[5] Kunda, I.; *Uredba Rim II: ujednačena pravila o pravu mjerodavnom za izvanugovorne obveze u Europskoj Uniji*, Zbornik Pravni fakultet Sveučilišta u Rijeci (1991) v. 28, No 2, 1269-1324.; 1270., (2007).
[6] Župan, M.; *Izbor mjerodavnog prava u obiteljskim, statusnim i nasljednim stvarima*, Zb. Pravni fakultet Sveučilišta u Rijeci, (1991) v. 33, No 2, 629-666.; 662. (2012).
[7] Duraković, A.; *Razvod braka sa stranim elementom u bosanskohercegovačkom i europskom pravu – mogući pravci harmonizacije,* Zbornik radova Razvoj porodičnog prava- od nacionalnog do evropskog, Pravni fakultet Univerziteta Džemal Bijedić u Mostaru, Mostar, 2013., 69 – 83., 75.
[8] Babić, D.A.; *Opće uređenje stranačkog izbora mjerodavnog prava prema Uredbi (EZ) 593/2008 o pravu mjerodavnom za ugovorne obveze (RIM I)*, Zagrebačka pravna revija, Vol. 5. No. 3, Zagreb 2016., 271 – 294., 274.
[9] Kunda, op. cit. (5), 1282.

ECO-LABELLING OF HOSPITALITY FACILITIES OWNED BY HRVATSKE ŠUME d.o.o.

Draženka Birkić[1], Dijana Benko[2]

[1]Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, Karlovac, Croatia, dbirkic@vuka.hr
[2]Hrvatske šume d.o.o., Put Davorina Trstenjaka 1, Karlovac, Croatia, lovacki-dom-muljava@hrvatskesume.hr

Abstract

Eco-labels are an important instrument for promoting sustainable development policies in tourism and hospitality, their implementation aiming to reduce the negative impact of products and services on the environment, health, climate and natural resources while encouraging socially responsible business operation. They represent voluntary environmental preservation instruments through which business entities demonstrate their adherence to high environmental protection standards throughout the entire lifespan of products and services. The aim of this paper is to study the attitudes of the respondents, the managers of accommodation facilities owned by Hrvatske šume, about the possibilities of implementing eco-labelling in accommodation facilities owned by Hrvatske šume d.o.o. The primary activity of the company Hrvatske šume d.o.o. is the management of forest and forest lands, with 89% of its revenue generated from logging and the sale of timber assortment. However, other activities related to forest stays, such as tourism and hospitality, are gaining in importance. Responsibility towards nature and the environment is one of the key elements of operations for socially responsible companies.

For the purpose of writing this paper, in addition to secondary research, primary research was conducted using a structured online questionnaire sent to the managers of accommodation facilities owned by Hrvatske šume d.o.o.

Research results indicated that the accommodation facilities owned by Hrvatske šume do not have any eco-labels implemented, even though their business practices show sustainable and responsible behaviour towards the environment. Furthermore, the research also highlighted a low level of awareness among the respondents about the negative impacts of tourism and hospitality on the environment. Regarding the obstacles in the eco-label implementation process, the respondents identified the lack of environmental awareness at higher levels of management and among employees as the main obstacle to the implementation and certification of any national or international eco-label. Every business organisation in the tourism system should adapt its business practices to the eco-labelling system, thereby improving and confirming its environmental excellence. The implementation of eco-labelling is crucial in the achievement of sustainable tourism development. The scientific and professional public can use this research as an incentive for further research and promoting education serving to implement green business policies and the implementation and certification of eco-labels not only in the hospitality facilities owned by Hrvatske šume, but also in the tourism industry of the Republic of Croatia.

Key words: sustainable tourism, eco-labelling, eco-labels, accommodation facilities, Hrvatske šume d.o.o.

1.INTRODUCTION

The concept of sustainable tourism development and ecological awareness attracts significant attention from professionals and the scientific community [1]. The concepts of tourism and the environment are closely interconnected. The tourism industry significantly depends on a preserved environment, and its profitable operation implies a preserved environment over a longer period of time [2]. Excessive and uncontrolled use of the environment by the tourism industry leads to its significant devastation and degradation, as well as the increase in greenhouse gas emissions, noticeable only over time. [3],[4]. According to Sustainable Travel International [5], international tourism is responsible for approximately 8% of CO2 emissions globally, with the hotel sector accounting for 21% of its carbon footprint by means of water and energy consumption, waste generation, and carbon dioxide emissions into the atmosphere. The constant growth in the tourism industry, amounting to 4% annually [6] increases the pressure on infrastructure, natural resources, and local communities. The tourism industry needs to implement more sustainable business policies so as to reduce its negative impact on the environment, increase visitors satisfaction, and avoid a bad reputation [4]. Greater awareness of the negative effects, together with growing concern about climate change, has led to the development of a wide range of green practices in the tourism industry to prevent its negative effect on the environment and respond to the broader social community's increasing concern for the environment [7][8][9] . Aware of changing consumer preferences, the tourism industry is making significant efforts to improve its social and ecological impact. A part of these efforts includes the implementation of voluntary eco-labelling or eco-certification programs aimed at motivating businesses to include environmentally friendly practices into their operations [10] Eco-labelling in the tourism industry stands for a system of implementation and certification of business policies that meet certain environmental standards and practices. It represents the identification of products and services that meet high ecological standards during their entire lifespan. Eco-labels promote the development of environmental awareness among tourism business owners, staff, and visitors. They are considered the most effective environmental strategy because of their simultaneous reduction of negative impacts on the environment, lowering operating costs, and fostering environmental awareness among both employees and end users [11]. By implementing green business policies and eco-labelling, managers in tourism reduce the risks of forthcoming restrictions based on the polluter pays principle, decrease operational costs, contribute to carbon footprint reduction and meet the growing demand for environmentally friendly products and services [12],[13].

Eco-labelling is carried out by means of certificates, eco-labels awarded by an independent third-party. They are a key tool for communicating and promoting policies of sustainable production and consumption, aimed at reducing the negative impacts of production and consumption on the environment, health, climate, and natural resources, as well as promoting socially responsible business and sustainable lifestyles. They also serve as guidelines for consumers, providing them with reliable information that products and services are of high quality and with minimal negative impact on the environment. Products or services labelled with an eco-label must meet certain environmental standards in order to receive it.

For a successful and widespread application of these programs, it is of the highest importance that companies generate positive market benefits because the process of implementation requires certain innovative technical and technological solutions, and therefore significant investment [10].The adoption of an eco-label is a lengthy process requiring significant financial resources for the certification procedure itself. These costs can discourage managers from pursuing eco-labelling despite meeting the label standards [14].Eco-labels are considered key tools in green marketing.[1] Advertising environmental excellence is becoming a competitive advantage in the tourism market compared to companies operating under the principle of business as usual [15]. Unfortunately, it is not uncommon for consumers or business partners to encounter acts of deception, known as greenwashing, when using private, unregulated eco-labels with no basis in the business policies of certain businesses [16], [17], [18] to promote the perception that business policies of an organisation, services or products are environmentally acceptable.

A 2020 study by the European Commission found that 55.3% of eco-labels on the EU market were determined to be "vague, misleading, or unfounded," while 40% were "unsubstantiated." [19].

Furthermore, according to a report of EU Ecolabelling Board, a 6-hectare campsite in France with an eco-label certification has achieved savings of approximately EUR 32,000 in energy (280,000 kW) and EUR 64,000 in water (18,400 m3), as well as an increase in recyclable waste by 14,800 kg over a seven-year period[19]. According to Prieto-Sandoval et al., [20] the implementation of an eco-label requires a multidimensional approach. Atkinson and Rosenthal [21] point out that eco-labels are communication tools providing information about the use, disposal, consumption, and production of products and services. One of primary incentives for hotels to go green is in response to growing customer awareness of environmental issues [22] Purchasing products with an eco-label is a purchase decision associated with ethics because people are responsible for the protection of their environment. According to research Khaleeli, M and Jawabri, A.(2021) ([23], consumers are becoming more aware of the importance of environmental protection, and the public is becoming highly sensitive to the quality of products they purchase and services they receive.

Moreover, numerous studies have shown a positive correlation between eco-labels and the intention to purchase in an environmentally conscious way [24]. Tourists heavily rely on eco-labels to guide their purchasing decisions [24]. According to Chi, (2021) [24]. and Majeed et al.(2022) [25], ecotourism destination market research has confirmed a positive correlation between eco-labelling and consumers' propensity to purchase. Environmentally efficient and ecologically innovative solutions have great potential to generate benefits and build competitive advantage in the tourism industry [26].

Finally, the energy crisis in Europe, rising prices, and the climate crisis have proven to be additional challenges for an effective management of the environmental aspects of business operations [27],[28]. A destination or tourism company committed to environmental excellence and reallocation of costs for environmental issues has an obligation to continuously improve its environmentally sustainable practices in a visible manner verifiable by third parties. It needs to be noted that eco-certification in tourism management processes, products, and services strongly relies on the current European

1 The term "green marketing" is used for describing marketing activities aimed at reducing the negative social and environmental impacts of existing products and production systems, while promoting less harmful products and services.

Green and Digital Transition [29],[30]. [31],[32]to increase sustainability and resilience of the tourism ecosystem.

In light of the aforementioned advantages and challenges related to eco-certification shema in the tourism industry, and having in mind the limited number of studies assessing their overall application, this paper studies the attitudes of the managers of hospitality facilities offering accommodation, food, beverage, and refreshments services owned by the public company Hrvatske šume d.o.o. towards the application of eco-labelling in their facilities. The paper also studies the attitudes towards the advantages and disadvantages of eco-labelling in their facilities and the possibilities of implementing eco-labelling as an important business policy of Hrvatske šume d.o.o[33]. Hrvatske šume d.o.o. is a public company for forest and forest land management in the Republic of Croatia. Most of their income, as much as 89%, comes from timber sales. However, they are increasingly developing economic activities related to tourism and hospitality. The research results are presented in the rest of this paper.

2.METHODOLOGY AND RESEARCH RESULTS

2.1.**Research methodology**

The first phase of the research involved conducting secondary research of existing data sources. Relevant and available professional and scientific literature and databases of relevant websites were searched. Desk research method was also used for this purpose. The collected data were processed using the methods of analysis, synthesis, induction, deduction, classification and description. The primary, empirical research was conducted by means of an online questionnaire, structured so as to study the attitudes of the managers of hospitality facilities owned by Hrvatske šume d.o.o. regarding the possibilities of implementing eco-labelling. The empirical research for collecting primary data by using the aforementioned questionnaire was conducted in the period from 1 June 2023 to 31 August 2023 on a selected set of eight accommodation facilities owned by Hrvatske šume d.o.o. (Table 1). The respondents were the managers of the same accommodation facilities owned by Hrvatske šume. Before conducting the research, phone conversations were held with all the managers, explaining the purpose and objectives of the research and requesting their participation. Online surveys were sent via email using Google Forms platform. The email explained the purpose and objective of the research, guaranteed the anonymity of the respondents, and clearly stated that the data would be used solely for scientific purposes. The questionnaire consisted of two main parts. The first part of the questionnaire related to general information about the accommodation facility, whereas the second part of the questionnaire related to the respondents' attitudes towards eco-labelling in their facilities. During the research, two reminders for the research were sent. The collected data were processed and analysed using descriptive statistical methods and presented by means of options offered by Google Forms platform.

2.2.Research results

The company Hrvatske šume d.o.o. provides hospitality services including accommodation, dining, and drinks and beverage service in hunting and mountain lodges, guesthouses, apartments and rooms. They also offer selling tourist services and package tours, and arranging business cooperation related to the sale of hunting-tourism arrangements, handled by the travel agency HŠ Tours.[2] Together with providing accommodation, all of these hospitality facilities have developed an authentic gastronomic offer primarily based on game specialties. Hrvatske šume d.o.o. provide their hospitality services in natural, forest environments or in the vicinity of hunting grounds.

A total of eight respondents, managers of hospitality accommodation facilities of the company Hrvatske šume d.o.o. (Table 1), took place in the research. The research included 80% of all facilities owned by Hrvatske šume d.o.o. that provide accommodation, dining, and drinks and beverage services. Table 1 presents the basic data about the hospitality facilities whose managers participated in the survey on the attitudes about the possibilities of an eco-label implementation.

Table 1: Hospitality facilities owned by Hrvatske šume that participated in the research

Name of the facility	Number of employees	Number of rooms	Number of seating places	Number of overnight stays in 2022
Hunting Lodge Muljava	11	8	200	2059
Hunting Lodge Kunjevci	16	6	80	1000
Hunting Lodge Radinje	2	9	42	118
Hunting Lodge Peski	5	12	80	-
Hunting Lodge Ubaš	0	3	-	110
Hunting Lodge Zlatna greda	6	16	90	912
Mountain Lodge Krasno	3	18	-	1036
Guesthouse Standard	4	11	100	1300

As can be seen from Table 1, a total of 8 managers of accommodation facilities owned by Hrvatske šume d.o.o. took part in the research. Basic data such as the number of employees, number of rooms, available beds and overnight stays vary significantly from one facility to another. Moreover, it is important to note that these facilities are visited by a large number of day-trippers, hikers, and other nature lovers throughout the year. However, the number of visitors is not systematically monitored, which is why none of the managers could estimate the number of visitors who come for a day trip and use the services offered by their facilities on a one-time basis throughout the year. According to the research findings, none of the hospitality facilities owned by Hrvatske šume d.o.o. has implemented an internationally or nationally recognised eco-label, nor is such an implementation planned in the near future.In the first part of the research, the respondents

[2] https://www.hrsume.hr/turizam/ (05.06.2023.)

were asked to express their agreement or disagreement with the statements shown in Table 2 using a rating scale from 1 - I strongly disagree - to 5 - I strongly agree.

Table 2: The respondents' attitudes towards the impact of tourism on the environment and assessment of the impact of eco-label implementation on the operation of hospitality services

	STATEMENTS	RATING+				
		1	2	3	4	5
1	Tourism and hospitality do not have a negative impact on the area and the environment	37.5	0.0	12.5	12.5	37.5
2	People who visit our hospitality facilities have a high level of awareness about nature and environment preservation and protection	12.5	0.0	37.5	25	25
3	The implementation of an eco-label will reduce operating costs of the accommodation facility	0.0	12.5	37.5	12.5	37.5
4	The implementation of an eco-label will reduce energy costs of the accommodation facility	12.5	0.0	37.5	12.5	37.5
5	The implementation of an eco-label will reduce the amount of waste produced by the accommodation facility	12.5	0.0	37.5	12.5	37.5
6	The implementation of an eco-label will reduce the amount of water consumed in the accommodation facility	0.0	0.0	37.5	12.5	50.00
7	The implementation of a credible, internationally recognised eco-label will attract a larger number of visitors to our facility	12.5	12.5	25.00	0.0	50.00
8	Eco-labelling of accommodation facilities is a result of market trends and does not significantly contribute to the preservation of nature and the environment	12.5	0.0	50.0	25.00	12.5
9	Hospitality services within Hrvatske šume need to implement at least one internationally recognized eco-label	0.0	0.0	25.00	12.5	62.5

+1-I strongly disagree, 2-I disagree 3-I neither agree nor disagree, 4- I agree , 5- I strongly agree

While analysing the results shown in Table 2 regarding the assessment of the impact of implementing an eco-label, we observe that the respondents are familiar with the key elements of eco-labelling and their potential impact on the operation of hospitality facilities. According to the results presented in Table 2, the low awareness of the respondents about the negative effects of tourism and hospitality on the environment is concerning. Specifically, 50% of the respondents believe that tourism and hospitality do not have a negative impact on the environment. At the same time, 50% of the respondents believe that visitors to their facilities and forest areas have a high level of awareness of nature and environmental preservation, while 37.5% does not have a clear stance on the environmental awareness of visitors. Regarding the implementation of an eco-label, 50% of the respondents believe that implementing an eco-label can contribute to reducing operating costs, particularly in terms of reducing energy and water consumption costs. Similarly, 50% of the respondents believe that implementing an eco-label in the hospitality facilities of Hrvatske šume could contribute to reducing the amount of waste. As much as 62.5% of the respondents believe that implementing an eco-label could reduce the amount of water consumed in their facilities. Moreover, 50% of the respondents believe that implementing an eco-label could attract a larger number of visitors. According to the results of the research, 75% of the respondents believe that Hrvatske šume should have one of the internationally recognised eco-labels in their accommodation facilities, while only 25% do not have a clear stance on the matter. In the following part of the research, the respondents were asked to express their views on the advantages of implementing eco-labelling in their hospitality facilities. They were provided with 6 possible answers (Table 3). When it comes to the advantages offered by the implementation of one of the internationally recognised eco-labels, all of them agreed that it would contribute to reducing operating costs, especially through the reduction of energy, waste and water costs. The respondents were also asked to express their views on business opportunities for their facilities and their operation in case of the implementation of an eco-label. They were provided with a total of 13 statements, among which they could choose multiple ones. The results are presented in Table 3.

Table 3: The respondents' views on the potential benefits of implementing an eco-label in the accommodation facilities owned by Hrvatske šume

STATEMENTS		AGREE WITH THE STATEMENTS IN %
1	Better promotion and market recognition	75 %
2	Reduced energy costs	62.5%
3	Aligning business operations with international trends	62.5%
4	Multiple benefits in business development	62.5%
5	Positive attitude of employees towards environmental preservation	50%

6	Positive attitude of visitors towards environmental preservation	50%
7	Improvement in product and service quality	37.5%
8	Enhanced networking and business management	37.5%
9	Better communication with visitors	37.5%
10	Reduced waste management costs	25%
11	Better cooperation with business partners	12.5%
12	Improved cooperation with employees	12.5%
13	It would not result in any benefits	0.0%

Analysing the results presented in Table 3, we can observe that the respondents rank marketing and market recognition as the primary advantage of implementing an internationally recognised eco-label, with 75% of the respondents choosing this statement. Furthermore, 62.6% of the respondents consider reduced energy costs as a benefit, while 62.5% believe alignment with international trends is beneficial. Moreover, 50% see a positive attitude of employees and visitors towards environment preservation as advantageous. Respondents were further asked to express their views on the main reasons/obstacles to implementing a national or international eco-label in the accommodation facilities owned by Hrvatske šume. They were provided with several options, and they had to choose one answer based on their own judgement. The question was: “In your opinion, can you choose the main obstacles/ reasons why not to apply for eco-labelling?” The research results are presented in Table 4.

Table 4: Obstacles in the process of implementing an eco-label

OBSTACLES		AGREE WITH THE STATEMENTS IN %
1	The lack of environmental awareness among employees	50%
2	The lack of interest among visitors for implementing ecological standards in business operations	37.5%
3	Unclear regulatory/legal framework	25%
4	The lack of human resources	25%
5	A complicated and demanding process	12.5%

6	The lack of time	12.5%
7	The lack of financial resources	0.0%
8	We do not know where to start	0.0%

Analysing the results presented in Table 4 regarding the main obstacles in the implementation of an eco-label, what stands out is that the respondents see the lack of environmental awareness at high levels of management structures and among employees as the primary obstacle in the implementation of any nationally or internationally recognised eco-labels. In most previous studies, the lack of financial resources has always been among the biggest obstacles. While the implementation process requires certain financial resources, the adjustment to the requirements of eco-labels also requires significant financial investments and investments into innovative technological and business solutions. However, the respondents who participated in this study do not emphasise financial resources, but the lack of environmental awareness.

3.CONCLUSION

Research results indicate that Hrvatske šume d.o.o. has not implemented or certified any of the offered eco-labels at the national or international level. According to the results, the main obstacle to the introduction and implementation of an eco-level is not the lack of financial resources, but the lack of developed environmental awareness at the level of higher management structures and employees. Dedication and positive attitudes of employees towards sustainable practices represent the basis for adopting green initiatives. Employees in hospitality facilities who recognise the importance of environmental preservation and the reduction of ecological impact will often be motivated to implement measures such as waste reduction, energy and water savings, and local procurement, which are, in part, the requirements of international, relevant eco-labels. According to the research results, the respondents are aware of the importance, necessity and benefits of the implementation and certification of eco-labels. They believe that eco-labelling would contribute to building a positive image and market recognition, reduce energy and water costs, and reduce the amount of waste. Individually, the purchase of products with an eco-label is characterised by a gradual change of behaviour and a very modest potential for improving the quality of the environment. However, cumulatively, this can reflect more significant resource savings at the level of the entire economy; such practices, easy to adopt, can encourage green spillover, i.e., prompt consumers to adopt different, more ambitious kinds of pro-green behaviour. Furthermore, a significant benefit resulting from eco-labelling should be successful cost-cutting due to the optimisation of natural resource use and the introduction of solutions that reduce environmental pollution, together with the associated financial obligations according to the polluter pays principle. Positive attitudes towards eco-labels can encourage the adoption of the same practices, thus creating a positive chain reaction in the tourism and hospitality industry. The scientific and professional public can use this research as an incentive for further research and promoting education serving to implement green business policies and eco-labels not only in the hospitality facilities owned by Hrvatske šume, but also in the tourism industry of the Republic of Croatia.

REFERENCES

[1] Nilashi, M.; Minaei-Bidgoli, B.; Alrizq, M.; Alghamdi, A.; Alsulami, A.A.; Samad, S.; Mohd, S.:An analytical approach for big social data analysis for customer decision-making in eco-friendly hotels, *Expert Systems With Applications,2021.*

[2] Mensah, I.: Environmental management practices among hotels in the greater Accra region. *International Journal of Hospitality Management,(2006), 25*(3), 414–431.

[3] Koutroulis, A. G.; Grillakis, M.; Tsanis, I., & Jacob, D.: Mapping the vulnerability of European summer tourism under 2 C global warming. *Climatic Change*,(2018) 151(2), 157–171.

[4] Lenzen, M.; Sun,Y.; Faturay, F.; Ting,Y., Geschke,A; Malik, A.:The carbon footprint of global tourism, *Nature Climate Change*,(2018) No.8, p.p. 522–528

[5] Sustanable Travel International. Carbon Footprint of Tourism; How Travel Contributes to the Climate Emergency, *Available from*: https://sustainabletravel.org/issues/carbon-footprint-tourism/[*Accessed:*21.04.2024.]

[6] The World Tourism Organization, Statistics of tourism, *Available from*: https://www.unwto.org/tourism-statistics, [*Accessed*:21.05.2024.]

[7] OECD. *OECD Tourism Trends and Policies 2020*. OECD. *Available from*: https://doi.org/10.1787/6b47b985-en [*Accessed*:21.05.2024.]

[8] Merli, R.; Preziosi, M.; Acampora, A. & Ali, F.: Why should hotels go green? Insights from guests experience in green hotels. *International Journal of Hospitality Management, 2019, 81*, 169–179.

[9] Yadegaridehkordi, E.; Nilashi, M.; Nizam Bin Md Nasir M. H.; Momtazi, S.; Samad, S.; Supriyanto, E.;& Ghabban, F.: Customers segmentation in eco-friendly hotels using multi-criteria and machine learning techniques. *Technology in Society,* (2021). *65*, https://doi.org/10.1016/j.techsoc.2021.101528

[10] Bello, B.R; Kassim, O.; Bello, S.O.: Eco-labeling and price premium: Does a sustainable tourism label affect hotel room pricing? SSRN,(2023) *Available from*: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4317178 [*Accessed*:11.03.2024.]

[11] Cavero-Rubio, J.A.;Amorós-Martínez , A.: Environmental certification and Spanish hotels' performance in the 2008 financial crisis, *Journal of Sustainable Tourism*, (2020), Volumen 28, Número,5, Páginas,771-796,Editor, Routledge

[12] Bernard, S; Nicolau, J.L.: Environmental certification and hotel market value, *International Journal of Hospitality Management*, 2022, 101.

[13] Sun, Y. Y.; Cadarso, M. A.; Driml, S.: Tourism carbon footprint inventories: A review of the environmentally extended input-output approach, *Annals of Tourism Research*, 2020, Elsevier, vol. 82(C).

[14] Ayuso, S.: Comparing voluntary policy instruments for sustainable tourism: The experience of the Spanish hotel sector. *Journal of Sustainable Tourism.* 2007, ***15***, 144–159.

[15] Hassan, S.: Determinants of Market Competitiveness in an Environmentally Sustainable Tourism Industry, *Journal of Travel Research*, 2000, 38(3):239-245, ,DOI:10.1177/004728750003800305

[16] Rahman, I.; Park, J.; Chi, C. G. Q.: Consequences of "greenwashing" Consumers' reactions to hotels' green initiatives, *International Journal of Contemporary Hospitality Management*, 2015,27(6), 1054-1081.

[17] Smith, V.; L.; Font, X.: Volunteer tourism, greenwashing and understanding responsible marketing using market signalling theory. *Journal of Sustainable Tourism*, (2014), 22(6), 942-963

[18] Karlsson, L., & Dolnicar, S. (2016). Does eco certification sell tourism services? Evidence from a quasi-experimental observation study in Iceland. *Journal of Sustainable Tourism,* 24(5), 694-714.

[19] Consumers, Making sustainable choices count, *Available from:* https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel/consumers_en [*Accessed*:22.03.2024.]

[20] Prieto-Sandoval, V.; Alfaro, J.A.; Mejía-Villa, A.; Ormazabal, M.: ECO-Labels as a Multidimensional Research Topic: Trends and Opportunities. *Journal of Cleaner Production*, **2016**, *135*, 806–818. DOI:10.1016/j.jclepro.2016.06.167

[21] **]**Atkinson, L.; Rosenthal, S.: Signaling the Green Sell: The Influence of Eco-Label Source, Argument Specificity, and Product Involvement on Consumer Trust, Journal of Advertising, **2014**, *43*,(1) 33–45. DOI:10.1080/00913367.2013.834803

[22] Acampora, A.; Preziosi, M.; Lucchetti, M.C.; Merli,R.:The Role of Hotel Environmental Communication and Guests' Environmental Concern in Determining Guests' Behavioral Intentions, *Sustainability* ,2022, *14*(18), 11638; https://doi.org/10.3390/su141811638

[23] Khaleeli, M.; Jawabri, A.: The effect of environmental awareness on consumers' attitudes and consumers' intention to purchase environmentally friendly products: Evidence from United Arab Emirates, *Management Science Letters* , (2021), 11(2), 555-560.

[24] Chi, N.T.K.: Understanding the Effects of Eco-Label, Eco-Brand, and Social Media on Green Consumption Intention in Ecotourism Destinations. *Journal of Cleaner Production,* **2021**, *321*, 128995.

[25] Majeed, M.U.; Aslam, S.; Murtaza, S.A.; Attila, S.; Molnár, E.: Green Marketing Approaches and Their Impact on Green Purchase Intentions: Mediating Role of Green Brand Image and Consumer Beliefs towards the Environment. *Sustainability* **2022**, *14*, 11703.

[26] Goffi,G.; Cucculelli,M.; Masiero, L.:Fostering tourism destination competitiveness in developing countries: The role of sustainability, *Journal of Cleaner Production*, 2019, 209, 101-115, Elsevier

[27] Goldhau, A.C.; Youngs, R.:EU Energy Crisis and a New Geopolitics of Climate Transition, JCMS Journal of Common Market Studies, 2023,pp.1-10.

[28] Global Electricity Review; Wiatros-Motyka, *Avaiable from*: https://ember-climate.org/insights/research/global-electricity-review-2023/, Ember, Accessed: 10.april 2024.

[29] Council of the EU (2022) *'Fit for 55': Council Agrees on Stricter Rules for Energy Performance of Buildings* (Brussels). *Avaiable from*: https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55/, *Accessed* 12.april,2024.

[30] Council of the European Union (2022a) *Council Conclusions on the Civilian SCDP Compact* (Brussels), *Avaiable from*: https://data.consilium.europa.eu/doc/document/ST-15682-2022-INIT/en/pdf, *Accessed* 12.april,2024.
[31] Council of the European Union (2022b) 'Council Regulation (EU) 2022/2578 of 22 December 2022 Establishing a Market Correction Mechanism to Protect Union Citizens and the Economy Against Excessively High Prices'. *Official Journal of the European Union*, L 335/45,(29.12.2022). *Avaiable from*: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R2578, *Accessed:* 12.april 2024.
[32] Council of the European Union (2023) *Council Conclusions on Climate and Energy Diplomacy."Bolstering EU Climate and Energy Diplomacy in a Critical Decade"* (Brussels), *Avaiable from*: https://climate-pact.europa.eu/news-and-events/news/ready-take-your-climate-action-step-further-heres-how-2024-06-24_en?gad_source=1&gclid=CjwKCAjwhIS0BhBqEiwADAUhc5d5ncafLqp77h-iKqPfDY0DuxKMmlKT9t-6ok4WHXilWNToND9L-BoCGYMQAvD_BwE, *Accessed:* 12.april 2024.
[33] Godišnja poslovna izvješća, 2022, Available from: https://www.hrsume.hr/o-nama/godisnja-izvjesca/[*Accessed*:22.03.2024.]

THE EFFECTS OF MICROPLASTICS ON HUMAN HEALTH AND ENVIRONMENT

Lidija Jakšić[1], Marta Markota (student)[2]

[1] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47 000 Karlovac, CROATIA, lidija.brckovic@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47 000 Karlovac, CROATIA, marta.markota@student.vuka.hr

Abstract: *Microplastic pollution has emerged as a pervasive and concerning issue in recent years, with implications for both human health and the environment, and numerous studies have revealed their extremely harmful influence on ecosystems. These small plastic particles, measured less than 5 mm in diameter, have infiltrated various ecosystems and food chains, and because of that, they represent a global problem and ecological effect on organisms. Understanding the origins, impacts, and mitigation strategies related to microplastics is crucial in addressing this global environmental threat. This paper provides an overview of the potential health risks of microplastics on human health and the environment and also perceptions of the general public about microplastic issues in Croatia.*

Keywords: *microplastics, environmental pollution, health effect, waste management, questionnaire*

1. INTRODUCTION

Plastics are made up of synthetic polymers that can easily be molded and modified in any desired shape or size by applying the thermal pressure [1]. Plastics production has increased dramatically worldwide over the last years and is still growing. Global plastic production reached a whopping 400.3 million metric tons in 2022, an increase of about 1.6 percent over the previous year [2].

Microplastics (MP) represent synthetic, high-molecular weight compounds that have been micronized into plastic particles smaller than 5 millimeters in size, often invisible to the naked eye. Such materials have a low biodegradation rate and therefore mostly remain in the environment and adversely affect the human body, the final consumer in the food chain [3].

Microplastics can have different impacts on living organisms based on the physical and chemical properties of the particles. Chemical properties of MP reflect the chemical nature of the polymer and properties of the additives. The most common types of MP that cause pollution are polyethylene (PE), polypropylene (PP), and polystyrene (PS) particles. The additives include inert or reinforcing fillers that give the plastic specific properties: plasticizers, antioxidants, UV stabilizers, lubricants, dyes, and flame retardants. Physical properties of MP include size and shape, the elasticity, shear strength, and surface charge of the particles. Microplastics can be classified according to their source and fragment size.

By shape, MP can be categorized into fibers, grains, granules, fragments, films, and foams. The high surface-to-volume ratio of MP makes them very good adsorbents of pollutants and microorganisms [4].

By origin, microplastics can be categorized as primary and secondary microplastics. Primary MP which are intentionally fabricated plastic particles for consumer and industrial purposes, to be used as cleaning abrasives, cosmetics, polymer carriers for drug delivery, sandblasting agents, plastic-coated fertilizers, etc. Secondary MP are plastic products that have spontaneously decomposed after being exposed to the environment [4], [6].

The increasing presence of microplastics in the environment is causing serious pollution worldwide and is widespread in all ecosystems. The presence of microplastics has been detected in soil ecosystems, surface waters [6], coastal sediments [7], beach sands [8], freshwater sediments [9] and deep environments [10], and also even rain and snow contain significant numbers of microplastics that can sometimes be invisible to the naked eye. Intensive use of plastic materials and poor waste management have led to a huge accumulation of plastic waste in the environment [11]. Particular concern represents the impact on marine ecosystems where it poses a threat to the system's biodiversity [12].

2. EXPOSURE AND EFFECTS ON HUMAN HEALTH

Humans are exposed to microplastics mainly by using various plastic products, such as different plastic packaging containers, textiles, personal hygiene products, decomposing plastic materials, etc. Humans can be exposed to microplastics through direct ingestion, direct contact, and inhalation [13]. Microplastics can affect various systems in the human body, including the digestive, respiratory, endocrine, reproductive, and immune systems. Microplastics have irregular shapes, such as cubic, spherical, and rod shapes, depending on their morphological characteristics, which should be considered when assessing risks to humans and the environment. Sharp microplastic particles can cause toxicity by physically stimulating the human body. Also, various chemicals are used when synthesizing plastic polymers, most of which are endocrine disruptors. Microplastics can also carry other toxic chemicals such as heavy metals and organic pollutants during adsorption, which can adversely affect the human body [3]. The gastrointestinal tract is believed to be the major entry point for MP into the human body [14]. This ingestion primarily stems from consuming contaminated seafood, milk, beer, honey, sugar, salt, and bottled water [15]. The studies show that the human person eats at least 50,000 microplastic particles every year because of the infiltrated food chain, drinking water, and breathing air [16].

3. MATERIALS AND METHODS

The survey was conducted in the period from June 1, 2024, to June 26, 2024. This study aims to assess and discuss the perceptions of the general public about microplastic issues in Croatia, especially young people, and also to examine awareness about waste issues and the environment and how they contribute to the preservation of the environment. The survey included 20 questions which can be classified into several categories. The first category of questions (1 to 5) included general information about respondents (gender, age, type of education, county where they live, whether they live in a city or a village). The second category (6 to 9) consisted of questions about waste and microplastics. The third category (10 to 12) tested respondents' knowledge about waste management issues and their habits when dealing with waste from households. The fourth category (13 to 14) included questions about using plastic materials and question (15) about their attitudes toward ways of environmental protection. Participants were also asked to rate their opinions and attitudes on a given subject using a five-point Likert scale in the questionnaire survey (16 to 20).

2. RESULTS AND DISCUSSION

In the survey participated 162 citizens, of which 104 were females (64%) and 58 were males (36%) (Figure 1). Previous studies demonstrated that gender has an impact on recycling behaviors, revealing that women tend to be more engaged in waste separation compared to men [17], [18]. According to Figure 2, the respondents are mostly citizens from 21 to 30 years, while two respondents (1%) are older than 60 years. According to Figure 3, the respondents are mostly citizens who have finished high school (60%) and 39% finished higher education. The respondents mostly live in the village (70%) (Figure 4). The majority of respondents live in Sisak-Moslavina County (64%) (Figure 5).

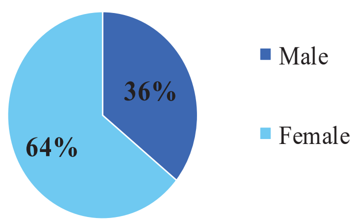


Figure 1: Gender of respondents

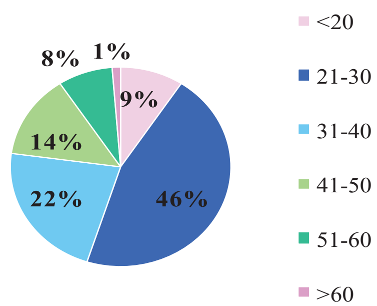


Figure 2: Age of respondents

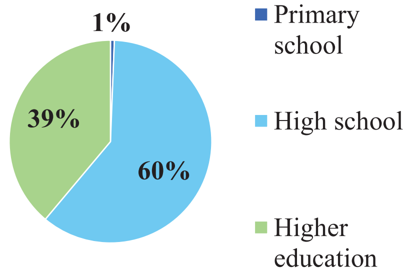


Figure 3: Distribution of responses to the question of their educational qualifications

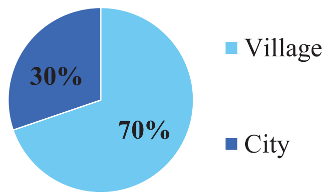


Figure 4: Distribution of responses to the question whether they live in a city or a village

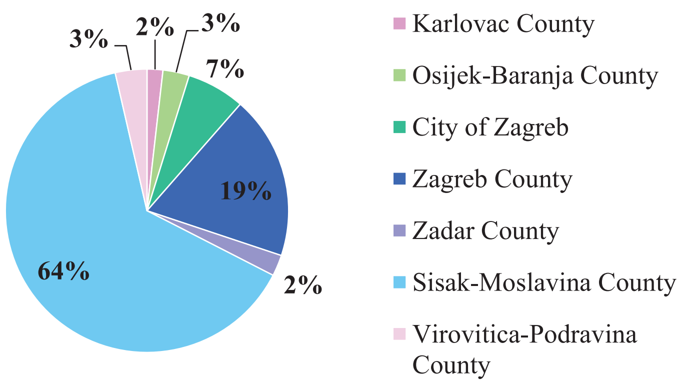


Figure 5: Distribution of responses to the question of their educational qualifications

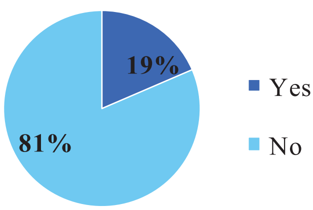


Figure 6: Distribution of responses is waste the same as garbage?

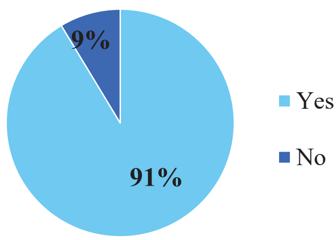


Figure 7: Distribution of responses answers to the question of whether they are familiar with the term microplastics

According to the results shown in Figure 6, the majority of respondents believe that waste is not the same as garbage (81%). Waste is any substance or object that the holder discards, intends or must discard[19]. On the contrary, garbage is mixed waste that most often ends up in landfills, and often ends up in illegal landfills and discarded in nature. The management of waste will determine whether it is seen as a problem or an opportunity[20].

Although the term microplastics is one of the newer topics today, despite this, the research showed that 91% (Figure 7) of respondents are familiar with microplastics and believe that microplastics are more harmful than plastic (98%) (Figure 8). The majority of respondents, recycled or not, are concerned about the impact of plastics and microplastics on the environment (Figure 9).

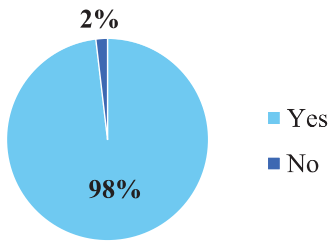


Figure 8: Distribution of answers to the question whether they think microplastics are more harmful than plastic

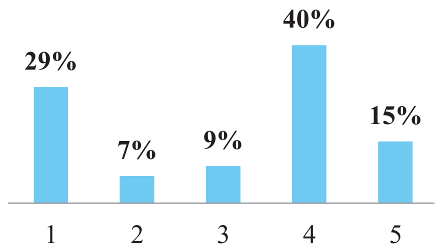


Figure 9: Distribution of responses to the question of how worried they are about the impact of plastic and microplastics on the environment

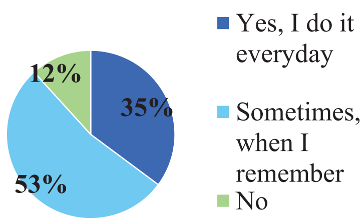


Figure 10: The distribution of respondents' answers to the question of whether they sort waste into the designated containers

The research shows (Figure 10) that 53% of respondents recycle only when they remember, 35% of respondents recycle every day, while 12% of respondents do not recycle at all. It is important to make people aware of recycling because most plastic waste comes from households. Household activities generate almost three quarters of the releases during the use phase and maintenance of plastic products [21].

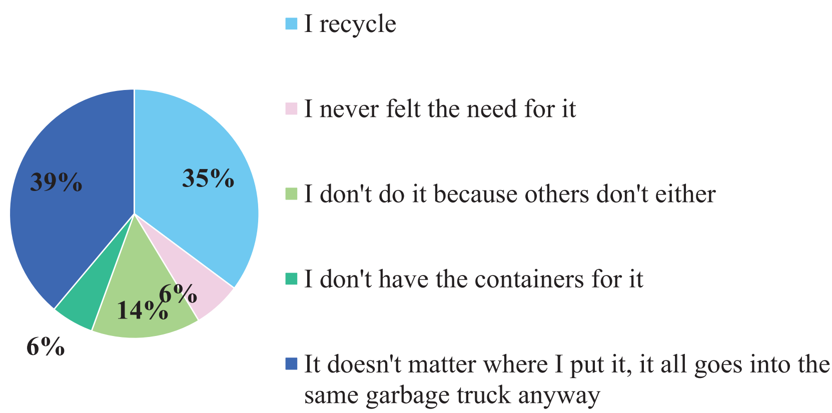


Figure 11: Distribution of responses to the question, what is the reason they do not recycle waste or rarely do so

According to the results shown in Figure 11, respondents who do not recycle waste or do so only occasionally say that they do not care where they dispose of it because it all ends up in the same garbage truck (39%), while the statistics immediately follow that they do not sort because others do not do it either (14%). Increasing public awareness of the waste problem is crucial for encouraging citizens to take part in source separation and recycling programs [22], and it is believed that a positive attitude toward participation would reduce the pollution and domestic waste [23].

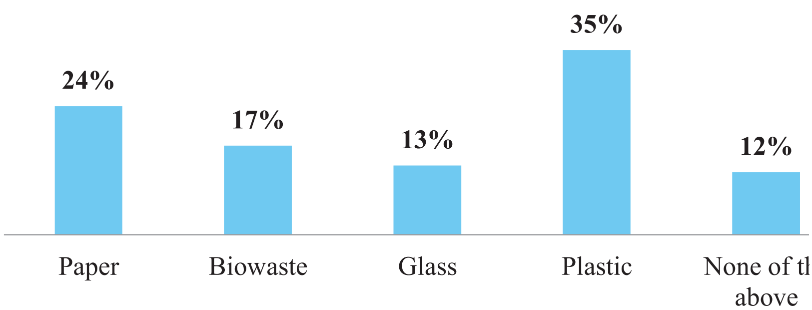


Figure 12: Distribution of responses to the question of which type of waste they recycle the most

The research showed that respondents who recycle (Figure 12), or sometimes do, recycle plastic packaging the most, followed by paper. Figure 13 shows that 43% of respondents use plastic bags when shopping, while 29% use cloth bags. Also, 19% use their own reusable bag that is not canvas. A smaller proportion of respondents stated that they do not use a single bag (3%) because they carry groceries in their hands or backpack/bag.

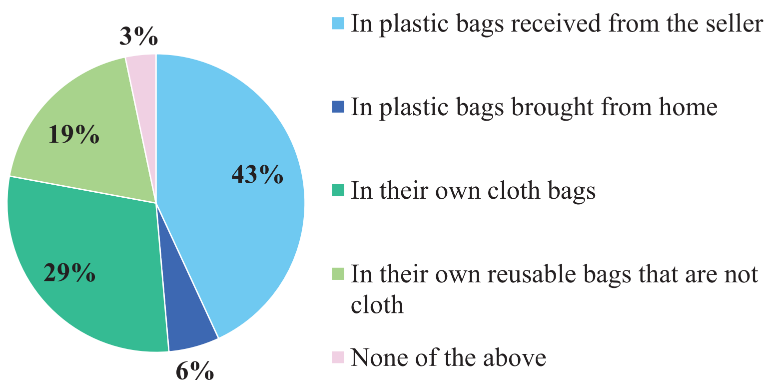


Figure 13: Distribution of respondents' answers to the question in which they most often refer to purchased food items when shopping

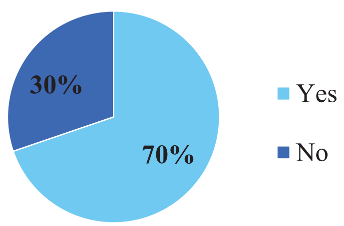


Figure 14: Distribution of respondents' answers to the question of whether they support banning/reducing the use of plastic bags, plates, cutlery, straws

It can be seen (Figure 14) that 70% of respondents support the ban on the use of plastic products, such as bags, plates, cutlery, straws, and the use of paper ones, while the remaining 30% do not support the ban. It is very important to reduce use of single-use plastics. When asked what they would change in their place with the aim of protecting the environment and nature, respondents believe that citizens should be more educated, waste collection actions should be introduced, and people should be organized and supported in planting trees and flowers, i.e., expanding green areas (Figure 15).

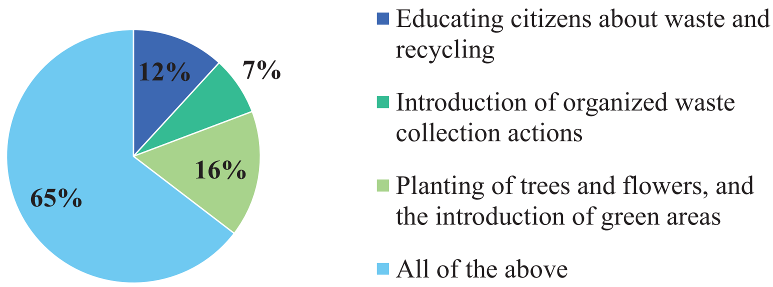


Figure 15: Distribution of respondents' answers to the question of which of the above would they change in their town/village with the aim of protecting the environment and nature

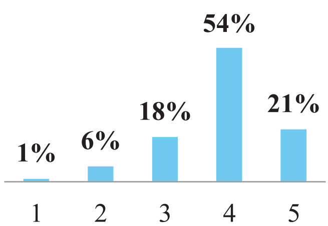


Figure 16: Distribution of respondents' answers to the question of their attitude as to whether too many plastic bags are bought and thrown away in Croatia

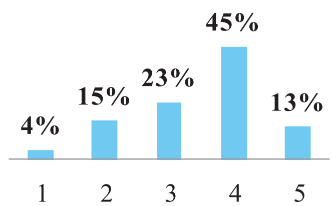


Figure 17: Distribution of respondents' answers to the question of their attitude as to whether plastic bags are among the biggest polluters of the environment

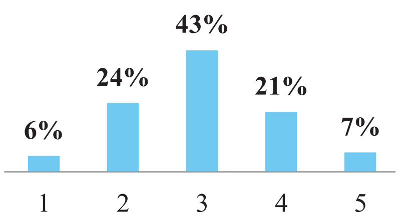


Figure 18: Distribution of respondents' answers to the question of their attitude as to whether they consider themselves an environmentally conscious person

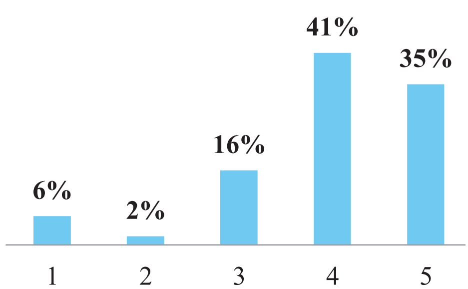


Figure 19: Distribution of respondents' answers to the question of their position on whether major social changes are necessary for the protection of the natural environment

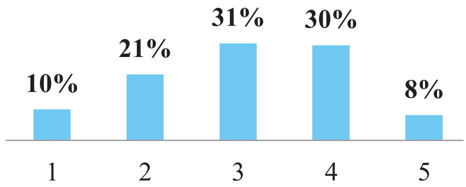


Figure 20: Distribution of respondents' answers to the question of their attitude as to whether people severely abuse the environment

According to the results shown in Figure 16 – Figure 20, the respondents stated that they agree that too many plastic bags are bought and thrown away, and that major social changes are necessary. They also agree that plastic bags are among the biggest polluters of the environment.

3. CONCLUSION

People produce millions of tons of plastic waste every year, and hardly a quarter of this amount is recycled and/or disposed of properly. The accumulating plastic waste breaks into small particles polluting the environment and spreads by wind and water. Because of the ubiquitous pollution of habitats, water, food, and inhalable air, microplastics accumulate in the bodies of living organisms, including humans. Environmental pollution by microplastics represents a significant threat to human health, but the evidence regarding the scale of this threat is ambiguous and fragmented. The impact of particular parameters of microplastics remains uncertain (e.g., the sorption capacity for pathogens, stage of decomposition, etc.). In order to reduce the negative impact of microplastic waste and potential health risks associated with plastics, it is necessary to reduce the use of single-use plastic, properly recycle, and in order to achieve this, an important role plays public awareness.

REFERENCES

[1] Torres-Agullo et al.: Overview on the occurrence of microplastics in air and implications from the use of face masks during the COVID-19 pandemic, *Available from:* https://doi.org/10.1016/j.scitotenv.2021.149555, *Accessed*: 2024-05-26.

[2] Annual production of plastics worldwide from 1950 to 2022, *Available from:* https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/, *Accessed*: 2024-05-26.

[3] Lee, Y.; Cho, J.; Sohn, J.; Kim, C.: Health Effects of Microplastic Exposures: Current Issues and Perspectives in South Korea, *Yonsei Medical Journal*, 64 (2023) 5, pp. 301-308, ISSN: 1976-2437

[4] Zolotova, N.; Kosyreva, A.; Dzhalilova, Dz.; Fokichev, N.; Makarova, O.: Harmful effects of the microplastic pollution on animal health: a literature review, *Peer J,* (2022), *Available from:* https://doi.org/10.7717/peerj.13503, *Accessed*: 2024-05-26.
[5] Guo, X.; Wang, J.: The chemical behaviors of microplastics in marine environment: A review, *Marine Pollution Bulletin*, 142 (2019), pp. 1-14, ISSN 0025-326X.
[6] Faure, F.; Saini, C.; Potter, G.; Galgani, F.; de Alencastro, L.F.; Hagmann, P.: An evaluation of surface micro- and mesoplastic pollution in pelagic ecosystems of the Western Mediterranean Sea, *Environmental Science Pollution Research*, 22 (2015), 16, pp. 12190–12197, *Available from:* https://doi.org/10.1007/s11356-015-4453-3, *Accessed*: 2024-05-26.
[7] Browne, M.A.; Dissanayake, A.; Galloway, T. S.; Lowe, D. M.; Thompson, R. C.: Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, Mytilus edulis (L*.), Environmental Science & Technology,* 42 (2008) 13, pp. 5026–5031, PMID: 18678044
[8] Liebezeit, G.; Dubaish, F.: Microplastics in Beaches of the East Frisian Islands Spiekeroog and Kachelotplate, *Bulletin of Environmental Contamination and Toxicology*, 89 (2012) 1, pp. 213–217, PMID: 22526995.
[9] Castañeda, R. A.; Avlijas, S.; Simard, M. A.; Ricciardi, A.: Microplastic pollution in St. Lawrence River sediments, *Canadian Journal of Fisheries and Aquatic Sciences*, 71 (2014) 12, pp. 1767–1771, *Available from:* https://doi.org/10.1139/cjfas-2014-0281, *Accessed*: 2024-05-27.
[10] Woodall, L. C.; Sanchez-Vidal, A.; Canals, M.; Paterson, G. L. J.; Coppock, R.; Sleight, V.; Calafat, A.; Rogers, A. D.; Narayanaswamy, B. E.; Thompson, R. C.: The deep sea is a major sink for microplastic debris, *Royal Society open science*, 1 (2014) 4, pp. 140317, ISSN: 2054-5703.
[11] Ziani, K.; Ioniță-Mîndrican, C. B.; Mititelu, M.; Neacșu, S. M.; Negrei, C.; Moroșan, E.; Drăgănescu, D.; Preda, O. T.: Microplastics: A Real Global Threat for Environment and Food Safety: A State of the Art Review, *Nutrients*, 15 (2023) 617, PMID: 36771324, *Available from:* https://doi.org/10.3390/nu15030617,. *Accessed*: 2024-05-27.
[12] Wright, S. L.; F. L. Kelly, Plastic and human health: a microissue?, *Environmental science & technology*, 51 (2017) 12, pp. 6634–6647, PMID: 28531345.
[13] Enyoh C. E.; Shafea L.; Verla A.W.; Verla E.N.; Qingyue W.; Chowdhury T. et al.: Microplastics exposure routes and toxicity studies to ecosystems: an overview, *Journal of Toxicology and Environmental Health*, 35 (2020) 1, pp. e2020004, ISSN: 2233-6567.
[14] Prata, J. C.; da Costa, J. P.; Lopes, I.; Duarte, A. C.; Rocha-Santos, T.: Environmental Exposure to Microplastics: An Overview on Possible Human Health Effects, *The Science of the total environment*, 702 (2020), pp. 134455, ISSN: 0048-9697.
[15] Giri, S.; Lamichhane, G.; Khadka, D.; Devkota, K. P.: Microplastics contamination in food products: Occurrence, analytical techniques and potential impacts on human health, *Current Research in Biotechnology*, 7 (2024), pp. 100190, ISSN 2590-262.
[16] Ahmad K. J.: Effect of Microplastic on the Human Health, In *Advances and Challenges in Microplastics*, IntechOpen, ISBN: 978-1-83768-305-5, Rijeka, (2023), *Available from:* https://www.intechopen.com/chapters/83763, Accessed: 2024-05-27.

[17] Ekere, W.; Mugisha, J.; Drake, L.: Factors influencing waste separation and utilization among households in the Lake Victoria crescent, Uganda, *Waste Management*, 29 (2009) 12, pp. 3047–3051, PMID: 19740642

[18] Padilla, A. J., Trujillo, J. C.: Waste disposal and households' heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia, *Waste Management*, 74 (2018), pp. 16–33, PMID: 29258776

[19] Waste Management Act (OG 84/21, 142/23), *Available from:* https://www.zakon.hr/z/2848/Zakon-o-gospodarenju-otpadom, *Accessed:* 2024-05-27.

[20] Reducing loss of resources from waste management is key to strengthening the circular economy in Europe, *Available from:* https://www.eea.europa.eu/publications/reducing-loss-of-resources-from, *Accessed:* 2024-05-27.

[21] Boucher, J.; Friot, D.: *Primary Microplastics in the Oceans: a Global Evaluation of Sources*, IUCN, ISBN: 978-2-8317-1827-9, Gland, Switzerland, (2017).

[22] Hasan, S.E.: Public Awareness Is Key to Successful Waste Management, Journal of environmental science and health, Part A, Toxic/hazardous substances & environmental engineering, 39 (2004) 2, pp. 483-92., PMID: 15027831

[23] Nasir, N. et al.: Plastic waste knowledge of households towards a sustainable environment, *IOP Conference Series: Earth and Environmental Science*, 1151 (2023) 1, pp. 012010, ISSN: 1755-1307.

THE EU'S GREEN DEAL: CAN IT CURB EMISSIONS IN NEW MEMBER STATES LIKE CROATIA?

Filip Kovačić[1], Mirsada Ćehić[1*]

[1]University of Applied Sciences in Security and Safety, Veslačka 2a, Zagreb, Croatia

*Corresponding author details: Dr. Mirsada Ćehić, email: mirsada@vss.hr

Abstract: *A substantial rise in anthropogenic greenhouse gas (GHG) emissions began with the Industrial Revolution. This period also witnessed a near seven-fold increase in human population. The conjunction of population growth and rapid industrialization, particularly the reliance on fossil fuels, has driven GHG emissions to critical levels.The European Union (EU) ranks among the world's leading emitters, surpassed only by China, the United States, and India. In response, the EU unveiled the ambitious European Green Deal (the Deal) in late 2019. This plan targets net-zero GHG emissions by 2050.This research analyzes trends and statistical data on GHG emissions within the EU over the past decade. A comparative analysis is conducted, contrasting the EU average with data from the Republic of Croatia, its newest member state and one rich in natural resources.The study aims to quantify the impact of the Deal's environmental policies and guidelines on mitigating GHG emissions in Croatia specifically, considering its recent EU membership.*

Keywords: *Green Deal, GHG Emissions, Croatia, Comparative Analysis*

1. INTRODUCTION

Even though global ecological awareness of humanity is largely a product of the 21st century, a significant increase in greenhouse gas emissions caused by anthropogenic activities dates to the latter half of the 18th century with the onset of the First Industrial Revolution. Since then, the Earth's population has increased almost sevenfold. The increase of in the global population has led to heightened demands for resources and increased environmental pressure. This surge in the population has resulted in various anthropogenic activities, such as industrial and agricultural practices, leading to amplified pollution of the natural environment. These pollutants originate from households as well as human agricultural and industrial endeavors. As previously mentioned, the European Union (EU) is a major emitter of greenhouse gases, ranking behind only China, the United States, and India (Fig. 1, 2).

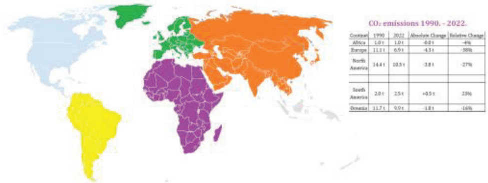


Figure 1: Per capita greenhouse gas emissions per continent [4]

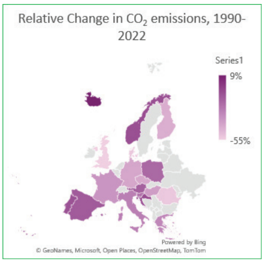


Figure 2: Per capita greenhouse gas emissions in Europe [4]

These issues have profound impacts on the planet's ecosystems and pose significant risks to human health. The World Health Organization (WHO) estimates that pollution is linked to approximately 7 million premature deaths annually [1]. This underscores the urgent need for sustainable practices and policies to mitigate the harmful effects of pollution and safeguard both the environment and public health. In response to this fact, the EU presented an ambitious plan to achieve climate neutrality called the European Green Deal at the end of 2019 (in further text: the Deal), whose main objective is to achieve net-zero greenhousegas emissions by 2050.

2. LEGISLATIVE FRAMEWORK

A comprehensive legal framework is essential for the effective implementation of environmental protection measures, particularly concerning greenhouse gas emissions. Therefore, over the years of its existence, and especially since the beginning of this century, the European Union has put forth a plethora of regulations and directives aimed at environmental protection and the reduction of the harmful impact of greenhouse gases. Some of the most important legislative acts in this regard are:

- Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC to improve and extend the greenhouse gas emission allowance trading scheme of the Community.
- Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources Energy Efficiency Directive (2012/27/EU).

- Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants.
- The European Green Deal.

Since its independence, the Republic of Croatia has had a legislative framework for environmental protection, regulating minimal requirements in terms of environmental protection principles and sustainable development, which were only partially aligned with the legal acquisitions of the European Union. However, upon Croatia's accession to the European Union in 2013, a range of legal acts, regulations, and directives became binding for Croatian legislation, including in the field of environmental protection. In terms of the legislative framework for environmental protection on a global level, it is impossible to overlook the Paris Agreement. The Paris Agreement stands as a binding global treaty concerning climate change. It was endorsed by 196 parties during the UN Climate Change Conference (COP21) in Paris, France, on December 12, 2015, and became effective on November 4, 2016. The Republic of Croatia is also among the signatories of the Paris Agreement.

3. DISCUSSION

Reducing greenhouse gas emissions is crucial for slowing down global warming and protecting the environment, and consequently, human health. The European Union, as a global leader in aspirations to combat climate change, has set certain binding targets for its member states through numerous legislative regulations. This includes achieving climate neutrality by 2050 and reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 level. Net greenhouse gas emissions in the 27 member states of the European Union have decreased by 30% since 1990 (as the reference point year of the European Green Deal, Fig. 2). Although the current energy crisis, caused by certain geopolitical and wartime disruptions in Europe and around the world, has led to higher emissions from the energy production sector, preliminary estimates for the further development of the Deal indicate a further decrease of 1.9% annually. Forecasts from EU member states suggest that by 2030, there will be a 48% reduction in net emissions compared to 1990 levels. While this indicates increased ambition compared to the previous projection of 41%, there is still a certain difference compared to the set target for the year 2030.

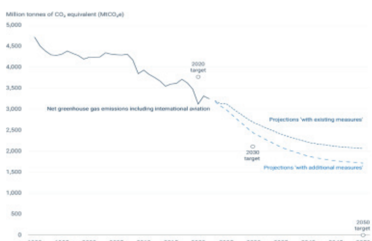


Figure 1: Member States' greenhouse gas (GHG) emission projections [2]

Analyzing the projections from the European Environmental Agency (EEA) presented in the graph above, it is evident that the gap between the set objectives and the expected impact of current and planned measures will further widen after 2030. It is projected that, considering the measures currently adopted and those planned, net emissions will reach a level of 60% below 1990 levels by 2040 and 64% by 2050, significantly lower than the set targets. This underscores the need for implementing transformative policies across all sectors to achieve climate neutrality. [2] As the European Union's youngest member state, the Republic of Croatia stands out as one of the wealthiest countries in terms of natural resources. Potable water represents a crucial natural resource in Croatia. Thanks to its favorable geographical position, relief, and climatic characteristics, Croatia stands out as one of the richest countries in water resources in Europe. According to a UNESCO report covering 188 countries, Croatia ranks as the fifth country in Europe in terms of the richness and accessibility of water sources and 42nd globally. [3] Given this fact, the significance of environmental preservation for the Republic of Croatia is further heightened.

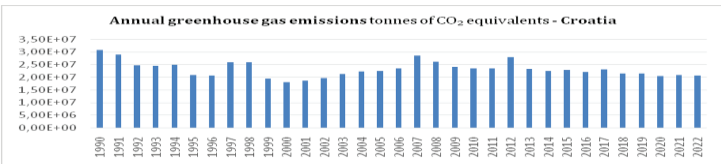


Figure 2: Per capita greenhouse gas emissions Croatia

Author's creation according toSource [5]

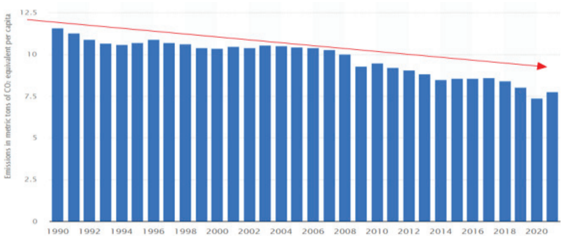


Figure 3: Greenhouse gas emissions per capita in the European Union (EU-27) from 1990 to 2021 (in metric tons of CO_2 equivalent) [7]

Comparing greenhouse gas emissions per capita in the Republic of Croatia (Fig. 3) with those at the average level of the European Union (Fig. 4), it is evident that Croatia lags the EU average. Nevertheless, the positive effects of emissions reduction are clearly visible. In 2022, carbon dioxide – CO_2 emissions per capita in Croatia were 4.8 tons, while the EU27 average was 3.8 tons. This indicates that CO_2 emissions in Croatia were 26% higher than the EU27 average. Over the period from 2013 to 2022, CO_2 emissions in Croatia decreased by 20.4%, while the EU27 average was 24%. The cause of Croatia's somewhat lower success in reducing emissions is primarily attributed to its high dependence on fossil fuels such as coal and oil in the energy and transportation sectors. Furthermore, this situation is also a result of limited development and investment in renewable energy sources such as solar or wind energy.

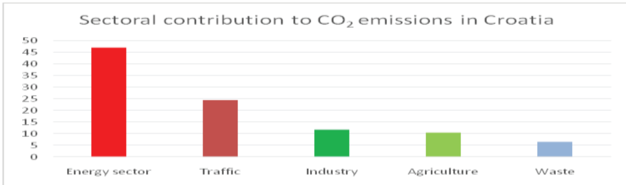


Figure 4: Contributions of individual sectors to greenhouse gas emissions in the Republic of Croatia [6]

However, the Republic of Croatia is taking further steps to accelerate the reduction of greenhouse gas emissions. Croatia has ratified the Paris Agreement, committing to reducing CO_2 emissions by 40% by 2030 compared to 1990 levels. Additionally, investments are being made in the development of renewable energy sources and the advancement of strategies to improve energy efficiency.

4. CONCLUSION

This study investigates the European Green Deal's role in achieving climate neutrality by 2050 within the European Union (EU). The analysis focuses on the Republic of Croatia, the newest EU member state. This work is important because it provides insight into the current state of greenhouse gas emissions. It has been shown that the EU is making efforts to achieve a green European deal, but despite this it is among the world's top 5 emitters of GHGs. GHGs emissions, as shown, are responsible for a large number of deaths according to the WHO and represent a major challenge for all countries of the world. The EU has set a target, but the results show that the efforts so far have not been in line with initial expectations. While Croatia demonstrates a lag in greenhouse gas emission reduction compared to the EU average, positive trends suggest that collaborative efforts, particularly educational initiatives promoting sustainable practices, are instrumental in mitigating climate change and fostering environmentally conscious societies. The research emphasizes the importance of education on sustainable development goals, including resource conservation and renewable energy utilization, in cultivating environmentally responsible communities. Croatia serves as a case study, with data analyzed from pre- and post-EU accession (2013) periods.

REFERENCES

[1] World Health Organization, official site, *Availlable from* https://www.who.int/teams/environment-climate-change-and-health/air-quality-energy-and-health/health-impacts/exposure-air-pollution *Accessed*: 2024-03-15

[2] European Environment Agency, official site, *Availlable from* https://www.eea.europa.eu/en/analysis/indicators/total-greenhouse-gas-emission-trends?activeAccordion=ecdb3bcf-bbe9-4978-b5cf-0b136399d9f8#footnote-9GSHYS54 *Accessed*: 2024-03-15

[3] United Nations, official site, *Availlable from* https://unesdoc.unesco.org/ark:/48223/pf0000388952 *Accessed*: 2024-03-15

[4] Global Carbon Budget (2023); Population based on various sources (2023) – with major processing by Our World in Data. “Annual CO_2 emissions (per capita) – GCB” [dataset]. Global Carbon Project, “Global Carbon Budget”; Various sources, “Population” [original data]. *Availlable from* https://ourworldindata.org/co2-and-greenhouse-gas-emissions *Accessed*: 2024-03-15

[5] Jones et al. (2024) – with major processing by Our World in Data. “Annual greenhouse gas emissions” [dataset]. Jones et al., “National contributions to climate change 2024.1” [original data]. *Availlable from* https://ourworldindata.org/greenhouse-gas-emissions *Accessed*: 2024-03-15

[6] Ministarstvo zaštite okoliša I energetike (2018) Sedmo nacionalno izvješće i treće dvogodišnje izvješće Republike Hrvatske prema okvirnoj konvenciji Ujedinjenih Naroda o promjeni klime (UNFCCC), *Availlable from* https://mingor.gov.hr/UserDocsImages/KLIMA/SZOR/7%20Nacionalno%20izvje%C5%A1%C4%87e%20prema%20UNFCCC.pdf *Accessed*: 2024-03-15

[7] Statista (2023); CO_2 emissions per capita EU, *Availlable from* :https://www.statista.com/statistics/986460/co2-emissions-per-cap-eu/ *Accessed*: 2024-03-15

SAFETY PRECAUTIONS IN ENVIRONMENT CONTAMINATED WITH H_2S

Nenad Lorković[1], Marina Tevčić[2], Domagoj Opačak

[1] University of Applied Sciences, Trg J. J. Strossmayera 9, Karlovac, Croatia,
nenad.lorkovic@vuka.hr

[2] University of Applied Sciences, Trg J. J. Strossmayera 9, Karlovac, Croatia,
marina.tevcic@vuka.hr

[3] University of Slavonski Brod, Trg I. B. Mažuranić 2, Slavonski Brod, Croatia,
domagoj.opacakk@gmail.com

Abstract: *Hydrogen sulfide (H_2S) is a colorless, flammable and extremely hazardous gas. It is very present in nature and it occurs in crude oil, natural gas, hot springs and oil wells. Furthermore, H_2S is a common by-product of processes such as petroleum production and the treatment of wastewater. Considering all these gas characteristics and facts where and when it occurs, it can be concluded that H_2S is very dangerous to human health and to the environment in general. Therefore, it is very important to follow safety measures to prevent exposure to hydrogen sulfide and know what to do if it happens. Mandatory safety requirements and regulations for preventing exposure to H_2S and activities in case of accident, will be presented in this article. Likewise, an example of specific protection measures for an oil well in the Netherlands will be presented.*

Keywords: *hydrogen sulfide, hazardous gas, safety precautions, human health, environment*

1. INTRODUCTION

Hydrogen sulfide (H_2S) is one of the most dangerous gases found in the oil and gas industry. Even today, there are regular occurrences of injuries and deaths due to H_2S exposure. That is why it is so important to have proper knowledge and training on how to detect it, how to protect yourself, and what to do in case of high concentration exposure. For this purpose, it is necessary to be familiar with the characteristics of the H_2S, its impact on the human body and health, and how to provide maximum protection by combining applicable methods. Safety requirements and regulations on the safe handling of hydrogen sulfide will be presented in this article, together with a practical example of specific protection measures for an oil well in the Netherlands.

2. THE CHARACTERISTICS OF H_2S AND HAZARD STATEMENTS

H_2S is colorless and invisible but can be identified in very low concentrations by our sense of smell. Because of its specific odor of rotten eggs, it is also known as sewer gas. H_2S is heavier than air and therefore often collects in working areas near the ground. As extremely flammable gas may explode if heated. Fatal if inhaled and very toxic to environment, especially to aquatic life. [1, 2]. Hazard symbols specific to hydrogen sulfide are presented in Figure 1 [3].

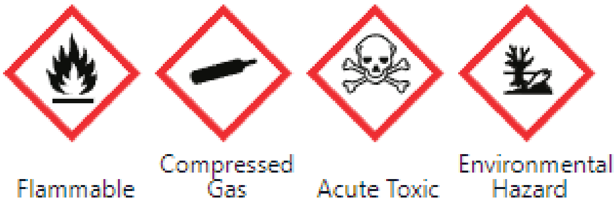


Figure 1: Hazard symbols relating to H_2S [3]

3. THE IMPACT OF HYDROGEN SULFIDE ON THE HUMAN BODY

Primary mode of exposure to hydrogen sulfide is inhalation and rapidly absorbing by the lungs. H_2S damages the lungs and the central nervous system and can cause skin irritation. The most significant symptoms of poisoning are headache, dry mouth, confusion, breathing difficulties, etc. Typical health impacts are shown in Figure 1 [4]

Figure 2: Health impact of H_2S on the human body [4]

Health impact depends on the H_2S concentration and duration of exposure. Table 1 presents exposure limits and consequences on human health [4, 5].

Ppm (parts per million) is used to express concentration in relative proportions and is a dimensionless quantity [6]. As it can be seen in Table 1, there are three major limits of H_2S concentrations, expressed in values of *ppm*, which differently impacts human health.

Furthermore, combination of concentration and exposure time is very important and is defined according to Workplace exposure limits (WELs). These are concentrations of hazardous substances in the air, averaged over a specific period of exposure referred to as a time-weighted average (TWA) [7, 8].

Two major time periods are specified: long-term (8 hours) and short-term (15 minutes).

Short-term exposure limits (STEL) prescribe that a person must not be in the environment for more than 15 minutes if the concentration of H_2S is 15 *ppm*. Related to the long term exposure, and if the concentration is less than 5 *ppm*, a person can work in such environment, but wearing a respirator mask.

Table 1: Exposure limits and consequences on human health [4, 5]

Concentration of H_2S (*ppm*)	Consequences
0 – 20 *ppm* Low concentration	Odor of H2S can be detected. Eye, nose and throat irritation, as well as headache occur.
21 – 99 *ppm* Moderate concentration	Concentration specified as Occupational Exposure Level (OEL). Strong and unpleasant odor. Serious eye irritation and possibly damage. Difficulty breathing and nausea.
100 – 1000 *ppm* High concentration	Concentration specified as Immediately Dangerous to Life and Health (IDHL) Sense of odor will be lost when concentration raises above 100 ppm Rapid breathing, nervous system failures, memory losses, loss of consciousness leading to death

4. GENERAL PROTECTIVE MEASURES AGAINST H_2S EXPOSURE

In general, exposure to H_2S can be prevented by three control methods which should be combined to provide maximum protection. Those methods are [8, 9]:

a) Engineering Controls
- Eliminate H_2S and prevent exposure
- H_2S levels must be monitored wherever gas is likely to exist
- H_2S detectors should be installed

b) Administrative controls
- Regular education and training of workers about dangers of H_2S exposure and how to use required personal protective equipment (PPE)
- Development of safe work practices and procedures (SWP)

c) Personal Protective Equipment (PPE)
- Person must wear appropriate PPE which must be suitable for the type of work and H_2S concentration levels
- Including gas monitors, respirators, safety googles, gloves, etc.

Basic H_2S detectors and monitors will be shown below. Common to all such equipment is reliability all the time and in all working conditions that it has a fast response time and a wide temperature range and has an alarm that warns of high levels [4].

There are:

a) Personal gas detectors: must be always worn attached to clothing,
b) Portable gas monitors: provide continuous reading of H_2S levels and used to test the area before entering,

c) Fixed gas monitors: installed in various locations in the facility, connected to gas alarm monitoring panel.

Figure 3: Personal detector, portable monitor and fixed monitor [4, 11]

Respiratory protection equipment consists of several kinds of breathing apparatus as devices that protect employees from inhaling harmful substances. Breathing apparatus must be used to provide protection during operations where engineering and administrative controls are not able to provide sufficient protection [10].

Major types of breathing apparatus are presented as follows.

a) Emergency escape breathing device (EEBD): contains 10-15 minutes of air and used for escape purposes,
b) Self-contained breathing apparatus (SCBA): contains 30 minutes of air and used for entering and working in H_2S contaminated area,
c) Cascade system (large air storage manifold for many users): reservoir which allows EEBD and SCBA to connect to it and refill the air.

Figure 4: EEBD, SCBA and Air manifold [4, 11]

5. SITE SPECIFIC PROTECTIVE MEASURES AGAINST H_2S EXPOSURE

In addition to general protective measures against exposure to hydrogen sulfide, each branch of industry where hydrogen sulfide appears has its own specific protective measures. Here will be presented site specific instructions which are carried out in NAM (Nederlandse Aardolie Maatschappij) rafinery located in Schoonebeek, Netherlands.

NAM is a company which explores, develops and produces oil and gas from the subsurface. Their mission is to do this safely and efficiently, without harming people and the environment. The site-specific instructions, valid for the whole facility, are issued to all employees, visitors and contractors [11].

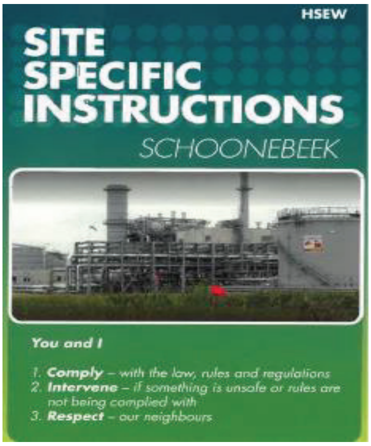


Figure 5: NAM Site specific instructions [11]

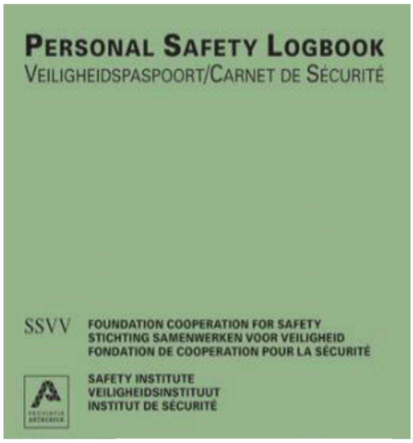


Figure 6: Personal Safety Logbook [11]

Those instructions include:

a) Location map with marked buildings, storages, hydrants, escape route and first aid spots,
b) Instructions for the implementation of protective measures and list of regular education and trainings,
c) Evacuation program,
d) Traffic rules inside facility.

The most important is NOGEPA 0.8 H_2S Course [12]. This is mandatory training for all employees, contractors and subcontractors which can come into contact with installations where an increased concentration of H_2S can be expected. Content of NOGEPA 0.8 H_2S Course is as follows.

a) Properties, risks and hazards of H_2S,
b) Regulations in case of working with H_2S,
c) Correct use of required PPE, personal detection devices and alarm equipment,
d) Evacuation procedures and first aid.

Training must be recorded in Personal Safety Logbook (PSL) together with all other personal particulars. This is a personal document which proves that the person is trained and qualified for safe work. The validity of NOGEPA 0.8 H_2S Course is four years.

6. CONCLUSION

Hydrogen sulfide H_2S is a colorless gas that is toxic even at extremely low concentrations and highly flammable and explosive in nature. It is a silent killer responsible for lot of accidents and fatalities over the years. However, the exposure risks to workers, the public and to the environment cannot be eliminated, but can be foreseen, assessed and controlled. The most important activity for proper conduction of protective measures against H_2S exposure is education and training the employees. This includes educating the workers about the dangers of H_2S exposure, how to use monitoring systems, how to use proper PPE and what to do in case of incident. As was presented in this article, contribution to proper and efficient prevention of H_2S exposure is combination of engineering and administrative controls, using of approved and proper personal protective equipment and developing and implementing safe work procedures.

REFERENCES

[1] Robert H. Dreisbach: *Dreisbach's Handbook of Poisoning-Prevention, Diagnosis and Treatment (13th Edition)*, Boca Raton, USA, (2019)
[2] Agency for Toxic Substances and Disease Registry (ATSDR): *Hydrogen Sulfide CAS ID 7783-06-4*, USA, (2021)
[3] National Library of Medicine: *PubChem Hydrogen Sulfide Compound Summary*, Bethesda, USA, (2004)
[4] Drägerwerk AG & Co. KGaA: *Basic information on the safe handling of hydrogen sulfide*, Lübeck, Germany, (2020)
[5] Occupational Safety and Health Administration (OSHA): *OSHA Fact Sheet DSG 10/2005*, Washington, USA, (2005)
[6] Leksikografski zavod Miroslav Krleža: *Hrvatska enciklopedija* (Svezak 9), Zagreb, Hrvatska, (2009.
[7] Health and safety Executive (HSE): *Managing hydrogen sulfide detection offshore Information sheet No. 6/2009*, London, UK, (2009)
[8] International Organization for standardization: *ISO 10418 Petroleum and natural gas industries – Offshore production installations – Process safety systems*, Geneve, Switzerland, (2019)
[9] SAFE Work Manitoba Agency: *Protecting against hydrogen sulfide exposure in the petroleum industry, Bulletin 173*, Winnipeg, USA, (2016)
[10] Occupational Safety and Health Administration (OSHA): *Small Entity Compliance Guide for the Respiratory Protection Standard, OSHA 3384-09,* Washington, USA, (2011)
[11] NAM Schoonebeek Netherlands: *Site specific instructions,* Schoonebeek, Netherlands, (2017)
[12] Netherlands Oil and Gas Exploration and Production Association (NOGEPA): *Industry standard Nr.001 Training for the Oil and Gas Industry,* Den Haag, Netherlands, (2023)

ADVANCING ENVIRONMENTAL AND OCCUPATIONAL SAFETY: TRACE GASES DETECTION BY PHOTOACOUSTICS AND MACHINE LEARNING IMPLEMENTATION

Mladena Lukić[1]; Tatjana Golubović[1]; Žarko Ćojbašić[2]; Dragan Markushev[3]

[1] Faculty of Occupational Safety, Čarnojevića 10a, Niš, SERBIA, mladena.lukic@znrfak.ni.ac.rs, tatjana.golubovic@znrfak.ni.ac.rs

[2] Faculty of Mechanical Engineering, Aleksandra Medvedeva, Niš, SERBIA, zcojba@ni.ac.rs

[3] Institute of Physics, Pregrevica 118, Beograd SERBIA, dragan.markushev@ipb.ac.rs

Abstract*: Photoacoustic spectroscopy (PAS) is a powerful tool for gas sensing owing to its unique attributes: universality, high sensitivity and selectivity, wide dynamic range, cost effectiveness and easy handling. PAS is an advanced, laser-based technique that covers a variety of environmental, atmospheric, industrial, chemical, and medical applications. This review introduces PAS as a promising technique for trace gases detection primarily aimed at environmental and industrial applications. Unlike other spectroscopy techniques, PAS is commonly used in the detection of molecular relaxational time, which is an important parameter in chemical and physical analysis. This review also proposes application of machine learning (ML) as an effective tool for advanced PAS analysis.*

Keywords: *photoacoustic spectroscopy, trace gases detection, vibrational to translational relaxation time, laser beam, machine learning.*

1. INTRODUCTION

Trace gases exist in the atmosphere in very small concentrations, typically below 100 ppm*. Despite their low concentrations, they play critical roles in atmospheric and climate dynamics, air pollution, industrial process control, and workplace safety. Greenhouse gases, such as carbon dioxide - CO_2 (emitted from combustion, cement production, and respiration), methane - CH_4, and nitrous oxide - N_2O (with high global warming potential), water vapor - H_2O, are trace gases that trap heat in the atmosphere and significantly affect Earth's energy balance and climate.

* Concentrations are expressed as parts per million 10^6 (ppm), billion 10^9 (ppb) or trillion 10^{12} (ppt), in all cases by volume

Some trace gases such as nitrogen oxides – NO_x (especially NO_2) and sulfur oxides - SO_x (especially SO_2) emitted from industrial processes, high temperature combustion vehicles, and natural sources, contribute to smog and acid rain formation, affecting air quality and human health. Exposure to trace gases such as carbon monoxide - CO (product of incomplete combustion of fuel), ammonia – NH_3 (emitted mainly from agriculture), hydrogen sulfide - H_2S (emitted from oil and gas wells, gas and petroleum plants), and various volatile organic compounds - VOCs can cause acute and chronic health effects, ranging from respiratory to neurological diseases and death. Therefore, monitoring and detecting trace gases are of great importance for environmental and workplace safety.

Detection of each molecule is based on its specific absorption line those formed after absorption in the UV/visible, near infrared or mid infrared region of electromagnetic spectrum. PAS is one of the most effective optical spectroscopy techniques for qualitative and quantitative trace gases analysis. PAS is a laser technique, based on light absorption by the sample and detection of the generated acoustic signal. Photoacoustic effect (PA) is discovered 1880 by Graham Bell. He found that a solid sample irradiated by sunlight radiation generates sound. The PA effect occurs in all states of matter (fluids and solids), and excitation can be achieved by all kinds of light sources. With the rapid development of lasers and sensors, PAS has established as a powerful, robust, cost-effective, easy handling technique with high sensitivity (ranging from ppm to ppt), high selectivity, and a wide dynamic range, applicable for in situ and real-time monitoring.

2. THEORETICAL BACKGROUND

The process of generation and detection of sound (PA signal) can be described in three steps (figure 1):

1. Heat generation by absorption of radiation. Molecules in the sample absorb laser radiation and excite it to a high vibrational-rotational quantum state.

2. Generation of PA waves. Excited molecules relax by collisions and transfer energy from vibrational to translational modes of surrounding molecules. Localized heat release led to thermal expansion, pressure changes and sound (PA signal) generation.

3. Detection of the sound wave by a sensitive detector (microphone). For trace gases detection PA equipment usually utilizes electret or condenser microphone.

A typical PA experimental setup for gas monitoring consists of a laser (radiation source), PA cell, and detector (figure 1). Two PAS characteristics are advantageous for trace gases detection. The PA signal is directly proportional to the laser power, allowing high sensitivity (ppm to ppt) with high-power lasers usage. Additionally, PAS is an ideal, “zero background" technique, as the PA signal is generated only by the absorbing species. The amplitude of the PA signal, in the case of a gas mixture (consisting of absorber molecules and a non-absorbing buffer gas), can be calculate from [1]:

$$S(\lambda) = C\langle P(\lambda)\rangle Nc\sigma(\lambda) \qquad (1)$$

where C is a cell constant, $P(\lambda)$ is the average power of the incident laser radiation at the wavelength λ, N is the molecular density, c is the concentration of absorber molecules and $\sigma(\lambda)$ is the absorption cross section at the wavelength of the incident laser radiation. PAS is an indirect detection technique that requires calibration, i.e., recognition of the relationship between energy absorbed by the sample and intensity of the PA signal.

3. PHOTOACOUSTIC SPECTROSCOPY FOR ENVIRONMENTAL AND INDUSTRIAL TRACE GASES DETECTION

Unlike well-known, gas detection techniques (gas chromatographs, semiconductor gas sensors or electrochemical analysis), PAS offers advantages of in situ measurement (without requirements for sample preparation) and fast response (with time constants < 1s or real-time operation).

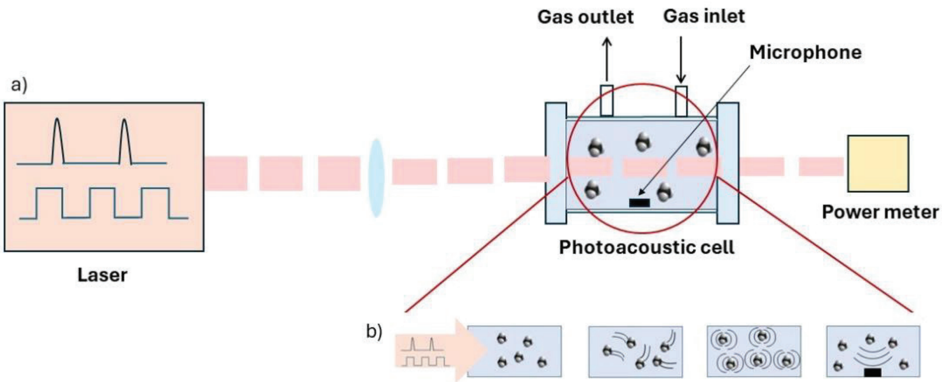


Figure 1: a) Conventional PA experimental setup with laser radiation source, PA cell and detector (microphone). b) Molecules in the PA cell absorbed laser radiation and released by collision. Localized temperature and pressure changes generated sound.

These features are especially important for detection and monitoring toxic or flammable gases in industry, process control, and atmospheric pollution with changing spatial and temporal pollutants. Significant interest in environmental and occupational safety has focused on molecules such as: CO_2, CO, NH_3, CH_4, nitric oxide - NO, N_2O, NO_2, SO_2, benzene - C_6H_6, ethane - C_2H_6, formaldehyde - H_2CO, H_2S, and H_2O. To enhance PA detection various modifications of traditional PA schemes have been developed. Principal attention is aimed on increasing the laser power, improving the PA cell design, and developing more efficient acoustic sensors. Detection limits of some selected gas species (e.g. SO_2 - 0.12 ppb, NO_2 – 2 ppb, NH3 – 0.4 ppb) monitored by conventional PAS are reported in [2]. Sigrist's group at ETH Zurich enhanced PAS sensitivity PAS using a multipass PA cell that folds the beam path and performs intracavity operation.

Novel sensing PAS methods, effective in the trace gases detection, include quartz-enhanced photoacoustic spectroscopy (QEPAS) and cantilever-enhanced photoacoustic spectroscopy (CEPAS), characterized by higher sensitivity, and better signal/noise ratio. QEPAS introduced by a group at Rice University [3]. QEPAS sensor uses resonant quartz tuning fork (QTF) (extremely highly sensitive), as acoustic detector. QEPAS has been successful in detecting numerous gas species (CH_4, NH_3, CO, CO_2, N_2O) from ppm to ppt ranges [4]. Recently, De Palo et al. reported QEPAS application on eight different air pollutants, achieving minimum detection limits of 40, 13, 800, 230, 450, 78, 18, and 5.8 ppb for CH_4, NO_2, CO_2, N_2O, CO, NO, SO_2, and NH_3, respectively are achieved [5]. In the chemical industry sensitive NH_3 detection is particularly importance for preventing explosions and fires. Atmospheric NH_3 concentrations can vary from a few ppb to several hundred ppb in polluted areas; in industrial plants, they range from a few ppm to a hundred ppm (after leaking). A wide dynamic range (ability to measure concentrations differing by several orders of magnitude) is an important feature of PAS. In ozone formation, industrial exhaust gas NO_2 plays a key role. With improvements and modifications detection limits for CH_4 of 2.41 ppm [6] and NO_2 of 54 ppt [7] have been reached using QEPAS. In numerous industrial processes some pollutants are emitted simultaneously, and their absorption spectra can overlap, affecting selectivity. Simultaneous emission of H_2S and CH_4 from sources like oil and gas wells, petroleum refiners and others can cause serious environmental and health consequences. Using QEPAS minimum detection limits of 2.5 ppm for H_2S and 85 ppm for CH_4 have been achieved [8]. QEPAS based CO sensor for in situ measurement and real-time operation have reported minimum detection limit of 12ppb CO in air [9]. For N_2O, CH_4 and H_2O detection limits of 5 ppb, 18 ppb and 20 ppm, respectively, have been achieved [10]. Atmospheric CO_2 detection using QEPAS achieved a detection limit of 29 ppm [11]. Applying enrichment-enhanced PAS, a detection limit of 1.3 ppb for NO was achieved [12].

Investigations of VOCs (hydrocarbons and benzene, toluene, ethylbenzene, and xylene - BTEX) became a primary concern. BTEX emitted from transportation, engine exhaust, petrochemical refineries, and other sources pose serious health risks even at the ppb level. Specially designed QEPAS equipment for practical BTEX monitoring is reported in [13] achieving detection limits of 113 ppb, 3 ppb, and 3 ppm for toluene, benzene, and propane, respectively.

To enhance PAS sensitivity a group at University of Turku proposed cantilever – based laser PAS that uses a miniature silicon or micromechanical cantilever as the sensing element [14]. CEPAS is more sensitive than other PA methods. It was shown in [15] that with CEPAS detection limit of 150 ppt for C_6H_6 can be achieved.

4. MACHINE LEARNING APLICATION IN PHOTOACOUSTICS

The high sensitivity and selectivity of PA devices are prerequisite for successful trace gases analysis. In PAS, high-power laser radiation induces a series of highly complex multiphoton absorption (MPA) processes. The PA signal contains information about the molecular relaxation and transformation of absorbed energy into heat. The dominant process is vibrational-to-translational relaxation, characterized by $\tau_{V\text{-}T}$ relaxation time. With the appropriate laser wavelength, PAS allows for the selective excitation of molecules quantum states, which is fundamental for determining absorption and relaxation characteristics, as well as concentrations. However, the spatial profile of the high-power lasers beam can vary up to 20%. It has been shown experimentally and theoretically that variations in the experimental laser beam parameters (spatial profile, and laser fluence) can cause significant changes in the absorption and consequently in the PA signal intensity.

To increase precision in PA parameters determination, several machine learning (ML) algorithms have been proposed for the simultaneous determination of the radius of the laser beam spatial profile r_L, relaxation time τ_{V-T}, and laser fluence Φ [16-18]. Results indicates that multilayer perceptron neural network (MLPNN), can estimate parameters of the experimental PA signal (r_L, τ_{V-T}, and Φ) in real time with satisfactory precision. Real time operation allows for the correction of the spatial laser beam profile between two successive laser pulses [17]. Additionally, real-time determination of laser fluence variation using an Adaptive Neuro-Fuzzy Inference System (ANFIS), can improve PAS experimental setup, by replacing additional optical instruments for laser beam measurement, with appropriate software [19]. Without additional optical devices, the PAS setup would be more suitable for in situ measurement, and laser beam correction can be made in real time by software modification.

Metaheuristic optimization algorithms are also an effective ML tool for fitting a function, with a capability to find solutions in a wider solution space. Lukić et al. compared the performances of several metaheuristic algorithms: genetic algorithms (GA), particle swarm optimization (PSO), artificial bee colony (ABC), and simulated annealing (SA) in the simultaneous determination of PA signal parameters [16, 18, 19]. Although these algorithms follow different steps in searching the solution space, and require different implementation approaches, they were compared based on several common criteria: accuracy and the number of function evaluations. Sufficiently good matching between estimated parameters (r_L and τ_{V-T}), and experimental/simulated PA signal parameters was achieved by all metaheuristic algorithms. Algorithms with a smaller number of function evaluations (PSO and SA, as well as ABC) were more efficient in solving the inverse problem of determining PA signal parameters. Even though metaheuristic algorithms do not work in real time, they have advantages such as fewer parameters to set, the ability to perform well in a wide solution space, and the capability to deal with noisy data. The obtained results suggest that the implementation of ML algorithms can improve the PA analysis of trace gases detection, enhancing its recognized potentials: sensitivity, selectivity, wide dynamic range, easy handling and cost effectiveness.

5. CONCLUSION

PAS is a powerful technique that has gained attention in recent decades due to its unique characteristics: high sensitivity and selectivity, a wide dynamic range (several orders of magnitude in concentration), and no sample-preparation required. Along with rapid technology development, PAS has become of immeasurable importance in various fields: environmental monitoring and pollution control, workplace safety, agriculture, medical and life sciences, and other areas. ML application can push PAS toward on-line, real-time analysis in environmental monitoring and pollution control, improving its sensitivity and selectivity. Additionally, ML implementation can establish PAS as a versatile, application-oriented technique with a self-correction capability.

ACKNOWLEDGEMENT

This research was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia - Agreements on the implementation and financing of scientific research in 2024 [number 451-03-66/2024-03/ 200148].

REFERENCES

[1] Sigrist, M.W.: Air Monitoring by Laser Photoacoustic Spectroscopy. In: Sigrist M.W. (ed) *Air Monitoring by Spectroscopy Techniques*, John Wiley & Sons, New York, pp.163- 238,(1994).

[2] Sigrist, M.: Photoacoustic Spectroscopy, Methods and Instrumentation, *Encyclopedia of Spectroscopy and Spectrometry*, Academic Press, pp. 598-602, (2017).

[3] Kosterev, A.; Bakhirkin, Y.; Curl, R. & Tittel, F.: Quartz-enhanced photoacoustic spectroscopy. *Optics Lett*ers, 27, pp. 1902–1904, (2002).

[4] Sampaolo, A.; Patimisco, P.; Giglio, M. et al.: Quartz-enhanced photoacoustic spectroscopy for multi-gas detection: A review, *Analytica Chimica Acta*, 1202, p. 338894, (2022).

[5] De Palo R.; Elefante A.; Biagi G. et al.: Quartz-Enhanced Photoacoustic Sensors for Detection of Eight Air Pollutants, *Advanced Photonics Research*, 4, p. 2200353, (2023).

[6] Lin, C.; Yan X. & Huang. Y. An all-optical off-beam quartz-enhanced photoacoustic spectroscopy employing double-pass acoustic microresonators, *Optics Communications*, 503, p. 127447, (2022).

[7] Yin, X.; Dong, L.; Wu H. et al.: Sub-ppb nitrogen dioxide detection with a large linear dynamic range by use of a differential photoacoustic cell and a 3.5W blue multimode diode laser, *Sensors and Actuators B*: *Chemical*, 247, pp. 329-335 (2017).

[8] Olivieri, M.; Menduni, G.; Giglio, M. et al.: Characterization of H_2S QEPAS detection in methane-based gas leaks dispersed into environment, *Photoacoustics*, 29, 100438, (2023).

[9] Sgobba, F.; Sampaolo, A.; Patimisco, P. et al. Compact and portable quartz-enhanced photoacoustic spectroscopy sensor for carbon monoxide environmental monitoring in urban areas, *Photoacoustics*, 25, p.100318, (2022).

[10] Elefante, A.; Giglio, M.; Sampaolo, A. et al.: Dual-Gas Quartz-Enhanced Photoacoustic Sensor for Simultaneous Detection of Methane/Nitrous Oxide and Water Vapor, *Analytical Chemistry* 91 (20), pp.12866-12873, (2019).

[11] Zheng, H.; Dong, L.; Liu, X. et al.: Near-IR telecommunication diode laser based double-pass QEPAS sensor for atmospheric CO_2 detection, *Laser Physics*, 25, p.125601, (2015).

[12] Feng, C.; Li, B.; Jing, Y. et al.: Enrichment-enhanced photoacoustic spectroscopy based on vertical graphene, *Sensors and Actuators B*: *Chemical*, 417, p. 136204, (2024).

[13] Kinjalk, K.; Paciolla, P.; Sun, B. et al.: Highly selective and sensitive detection of volatile organic compounds using long wavelength InAs-based quantum cascade lasers through quartz-enhanced photoacoustic spectroscopy, *Applied Physics Reviews,* 11, p. 021427, (2024).

[14] Wilcken, K. & Kauppinen, J.: Optimization of a microphone for photoacoustic spectroscopy. Applied Spectroscopy 57, pp. 1087–1092 (2003).

[15] Karhu, J. & Hieta, T., Enhancement of photoacoustic spectroscopy with sorption enrichment for ppt-level benzene detection, *Applied Optics*, 61, pp. 1892-1897, (2022).

[16]Lukić, M.; Ćojbašić, Ž.; Rabasović, M. et al.: Computationally intelligent pulsed photoacoustics, *Measurement Science and Technology*, 25, p. 125203, (2014).

[17] Lukić, M.; Ćojbašić, Ž.; Rabasović, M. et al.: Laser fluence recognition using computationally intelligent pulsed photoacoustics within the trace gases analysis, *International Journal of Thermophysics*, 38, p. 165, (2017).

[18] Lukić, M.; Ćojbašić, Ž. & Markushev, D.: Neuro fuzzy prediction of laser fluence based on photoacoustic signal analysis in different gas mixtures, *Measurement*, 210, p. 112533, (2023).

[19] Lukić, M.; Ćojbašić, Ž. & Markushev, D.: Trace gases analysis in pulsed photoacoustics based on swarm intelligence optimization, *Optical and Quantum Electronics* 54, p. 674, (2022).

DEFINING THE STANDARD CONTENT OF THE PRE-FEASIBILITY STUDY FOR GEOTHERMAL POWER PLANTS BASED ON THE ORGANIC RANKINE CYCLE

Nenad Mustapić[1], Toni Kralj[2]
Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, Karlovac, Croatia
[1] nenad.mustapic@vuka.hr
[2] toni.kralj@vuka.hr

Abstract: *Previous research has established that the Republic of Croatia has significant energy potential in low and medium-temperature geothermal sources which have a geothermal fluid temperature between 120°C and 180°C. For this reason, in the near future the construction of a certain number of geothermal power plants is expected, where plants based on the Organic Rankine Cycle will produce a significant amount of electricity from a renewable energy source. In the phase of preparations for the construction of a geothermal power plant, it is necessary to carry out a detailed analysis of possible variants of the plant, which is carried out through a pre-feasibility study. This article describes the development of the methodology that prescribes the standard content of the pre-feasibility study for geothermal power plants based on the Organic Rankine Cycle (ORC). The methodology includes thermodynamic and economic analysis and optimization of the specified type of power plants. As part of the pre-feasibility study, only the above-ground part of the geothermal power plant is analysed, and it is assumed that the characteristics of the geothermal source are known.*
Keywords: *Organic Rankine Cycle, geothermal, pre-feasibility study, power plant*

1. INTRODUCTION

In this paper an approach is proposed for a feasibility study for the geothermal Organic Rankine Cycle (ORC) based power plant which includes thermodynamic analysis and optimization, component analysis and techno-economic analysis and design. In geothermal ORC design process there is five main design variables:

1. working fluid selection,

2. selection of ORC component types (heat exchangers and turbine),

3. selection of ORC configuration,

4. ORC process design parameters (pinch points, degree of superheat or subcooling, evaporation and condensation pressures and temperatures),

5) sizing of main ORC components (turbine power output, pump(s) and fan power input and size (area) of heat exchangers).

Within the framework of the mentioned five main ORC plant design variables, the scientific literature deals with topics such as ORC system design, modelling and analysis [1,2], thermodynamic and thermoeconomic optimization of the ORC system [3], ORC working fluid [4] and ORC configuration selection [5,6]. The criteria for the selection of ORC component types, such as heat exchangers [7], ORC condensate cooling system [8], expanders [9] and pumps [10], were analysed as part of the extensive research. In addition to the aforementioned research, an analysis of the dynamic behaviour of ORC plants [11,12] was performed, and related to this, guidelines were given for choosing the optimal control strategy [13] for ORC plants.

Within the framework of the pre-feasibility study (the above-ground part), it is necessary to carry out an extensive analysis and optimization of the ORC plant with the aim of determining the most suitable five main design variables that will enable the most precise economic profitability of the plant, and its impact on the environment. It is also necessary to examine the plant dynamic characteristics of the ORC plant, on the basis of which control strategies can be selected.

2. METHODOLOGY

2.1. Thermodynamic System Models and Assumptions

Selected Organic Rankine Cycle configurations are shown in Figure 1. Only subcritical configurations that are most often used in practice are shown. Each component in the ORC configuration is defined as a control volume, for which thermodynamic expressions are defined in accordance with first law of the thermodynamics and mass conservation principle. For ORC configurations subcooling in the condenser and superheating of working fluid are provided, which describe more realistic plant operation. During optimization design variables (independent variables), are determined. In order to make this possible, assumed constant values of fixed variables (model parameters), must be included in the thermodynamic model. Model parameters, assumptions and their selected values are in accordance with the values that are common in the scientific literature [14].

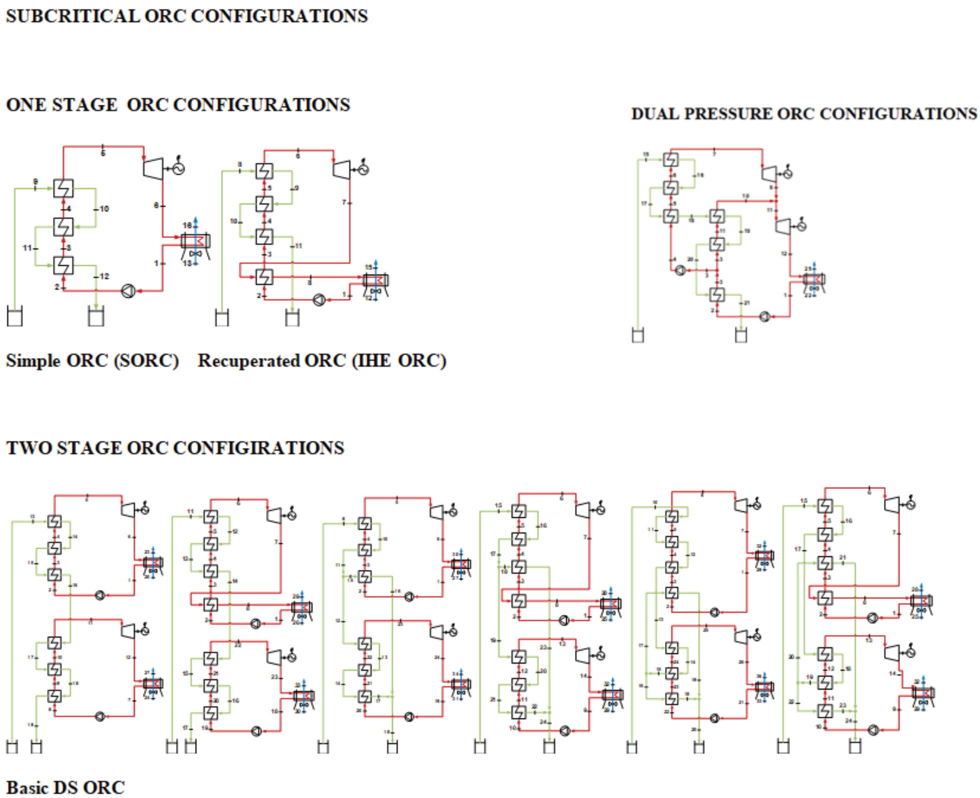


Figure 1: Overview of the possible subcritical ORC configurations

2.3. Selected Working Fluids

Selection the appropriate working fluid represents one of the five main design variables in the design of an ORC plant. Selecting a working fluid is a complex task because it is necessary to select a candidate (or candidates) that meet a number of properties. The stated properties that must be met by working fluids can be classified into various categories: thermodynamic characteristics, characteristics of the working fluid that are process related, technical characteristics, safety characteristics and the impact of the working fluid on the environment. The specified properties that must be met by the working fluid are: Density, Latent heat of vaporization, Liquid heat capacity, Viscosity, Thermal conductivity, Melting point temperature, Critical temperature, Efficiency, Maximum operation pressure, Critical pressure, Availability and cost, Vapour curve (isentropic, wet and dry working fluids), Thermal stability, Compatible with lubricating oil, Material capability, Condensing pressure, Toxicity, Flammability, Ozone depletion potential (ODP), Global warming potential (GWP).

Selected working fluids are listed in Table 2, where their thermodynamic characteristics, environmental characteristics and safety characteristics are shown. The mentioned working fluids were selected on the basis of several criteria. Some of them were chosen because of their good thermodynamic characteristics, which they realized in a large number of previous studies, while others were chosen because of their good environmental properties. Some of the working fluids are often used in practice, while the practical use of other working fluids is still under consideration.

Table 2: Selected working fluids and their characteristics (CR – critical point, ODP - ozone depletion potential, GWP - global warming potential, $T_{geo,max}$ – maximum geothermal temperature, $\Delta T_{crit,max} = T_{geo,max} - T_{cr}$)

Name	P_{cr} (bar)	T_{cr} (°C)	Safety group	ODP	GWP	Type	$T_{geo,max}$ (°C)	$\Delta T_{crit,max}$ (°C)
Cyclopentane	45,71	238,6	A3	0	11	dry	374,4	135,8
n-Pentane (R601)	33,64	196,5	A3	0	20	dry	316,6	120,1
Isopentane (R601a)	33,70	187,2	A3	0	20	dry	299,5	112,3
R245fa	36,51	154,0	B1	0	1050	isentropic	201,3	47,3
n-Butane (R600)	37,96	152,0	A3	0	3	dry	200,1	48,1
R236ea	34,29	139,3	-	0	1410	isentropic	183,4	44,1
isobutane (R600a)	36,40	134,7	A3	-	0	dry	181,3	46,6
R236fa	32,00	124,9	A1	0	9810	dry	168,8	43,9
RC318	27,78	115,2	A1	-	10300	dry	153,2	38,0
R1234ze(E)	36,32	109,4	A2L	-	6	isentropic	156,5	47,1
R227ea	29,25	101,8	A1	0	3220	dry	142,2	40,4
R134a	40,59	101,0	A1	0	1430	isentropic	156,2	55,2
Propane (R290)	42,47	96,68	A3	-	0	wet	150,6	53,9
R1234yf	33,82	94,70	A2L	0	4,4	dry	139,3	44,6
Propylene (R1270)	46,65	92,42	A3	-	1,8	wet	151,8	59,4
R143a	37,61	72,70	A2	0	4470	wet	121,8	49,1

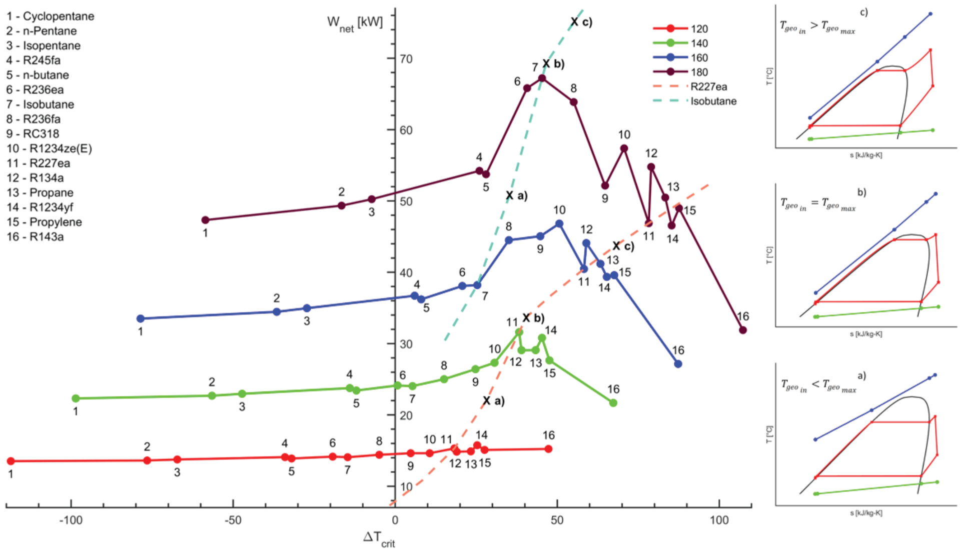


Figure 2: Net power output (W_{NET}) for SORC configuration at given temperatures of the geothermal fluid depending on ΔT_{crit}

3. RESULTS AND DISCUSSION

In this article a part of the complex methodology that describes the use of the thermodynamic optimization method for the case of a simple ORC (SORC) configuration will be presented. The aforementioned method of thermodynamic optimization are an integral part of the complex methodology within the framework of the pre-feasibility study for geothermal power plants based on the Organic Rankine Cycle (ORC). The aim of the mentioned research is to find the most suitable working fluids, for the case of SORC configuration, as well as their plants operation parameters, which ensure maximum net power output (W_{NET}) for different temperatures of geothermal sources (120 ºC, 140 ºC, 160 ºC, and 180 ºC). In the specific case of the pre-feasibility study of the ORC plant, thermodynamic optimization is carried out for a certain temperature of the geothermal fluid, but for several pre-selected ORC configurations. Subsequent analysis determines the best solutions. In thermodynamic optimization the objective function is net power output (W_{NET}) and independent variables are selected plant operation parameters. In our case, cycle maximal pressure (P_{max}) and superheating temperature difference (ΔT_{SH}) were selected.

After the thermodynamic optimization, the techno-economic optimization of the ORC plant configurations is carried out, which is two-stage and with the use of optimization methods with two objective functions in second stage. Due to the extensiveness of the matter, in this paper techno-economic optimization will not be considered.

The results of thermodynamic optimization obtained for simple Organic Rankine Cycle (SORC) are shown in Figure 2., where the abscissa shows the values of ΔT_{crit}, which represents the difference between the geothermal fluid inlet temperature and the critical temperature of the working fluid ($\Delta T_{crit} = T_{geo,in} - T_{,crit}$), and the values of the net power (W_{NET}) are shown on the ordinate. When the value of ΔT_{crit} reaches a value of approx.

25°C to 50°C, the highest values of net power output (W_{NET}) are realized with different working fluids. For example, the highest net power output (W_{NET}) values at 120 °C, 140 °C, 160 °C and 180 °C inlet temperature of the geothermal fluid are achieved by the working fluids R1234yf, R227ea, R1234ze(E) and Isobutane in the amount of 15.57 kW, 31.6 kW, 46.82 kW and 67.21 kW. It can be concluded from the above information that for simple Organic Rankine Cycle (SORC) the maximum net power output (W_{NET}) value for the given working fluid is achieved at a certain temperature of the geothermal fluid, which is higher than its critical temperature by a corresponding amount ΔT_{crit}. Figure 2. also shows the change in net power output (W_{NET}) as a function of the corresponding geothermal fluid temperature. In general, as the temperature of the geothermal fluid increases, so does the value of the realized net power output (W_{NET}). At a certain value of inlet geothermal fluid temperature ($T_{geo,in}$), the outlet temperature of the geothermal fluid achieves a minimal temperature difference (for example 9°C) with the inlet temperature of the working fluid in the preheater, which means that the temperature pinch point has shifted from the inlet of the evaporator to the inlet of the preheater. This value of the geothermal fluid inlet temperature is called the maximum temperature ($T_{geo,max}$). When the inlet geothermal fluid temperature ($T_{geo,in}$) becomes equal to the maximum temperature ($T_{geo,max}$) then net power output (W_{NET}) value is realized which, in comparison with other working fluids, at the same inlet geothermal fluid temperatures, is among the highest (if not the highest). This fact is strictly true for dry and isentropic working fluids. The value of maximum temperature ($T_{geo,max}$) depends on the thermodynamic characteristics of the working fluid, his (subcritical) maximum pressure, the evaporator temperature pinch point and the superheating temperature difference. The maximum temperature ($T_{geo,max}$) values are given for each considered working fluid in a separate column in Table 2

4. CONCLUSION

By analysing the results obtained by thermodynamic optimization of the SORC configuration, it can be concluded that the working fluids achieve the best values of net work (W_{NET}) at a certain values of the input temperatures of the geothermal fluid ($T_{geo,max}$). The previous analysis determined that maximum temperature ($T_{geo,max}$) is an important parameter for working fluid selection process based on thermodynamic characteristics.

REFERENCES

[1] Imran M, Usman M, Park B-S, Yang Y. Comparative assessment of Organic Rankine Cycle integration for low temperature geothermal heat source applications. Energy 2016;102:473–90. https://doi.org/10.1016/j.energy.2016.02.119.

[2] J. Vivian, G. Manente and A. Lazzaretto, "A general framework to select working fluid and configuration of ORCs for low-to-medium temperature heat sources," *Applied Energy,* vol. 156, pp. 727-746, 2015.

[3] M. Astolfi, M. C. Romano, P. Bombarda and E. Macchi, "Binary ORC (Organic Rankine Cycles) power plants for the exploitation of medium-low temperature geothermal sources—Part A: Thermodynamic optimization," Energy, vol. 66, pp. 423-434, 2014

[4] Xu J, Yu C. Critical temperature criterion for selection of working fluids for subcritical pressure Organic Rankine cycles. Energy 2014;74:719–33. https://doi.org/10.1016/j.energy.2014.07.038.

[5] Zare V. A comparative exergoeconomic analysis of different ORC configurations for binary geothermal power plants. Energy Convers Manag 2015;105:127–38. https://doi.org/10.1016/j.enconman.2015.07.073.

[6] S. Lecompte, H. Huisseune, M. v. d. Broek, B. Vanslambrouck and M. D. Paepe, "Review of organic Rankine cycle (ORC) architectures for waste heat recovery," *Renewable and Sustainable Energy Reviews,* vol. 47, pp. 448-461, 2015.

[7] Walraven D, Laenen B, D'haeseleer W. Economic system optimization of air-cooled organic Rankine cycles powered by low-temperature geothermal heat sources, Energy 2015;80:104–13. https://doi.org/10.1016/j.energy.2014.11.048.

[8] Usman M, Imran M, Yang Y, Lee DH, Park B-S. Thermo-economic comparison of air-cooled and cooling tower based Organic Rankine Cycle (ORC) with R245fa and R1233zde as candidate working fluids for different geographical climate conditions. Energy 2017;123:353–66. https://doi.org/10.1016/J.ENERGY.2017.01. 134.

[9] Alshammari F., Usman M., Pesyridis A.: Expanders for Organic Rankine Cycle Technology, In book: Organic Rankine Cycle Technology for Heat Recovery, DOI: 10.5772/intechopen.78720

[10] Borsukiewicz-Gozdur A. Pumping work in the organic Rankine cycle. Appl Therm Eng 2013;51:781–6. https://doi.org/10.1016/j.applthermaleng.2012.10.033.

[11] Quoilin S, Aumann R, Grill A, Schuster A, Lemort V, Spliethoff H. Dynamic modeling and optimal control strategy of waste heat recovery Organic Rankine Cycles. Appl Energy 2011;88:2183–90. https://doi.org/10.1016/j.apenergy.2011. 01.015.

[12] Casella F. Dynamic modeling and control of Organic Rankine Cycle plants. Elsevier Ltd 2016. https://doi.org/10.1016/B978-0-08-100510-1.00006-5.

[13] Usman M, Imran M, Lee DH, Park B-S. Experimental investigation of off-grid organic Rankine cycle control system adapting sliding pressure strategy under proportional integral with feed-forward and compensator. Appl Therm Eng 2017;110:1153–63. https://doi.org/10.1016/j.applthermaleng.2016.09.021.

[14] Mustapić, Nenad; Kralj, Toni; Vujanović, Milan: Split flow principle implementation for advanced subcritical double stage organic rankine cycle configuration for geothermal power production, Energy (Oxford), 303 (2024), 131870-13186. doi: 10.1016/j.energy.2024.131870

OPTIMIZATION AND ANALYSIS OF THE ORGANIC RANKINE CYCLE FOR COMBINED HEAT AND POWER PRODUCTION FROM GEOTHERMAL SOURCES

Nenad Mustapić[1], Toni Kralj[2]
Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, Karlovac, Croatia
[1] nenad.mustapic@vuka.hr
[2] toni.kralj@vuka.hr

Abstract: *With the rise of energy needs and decentralization of power generation, and especially the need for energy production from renewable sources, the use of power plants based on Organic Rankine Cycle is becoming more and more significant. However, this type of power plant wastes a lot of available heat after preheating of the working fluid. With the interest of mitigating wasted heat potential and increasing the overall efficiency of the power plant single stage Organic Rankine Cycle configuration for combined heat and power production is proposed. Geothermal sources considered in the article are low to medium temperature sources between 120°C and 180°C. The methodology includes thermodynamic analysis and optimization of the specified Organic Rankine Cycle configurations for combined heat and power production from geothermal sources.*
Keywords: *Organic Rankine Cycle, geothermal energy, combined heat and power, split flow principle*

1. INTRODUCTION

To meet current and future demands for heat energy from limited resources of renewable energy sources, district heating systems (DHS) play an important role in measures to increase energy efficiency. District heating systems (DHS) consists of a network of pipelines that supply thermal energy to buildings in certain urban zones, which can be of different sizes from a neighbourhood to an entire city. Thermal energy can be produced in a centralized plant, or in a number of decentralized units. The most energy-efficient way of producing thermal energy is the use of a wide range of combined heat and power (CHP) systems, especially those that use renewable energy sources. For this reason, geothermal CHP ORC plants have been extensively studied in the scientific literature. Wieland et al. [1] described six state-of-the-art CHP ORC configurations. Basic CHP ORC configurations are series, parallel [2,3] and series/parallel [4]. The series/parallel CHP ORC configuration combines the good properties of the parallel configuration, which enables high supply temperatures in the DHS, and the series configuration, which allows high utilisation of the heat source. The condensing CHP ORC configuration [5] is suitable for high-temperature heat sources, while the series/condensing configuration combines the advantages of both individual configurations. In addition to the basic CHP ORC configurations, a new configurations have been proposed in the open scientific literature [6,7], which under certain conditions achieve better characteristics than the mentioned basic configurations.

Future sustainable energy systems will be exclusively based on renewable energy sources, among which geothermal energy plays an increasingly important role. One of the main features of future sustainable energy systems is increasing energy efficiency, where District Heating Systems will have an important role. In EU Commission strategy for competitive, sustainable and secure energy [8] emphasize the need for high efficiency cogeneration, district heating and cooling systems and promotion of smart heating and cooling grids. Today's district heating (DH) systems are considered 3rd generation and will have to go through significant changes to meet the demands of low energy buildings and smart energy systems integration. Modern district heating systems are called low temperature district heating (LTDH) systems, or 4th Generation District Heating Systems (4GDH) [9].

The main task of this work is to determine how much heat can be delivered to the district heating (DH) and low temperature district heating (LTDH) systems from the ORC with implemented geothermal fluid split flow principle, assuming the maximum production of net power (W_{NET}), for the geothermal heat source from between 120°C and 180°C and sixteen selected working fluids.

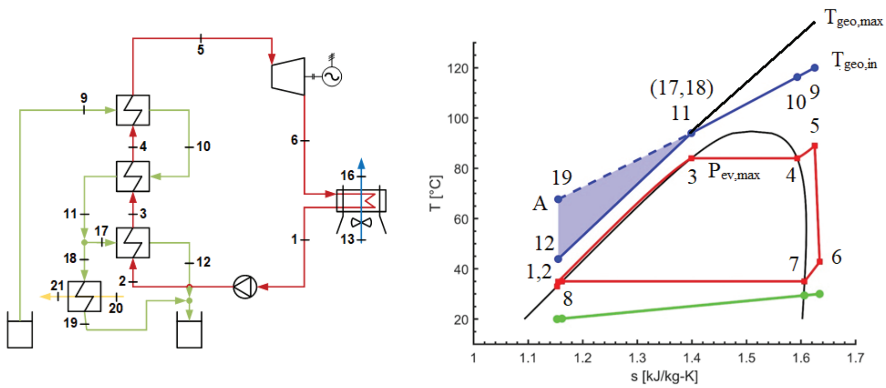


Figure 1: Thermodynamic scheme of the proposed CHP ORC configuration with geothermal fluid split flows (a), and representation of the compressed cycle in the Ts-diagram (b)

2. METHODOLOGY

2.1. Systems Description

Thermodynamic scheme of the proposed combined heat and power organic Rankine cycle (CHP ORC) configuration with geothermal fluid split flows are represented in Figure 1(a), and representation proposed CHP ORC configuration in the Ts-diagram is in Figure 1(b). Geothermal energy is used for preheat, evaporate and superheat the working fluid in the ORC plant. The produced superheated working fluid vapor goes to the turbine, where the energy taken from the working fluid is converted into mechanical work, which is converted into electrical energy in the electric generator. After the turbine, the working fluid is desuperheated, condensed and subcooled in the condenser using air in the air-cooled condenser. The subcooled working fluid goes to the pump where it is compressed to the working pressure. After the geothermal fluid transfers heat energy to the working fluid in the cycle, it is reinjected in the geothermal well.

After the geothermal fluid exits the evaporator, it is possible to use a split flow strategy and divide the geothermal fluid flow into two parts, one of which is used for preheat the working fluid in the preheater, while the other flow of geothermal fluid can be used for production of heat flow for district heating (DH) or low temperature district heating (LTDH). The geothermal fluid flow used to preheat the working fluid in the preheater should be minimal, which has the consequence that pinch point temperature difference (between the geothermal fluid and the working fluid) is formed at the entrance to the preheater (9 °C in our case).

2.2. Thermodynamic System Models and Assumptions

Each component in the ORC configuration is defined as a control volume, for which thermodynamic expressions are defined in accordance with the mass conservation principle and first law of the thermodynamics. For CHP ORC configurations subcooling in the condenser and superheating of working fluid are provided, which describe more realistic plant work. During optimization routine design variables, or independent variables, are determined. In order to make this possible, assumed constant values of fixed variables, or model parameters, must be included in the thermodynamic model. Model parameters, assumptions and their selected values are in accordance with the values that are common in the scientific literature [10].

2.3. Selected Working Fluids

Selection the appropriate working fluid represents one of the most important actions during the design of an CHP ORC plant. Nowadays, in addition to good thermodynamic characteristics, working fluids must also have good environmental characteristics. Ozone depletion potential (ODP) and global warming potential (GWP) are most often used as environmental factors. Therefore, it is desirable that the selected working fluid has zero ODP and a low GWP value (lower than 150), but also very good thermodynamic characteristics. Between selected working fluids, two working fluids are Hydrofluoroolefins (R1234yf and R1234ze(E)), five working fluids belong to Hydrochlorofluorocarbon refrigerants (R245fa, R236fa, R227ea, R134a and 143a), RC318 is Perfluorocarbon, while the rest are Hydrocarbons (cyclopentane, isopentane (R601a), n-pentane (R601), n-butane (R600), isobutane (R600a), propane (R290) and propylene (R1270)).

3. RESULTS AND DISCUSSION

The combined production of heat and power (CHP) can be characterized by CHP ORC plant (system) efficiency and can be expressed using the expression:

$$\eta_{CHP,\frac{DH}{LTDH}} = \frac{W_{NET} + Q_{\frac{DH}{LTDH}}}{Q_{AV}} \tag{1}$$

where W_{NET} is the produced net power, $Q_{DH/LTDH}$ represents the produced heat for district heating (DH) or low temperature district heating (LTDH), while Q_{AV} represents the available heat that can be processed in the plant. Another thermodynamic parameter that characterizes CHP ORC production is CHP coefficient is defined as the ratio between net power and produced heat for district heating (DH) or low temperature district heating (LTDH) and can be expressed by the equation:

$$\sigma_{DH/LTDH} = \frac{W_{NET}}{Q_{DH/LTDH}} \tag{2}$$

The assumed district heating (DH) supply temperature is 80 °C, while the return temperature is 60 °C. The geofluid transfers the heat flow to the DH system until it cools down to 70 °C, to avoid excessive temperature cross in the heat exchanger. For the LTDH system, a supply temperature of 60 °C is assumed, while the return temperature is 40 °C. The geofluid outlet temperature from the LTDH heat exchanger is 50 °C.

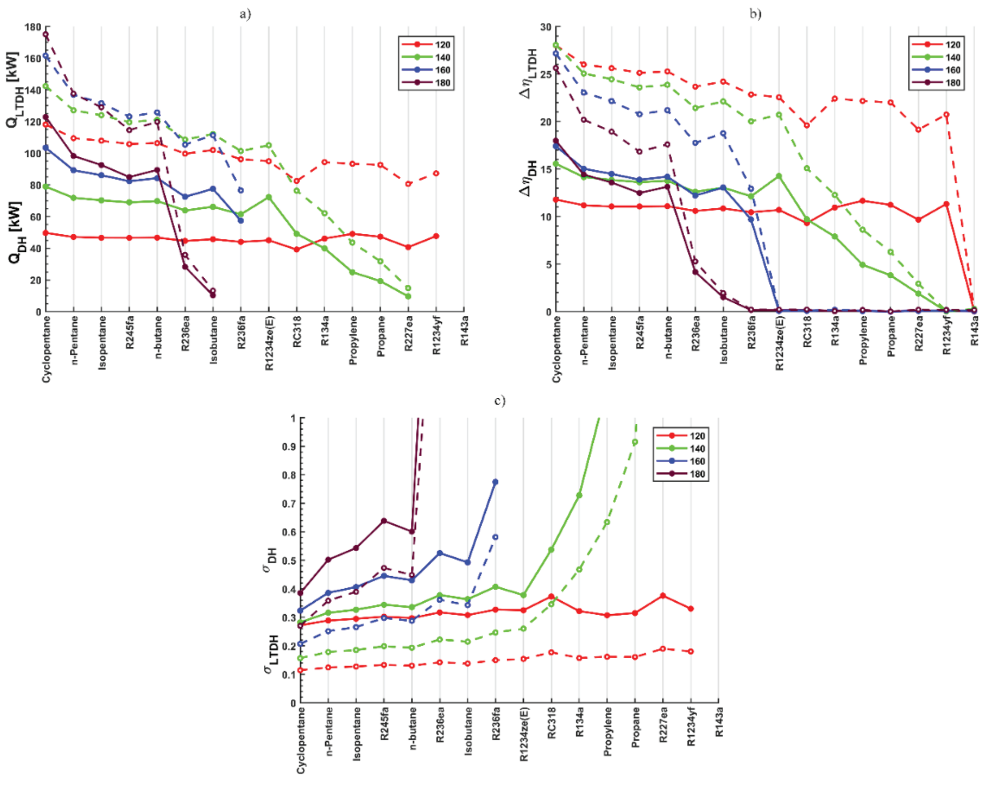


Figure 2: Results for the CHP ORC configuration for different working fluids and characteristic inlet temperatures of the geothermal fluid: a) Q_{DH} and Q_{LTDH}, b) $\Delta\eta_{DH}$ and $\Delta\eta_{LTDH}$, c) σ_{DH} *and* σ_{LTDH}

Figure 2 shows the essential results for the CHP ORC configuration for different working fluids and characteristic temperatures of the geothermal fluid. It should be noted that on the pictures, the working fluids are ordered by size of the $T_{geo,max}$. Figure 2.a) shows the produced heat flows for the needs of district heating (Q_{DH}) and low temperature district heating (Q_{LTDH}). In general, it can be concluded that the produced heat flows are significantly higher for the low temperature district heating (Q_{LTDH}) then for the district heating (Q_{DH}). The main reason for this is lower supply and return temperatures at low temperature district heating (LTDH). Earlier in the analysis, an effect was observed in the CHP ORC configuration that as the temperature of the geothermal fluid inlet temperature approaches $T_{geo,max}$, the share of produced net power in HTS ($W_{NET,HTS}$) in the total produced W_{NET} increases and the amount of heat processed in the ORC increases, and the share of the heat flow (mass flow) which separates for DH and LTDH decreases. This logically results in the reduction of Q_{DH} and Q_{LTDH} production. It can be noticed that value of the Q_{DH} and Q_{LTDH}, with the same value of geothermal fluid, decreases with working fluids that have a lower value of $T_{geo,max}$. For the same working fluid, Q_{DH} and Q_{LTDH} increase with increasing temperature of the geothermal fluid inlet temperature, which is especially visible for the DH. However, in LTDH for the same working fluid, Q_{LTDH} values for different geothermal fluid temperatures are quite similar. As the temperature of the geothermal fluid increases, the mass flow of the geothermal fluid in the LTDH heat exchanger decreases, while the unit heat flow output to LTDH increases. The negative increment of the geothermal fluid flow for LTDH needs is greater, so it is possible that with geothermal fluid temperature rise, the values of Q_{LTDH} stagnate, slightly decrease or increase. A good example is R236ea, which for geothermal fluid temperatures from 120 °C to 160 °C has very similar Q_{LTDH} values. For a geothermal fluid temperature of 120 °C, almost all considered working fluids can achieve Q_{DH} and Q_{LTDH}, except for the working fluid R143a ($T_{gei,in}$ is greater than $T_{geo,max}$). The Q_{DH} values are very similar and range from 39.19 kW/(kg/s) for RC 318, to 49.68 kW/(kg/s) for cyclopentanes. At the same time, RC 318 achieves 14.63 kW/(kg/s) net power output (W_{NET}), and cyclopentane achieves 13.52 kW/(kg/s). The highest amount of net power output (W_{NET}) is achieved by R1234yf with simultaneous district heating heat production of 47.67 kW/(kg/s). As the temperature of the geothermal fluid increases, the number of working fluids that can realize Q_{DH} or Q_{LTDH} is decreased due to the fact that their temperature $T_{geo,\ max}$ is lower than the inlet temperature of the geothermal fluid. The higher the working fluid temperature $T_{geo,max}$ is, the higher value of the Q_{DH} and Q_{LTDH} can be realized.

Figure 2.b) shows the values of $\Delta\eta_{DH}$ and $\Delta\eta_{LTDH}$, which represent the difference (in %) between CHP plant (system) efficiency and plant (system) efficiency without production of heat flows Q_{DH} or Q_{LTDH}. The general conclusion is that the introduction of combined heat and power (CHP) increases the energy efficiency of the plant. The effect is greater in LTDH, where plant (system) efficiency can be increased up to 18%. When DH is analyzed, the results are more modest, so that the plant (system) efficiency usually increases from 5% to 8% depending on the working fluid and the temperature of the geothermal fluid. In general, it can be concluded that considered CHP ORC configuration is more suitable for combined heat and power production in the LTDH system, where a higher heat flow, more favorable CHP coefficient values and higher CHP plant (system) efficiency are realized than in the DH system.

The CHP coefficient values for district heating and low temperature district heating (σ_{DH} *and* σ_{LTDH}), for different geothermal fluid inlet temperatures and considered working fluids, are shown in Figure 2.c). CHP coefficient values are better for LTDH than for DH. The smaller the value of the CHP coefficient is, it means that for a certain value of W_{NET}, a larger share of heat is produced for DH or LTDH. For DH and LTDH, the lower the temperature of the geothermal fluid is, the lower is the CHP coefficient. The explanation is the same as that given for Q_{LTDH} and Q_{DH}. In the case of DH, the CHP coefficient values (σ_{DH}) are greater than one (sometimes greater than 2), which means that W_{NET} is greater than the produced heat flow Q_{DH}.

4. CONCLUSION

From a thermodynamic, economic, but also ecological point of view, geothermal organic Rankine cycle (ORC) plants should primarily be designed in such a way that simultaneously with the production of electricity produce thermal energy that is distributed in district heating or in the future in low temperature district heating systems. That is reason why optimal combined heat and power organic Rankine cycle (CHP ORC) design is attracting increased interest from experts and scientists.

After performed thermodynamic analysis, it can be concluded that the proposed CHP ORC configuration is more suitable for combined heat and power production in the LTDH system, where a higher heat flow, more favorable CHP coefficient values and higher CHP plant (system) efficiency are realized than in the DH system.

REFERENCES

[1] Christoph Wieland, Dominik Meinel, Sebastian Eyerer, Hartmut Spliethoff: Innovative CHP concept for ORC and its benefit compared to conventional concepts, Applied Energy 183 (2016) 478–490

[2] Sarah Van Erdeweghe, Johan Van Bael, Ben Laenen, William D'haeseleer: Comparison of series/parallel configuration for a low-T geothermal CHP plant, coupled to thermal networks, Renewable 2017,111, 494-505.

[3] Florian Heberle, Dieter Brüggemann: Exergy based fluid selection for a geothermal Organic Rankine Cycle for combined heat and power generation, Applied Thermal Engineering 30 (2010) 1326-1332

[4] Muhsen Habka , Salman Ajib: Determination and evaluation of the operation characteristics for two configurations of combined heat and power systems depending on the heating plant parameters in low-temperature geothermal applications, Energy Conversion and Management 76 (2013) 996–1008

[5] Teng, S.; Feng, Y.-Q.; Hung, T.-C.; Xi, H.: Multi-Objective Optimization and Fluid Selection of Different Cogeneration of Heat and Power Systems Based on Organic Rankine Cycle. Energies 2021, 14, 4967.

[6] Daniele Fiaschi , Adi Lifshitz, Giampaolo Manfrida, Duccio Tempesti: An innovative ORC power plant layout for heat and power generation from medium- to low-temperature geothermal resources, Energy Conversion and Management 88 (2014) 883–893

[7] Muhsen Habka, Salman Ajib:Investigation of novel, hybrid, geothermal-energized cogeneration plants based on organic Rankine cycle, Energy, Vol. 70, 2014, 212-222

[8] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM (2010) 639 final, Energy 2020 - a strategy for competitive, sustainable and secure energy, Luxembourg, Publications Office of the European Union, 2011

[9] Henrik Lund, Sven Werner, Robin Wiltshire, Svend Svendsen, Jan Eric Thorsen, Frede Hvelplund, Brian Vad Mathiesen: 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems, Energy, 68, 1-11, 2014

[10] G. Manente, A. Lazzaretto and E. Bonamico, "Design guidelines for the choice between single and dual pressure layouts in organic Rankine cycle (ORC) systems," Energy, vol. 123, pp. 413-431, 2017..

7

FIRE AND EXPLOSION PROTECTION

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

RANKING OF VEHICLE FIRE RISK BASED ON HARMFUL GAS EMISSIONS

Dario Javor[1]; Dejan Krstić[2]; Nebojša Raičević[3]

[1,2] University of Niš, Faculty of Occupational Safety, Čarnojevića 10a, 18000 Niš, SERBIA, e-mail: dario.javor@znrfak.ni.ac.rs , dejan.krstic@znrfak.ni.ac.rs

[3] University of Niš, Faculty of Electronic Engineering, A. Medvedeva 14, 18000 Niš, SERBIA, e-mail: nebojsa.raicevic@elfak.ni.ac.rs

Abstract: *The risk of fire of electric vehicles (EVs) and internal combustion engine vehicles (ICEVs) can be ranked using multi-criteria decision-making methods based on harmful gas emissions and fire parameters such as: explosiveness, specific energy, toxicity of released substances, heavy metals, other combustion products, etc. The Best-Worst Method (BWM) as a weighting method, and afterwards the PROMETHEE method (Preference Ranking Organization METHod for Enrichment of Evaluations) as a multi-criteria optimization method, are used in this paper to rank the fire risks of four different types of vehicles based on experimentally measured emissions of harmful gases (CO_2, CO, THC, NO, NO_2, HF, HCl, HCN) during vehicle combustion.*

Keywords: *vehicle fire risk, multi-criteria optimization methods, harmful gas emissions*

1. INTRODUCTION

The risk of fire due to self-ignition of batteries in electric vehicles exists and it is additionally increased if the batteries are subjected to external influences: thermal, mechanical and electrical, which are especially present in extreme working conditions and in case of traffic accidents [1], [2]. Unlike lithium-ion batteries used in most portable electronic devices which usually do not have extreme working conditions during exploitation, in the case of electric vehicles, batteries suffer constant and rapid changes due to acceleration and deceleration in complex driving conditions in city traffic, as well as on the road [3]. The capacities of batteries in electric vehicles are thousands of times higher than in portable devices, so the risk of fire is significantly higher and therefore safety measures are more advanced. A battery health monitoring system (BMS) monitors temperature and voltage to maintain optimal conditions. It is necessary to ensure proper distribution of electricity and voltage and to provide cooling. In the event of a failure in the BMS, batteries may overheat, burst, throw sparks, release flammable gases and toxic fumes, which can further lead to ignition and fire, throwing flames and gas explosions [4].

Typical electric vehicle fires include: spontaneous combustion fires, fires during charging [5], traffic accident fires, re-ignition fires, and external factor fires. A particular danger is the spread of electric vehicle fires in closed spaces [6] such as tunnels and multi-vehicle parking garages.

Multi-criteria optimization methods can be applied to determine the hazard of vehicle fire from the point of view of protecting people and the environment, if experimental data are known for different types and models of vehicles. The measurements usually include harmful gases, toxic metals and compounds, and hazardous substances in smoke, soot and ash from fire. This paper presents the results of the application of the BWM (Best-Worst Method) [7], [8] and the PROMETHEE (Preference Ranking Organization METHod for Enrichment of Evaluations) [9], [10] in the case of fires of ICEV (internal combustion engine vehicle) and BEV (battery electric vehicle).

2. PROBLEM FORMULATION

Batteries work best at temperatures between 20 and 30 °C. Extremely high and extremely low temperatures affect battery performance. Long-term use of an EV in extreme temperatures reduces the life of the batteries. In conditions of high temperatures, unwanted chemical reactions take place in the batteries, so if the ability of thermal dissipation is reduced, it can result in overheating, ignition of the batteries and fire of the electric vehicle.

At low temperatures, the internal resistance of batteries is increased, which leads to metal deposition and heating effects inside the batteries. It can also cause batteries to catch fire. Overheating of the battery, that is, an increase in temperature by more than 10 °C/min, occurs due to violent exothermic thermochemical and electrochemical chain reactions that exceed cooling capabilities. The risk of thermal breakdown occurs when the battery temperature exceeds about 150 °C. As processes take place within individual cells, the risk of fire increases if overheating spreads throughout the battery. After overheating, a large amount of smoke is released through the safety valve or cracks in the battery case [11]. This smoke consists of a mixture of flammable and toxic gases, such as hydrogen fluoride (HF), hydrogen cyanide (HCN), carbon monoxide (CO), etc. Inhaling these gases can be very dangerous and cause fainting, headache, coma and even death. Fluorides as ingredients in lithium-ion batteries can form phosphorus oxyfluoride (POF_3), which can be even more toxic than hydrogen fluoride.

Gas emissions vary by manufacturer and battery type. The investigation found that HF concentrations were higher in lithium-iron-phosphate (LFP) cells than in lithium-nickel-manganese-cobalt (LNMC) or lithium-manganese-oxide (LMO) cells, which emitted more gas in a shorter time, while the total amount of HF released was approximately the same [12]. It is considered that the total amount released during an electric vehicle fire is about two times higher than that measured during an ICEV fire test [13]. By testing the fire of two ICEVs and two BEVs (Fig. 1), the emissions of combustion products were measured [14], and the presence of various metals in the soot was also established, such as: aluminum (Al), cadmium (Cd), lead (Pb), cobalt (Co), chromium (Cr), copper (Cu), lithium (Li), manganese (Mn), nickel (Ni), zinc (Zn), as well as organic compounds of polycyclic aromatic hydrocarbons (PAHs) and water-soluble anions: fluoride (F–), chloride (Cl–) and bromide (Br–), present in soot and ash. The measured amounts of toxic gases (CO_2, CO, total hydrocarbons (THC), NO, NO_2, HF, HCl, HCN) are given in Table 1. Since the data for THC refers to a mixture of hydrocarbons, this effect is not considered in this paper.

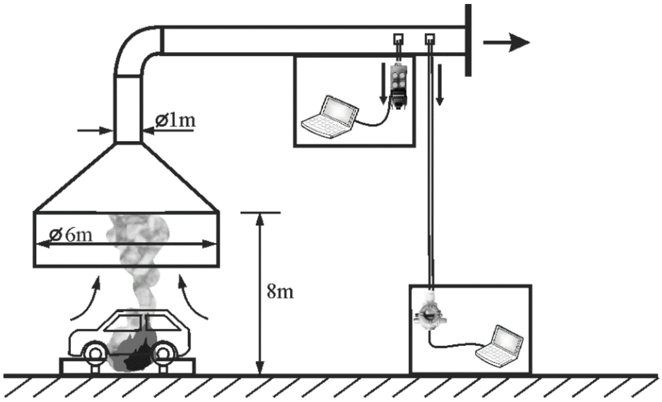


Figure 1: Test setup for vehicle fire

Table 1: Emissions of toxic gases during vehicle fire testing

Type of vehicle	CO_2 [kg]	CO [kg]	THC [kg]	NO [g]	NO_2 [g]	HF [g]	HCl [g]	HCN [g]
ICEV1	508	12.0	2.4	679	307	621	1990	167
BEV1	460	10.4	2.4	500	198	1540	2060	113
ICEV2	723	15.7	2.9	740	410	813	2140	178
BEV2	618	11.7	2.7	770	349	1470	1930	148

Table 2: Parameters of toxic gases

	CO_2	CO	NO	NO_2	HF	HCl	HCN
Molecular weight W_{mol} [g/mol]	44.01	28.01	30.01	46.01	20.01	36.46	27.03
Concentration C_g [mg/m^3]	72 000.36	1 374.73	122.74	37.63	24.55	74.56	55.27
Average weight of comb. product per vehicle [g]	577 250	12 450	672.25	316	1 111	2 030	151.50
IDHL [ppm]	40 000	1 200	100	20	30	50	50
Rate of toxicity per vehicle fire	14.43	10.38	6.72	15.80	37.03	40.60	3.03
Criterion grade	5	6	8	4	2	1	9

Criteria grades (Table 2) are used for the ranking of fire hazard. Each criterion grade is estimated based on the rate of toxicity per vehicle fire. Rate of toxicity is calculated as the ratio of average weight of combustion product per vehicle fire (calculated from data given in Table 1) and concentration C_g calculated as:

$$C_g = 0.0409 \cdot C_{ppm} \cdot W_{mol}, \tag{1}$$

for IDHL (Immediately dangerous to life or health air values concentration) equal to C_{ppm}. Values of IDHL are taken from [15].

3. RANKING OF VEHICLE FIRES HAZARD BY USING BWM AND PROMETHEE METHOD

BWM is the subjective weighting method used in this paper for determining the weight coefficients based on criteria grades. There are seven criteria for ranking of vehicle fires hazard: CO_2, CO, NO, NO_2, HF, HCl and HCN. These are the harmful gases which are released and measured during BEV and ICEV fires tests. The most important criterion is HCl due to its toxicity and this combustion product weight. It is marked as “the best” with a grade of 1. The least important criterion is HCN, marked as “the worst” with a grade of 9. Other criteria grades are also given in Table 2.

Based on these grades, BWM method is applied [16]. The results for the criteria weight coefficients are: 9.37 % for CO_2, 7.81 % for CO, 5.86 % for NO, 11.71 % for NO_2, 23.42 % for HF, 38.48 % for HCl and 3.35 % for HCN, as given in Fig. 2.

Four vehicle fires hazards are ranked in this paper by using PROMETHEE as the multi-criteria decision making method. Two ICEVs and two BEVs are the alternatives for this problem. Based on the seven criteria and weight coefficients obtained by BWM, the rank is determined and presented in Fig. 3 a). Fire of ICEV2 is the most hazardous, followed by BEV1, BEV2 and ICEV1. The reason for this is grater toxicity of all the gases released during ICEV2 fire except for the gas HF. Complete PROMETHEE II ranking and the net flows of the four vehicle fires are given in Fig. 3 a). The net flows are calculated from the positive and negative flows, for each of four alternatives. Fig. 3 b) shows PROMETHEE rainbow for the vehicle fires. HF is the most critical criterion in the case of BEVs if compared to ICEVs, which can be noticed in Fig. 3 b).

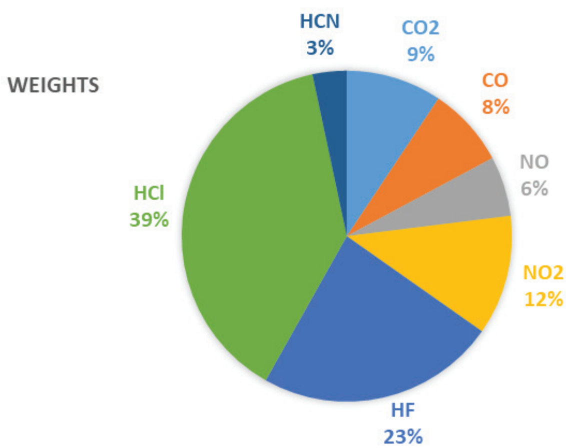


Figure 2: Weight coefficients obtained by BWM

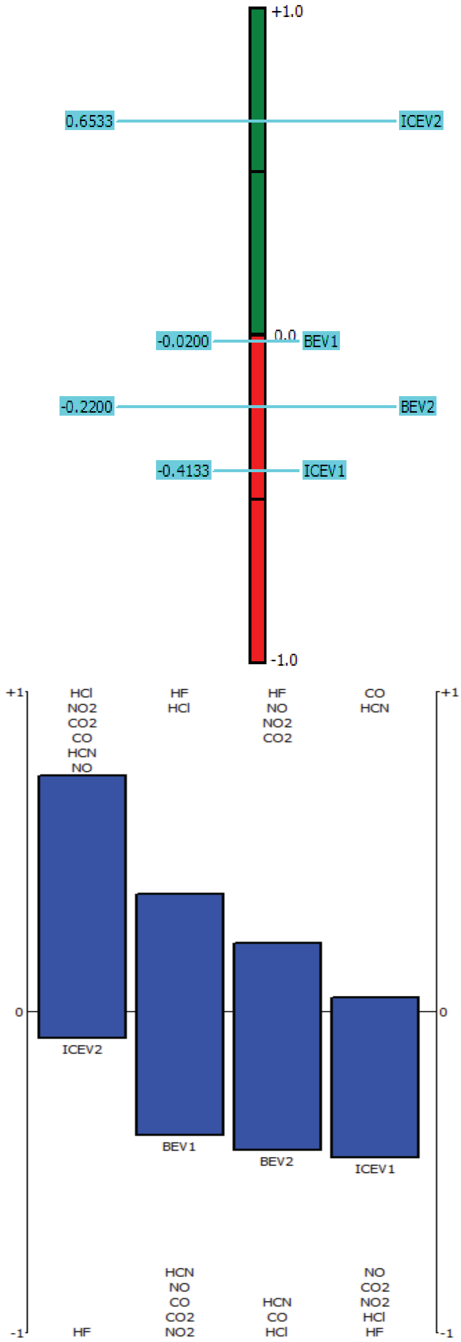


Figure 3: a) Complete PROMETHEE II ranking and the net flows of the four vehicle fires b) PROMETHEE rainbow for the vehicle fires

4. CONCLUSION

Ranking of vehicle fires hazard presented in this paper is based on toxicity, combustion products weights and concentrations of gases dangerous to life or health. Results of four vehicle fire tests are used to present the procedure using BWM and PROMETHEE methods and the seven gases are considered. The most hazardous vehicle fire is of one of the two ICEVs, but the analysis shows that HF is the most dangerous gas in the case of BEVs fires.

ACKNOWLEDGEMENT

This research is financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, according to the contract No. 451-03-66/2024-03/ 200148.

REFERENCES

[1] Liu, Y.; Sun, P.; Niu, H. & Huang, X.: Propensity to self-heating ignition of open-circuit pouch Lithium-ion battery pile on a hot boundary, *Fire Safety Journal*, (2020), doi:10.1016/j.firesaf.2020.103081

[2] He, X.; Restuccia, F.; Zhang, Y.; Hu, Z.; Huang, X. & Fang, J.: Experimental study of self-heating ignition of lithium-ion batteries during storage and transport: effect of the number of cells, *Fire Technology*, (2019)

[3] Javor, D.: *Multicriteria optimization of the microgrid using V2G technology*, Doctoral Dissertation, Faculty of Electronic Engineering, Niš, (2024)

[4] Lecocq, A.; Eshetu, G. G.; Grugeon, S.; Martin, N.; Laruelle, S. & Marlair, G.: Scenario-based prediction of Li-ion batteries fire-induced toxicity, *Journal of Power Sources*, Vol. (2016) No. 316, pp. 197-206, doi:10.1016/j.jpowsour.2016.02.090

[5] Javor, D. & Raičević, N.: The Effect of Ambient Temperature on the Costs of Battery Electric Vehicles Charging in the Microgrid, *Proceedings of 21st International Symposium INFOTEH 2022*, pp. 1-4, Jahorina, East Sarajevo, Bosnia and Herzegovina, March 2022, IEEE, (2022), doi: 10.1109/INFOTEH53737.2022.9751270

[6] RISE Report 2023 (42): Electric Vehicle Fire Safety in Enclosed Spaces, *Available from* https://www.diva-portal.org/smash/get/diva2:1744882/FULLTEXT01.pdf *Accessed*: 2023-09-26

[7] Rezaei, J.: Best-worst multi-criteria decision-making method, *Omega*, Vol. (2015) No. 53, pp. 49–57, https://doi.org/10.1016/j.omega.2014.11.009

[8] Rezaei, J.: Best-worst multi-criteria decision-making method: Some properties and a linear model, *Omega*, Vol. (2016) No. 64, pp. 126-130

[9] Brans, J. P.; Mareschal B. & Vincke, Ph.: PROMETHEE: A new family of outranking methods in multicriteria analysis, In *Operational Research*, Brans, J. P., (Ed.), North-Holland, Amsterdam, (1984), pp. 477–490

[10] Brans, J. P. & Mareschal, B.: PROMETHEE methods, In *Multiple Criteria Decision Analysis: State of the Art Surveys*, Figueira, J., Greco, S., Ehrgott, M. (Eds.), Springer Science & Business Media Inc., (2005), pp. 163–196

[11] Larsson, F.: *Lithium-ion Battery Safety-Assessment by Abuse Testing, Fluoride Gas Emissions and Fire Propagation*, Doctoral Dissertation, Chalmers University of Technology, (2017)

[12] Stephens, D.; Stout, P.; Sullivan, G.; Saunders, E.; Risser, J. & Sayre, J.: Lithium-ion Battery Safety Issues for Electric and Plug-in Hybrid Vehicles, *National Highway Traffic Safety Administration*, Report No. DOT HS 812 418, Washington DC, (2019)

[13] Lecocq, A.; Bertana, M.; Truchot, B. & Marlair, G.: Comparison of the fire consequences of an electric vehicle and an internal combustion engine vehicle, *International Conference on Fires in Vehicles - FIVE 2012*, Chicago, United States, Vol. (2012) No. 2, pp. 183–194

[14] Truchot, B.; Fouillen, F. & Collet, S.: An experimental evaluation of the toxic gas emission in case of vehicle fires, *Proceedings of 7th ISTSS 2016*, Montreal, Canada, (2016), pp. 419-429

[15] The National Institute for Occupational Safety and Health (NIOSH), *Available from* https://www.cdc.gov/niosh/idlh/intridl4.html *Accessed*: 2024-04-22

[16] Rezaei, J.: Best Worst Method, *Available from* https://bestworstmethod.com *Accessed*: 2023-07-07

[17] Mareschal, B.: Visual PROMETHEE, *Available from* http://en.promethee-gaia.net *Accessed*: 2022-08-12

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

RESEARCH ON THE EXPERIENCE AND QUALIFICATIONS OF FIREFIGHTERS FOR INTERVENTIONS IN ELECTRIC AND HYBRID VEHICLES

Danijel Knežević[1], Manuela Žakula[2], Damir Kralj[2]

[1] Student of Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, danijel.knezevic@student.vuka.hr

[2] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, HR-47000 Karlovac, manuela.zakula@vuka.hr & damir.kralj@vuka.hr

Abstract: *Firefighting interventions on electric vehicles are becoming a key topic for firefighters and traffic experts. The paper explores the attitudes and experiences of firefighters concerning electric vehicle interventions to understand key challenges and recommendations for future approaches. Specific issues of safety, technology, and firefighter training related to interventions on electric vehicles are analyzed. The goal is to question the attitudes and skills of firefighters in the Republic of Croatia in working with electric vehicles. The research confirmed that most firefighters did not participate in training for working with electric vehicles and rarely participated in interventions on them. However, most firefighters feel that training in electric vehicle interventions would be beneficial for the future. Also, firefighters from Public Fire Departments use applications to assist with technical interventions more often and have received training for working with electric vehicles more often than firefighters from Voluntary Fire Brigades. Through the results of the research, the need for specialized training and tactics for interventions on electric vehicles was highlighted. Although the lack of experience is evident, Croatian firefighters are ready to learn and adapt to new technologies to ensure the safety and efficiency of interventions in the future.*

Keywords: *research, firefighters, electric vehicles, technical interventions, experience and qualifications.*

1. INTRODUCTION

In today's rapidly changing traffic environment, with the increasing use of electric vehicles as an alternative option to conventional internal combustion vehicles, new issues are emerging that require attention and analysis. Firefighting interventions on electric vehicles are becoming a key topic, both for professional firefighters and for traffic and safety experts. With the increasing number of electric vehicles on the road, it is important to understand the specific challenges that such vehicles bring in emergencies. The research presented in this paper investigates the attitudes and experiences of firefighters concerning fire interventions on electric vehicles to illuminate key aspects, challenges, and recommendations for future approaches. Through the analysis of research results and comparison with existing literature, this paper aims to provide a deeper understanding of this important topic and point out the practical implications for firefighters and traffic experts. When designing this research, we were guided by the idea of how to contribute to the Croatian fire service and our personal growth and development. There are several key reasons for choosing this topic. The first reason is certainly its topicality. Electric vehicles are becoming more and more present in traffic, and with them come specific challenges, including safety and accident interventions. Furthermore, in terms of safety and technological progress, electric vehicles use different technologies and components compared to conventional vehicles. The work explores the potential and possibilities of firefighting interventions concerning differences in the field in terms of safety, access, and application of techniques for interventions on electric vehicles. Interventions with electric vehicles require special training and knowledge of firefighters. The paper also investigates the specific components and risks that firefighters face during these interventions and the possibilities for their improvement.

This work aims to investigate the experiences and qualifications of firefighters in the Republic of Croatia for interventions in electric and hybrid vehicles. The research methods used in the paper are written sources, online sources, knowledge acquired through firefighting school and study, and my own experiences.

2. METHODOLOGY

Following the aim of the research, the first theoretical research was carried out, which included: an analysis of the specifics and market penetration of electric vehicle technology [1], technology of manufacturing and behavior of batteries [2], problems of vehicle battery charging [3], basic firefighting regulations in the Republic of Croatia [4], manuals [5] and regulations [6, 7] for operational procedures, as well as examples of training courses [8]. According to the knowledge from theoretical research and own experiences from practice, five hypotheses were set: H1 – Most firefighters did not participate in training for working with electric cars; H2 – Most firefighters did not participate in interventions with electric vehicles; H3 – The majority of firefighters believe that training for electric car interventions would be useful; H4 – Firefighters from Public Fire Brigades use applications to help with technical interventions more often than firefighters from Voluntary Fire Brigades; H5 – Firefighters from Public Fire Brigades attended training involving electric vehicles more often than firefighters from Voluntary Fire Brigades.

An electronic survey form was created for the research process in the online service Google Forms. Applicants had to answer 17 questions. The first section related to socio-demographic data on the test population, the second section asked for basic information about firefighting work, then the experience in work and education regarding interventions with electric vehicles was examined, the self-assessment of competence and fear was asked, and the questionnaire ended with attitudes of firefighters about training. The questions are designed as a choice of one of several offered answers. A 5-point Likert scale was used in only 2 questions.

The survey was conducted on July 24 and 25, 2023, electronically. The target population was firefighters from all over the Republic of Croatia. The forms were sent electronically, mainly via e-mail and the Whatsapp platform. The analysis of the answers was carried out using the MS Excel program. Although originally the results were obtained with an accuracy of 10%, in the paper they are presented as whole numbers, which is accurate enough for this type of research. The participants took part in the research completely anonymously and of their own free will, and all responses are considered independent cases.

3. RESULTS

Applicants from 13 Croatian counties responded to the survey. The questionnaire was completed by 116 participants.

3.1. Sociodemographic data

99 (85%) male respondents participated in the research, 16 (14%) female respondents and 1% did not want to declare. In the rest of the paper, a gender-neutral presentation of the results is used.

Most firefighters are in the age group from 21 to 30 years old, a total of 46 of them (48%), followed by the age group from 31 to 40 years old, where a total of 21 respondents (22%) were found. There are 13 (14%) of them aged 41 to 50, and 11 (11%) over 50. The fewest participants belong to the group under the age of 20, a total of 5 of them (5%).

3.2. The respondent's actions within the firefighting profession

Most respondents came from Brodsko-Posavska County, a total of 45, which is 39% of the total number of respondents. The next in terms of the number of respondents is the Osiječko-Baranjska County with 18 (16%) respondents. Sixteen respondents (14%) operate in Zagrebačka County, 9 (8%) in Karlovačka County, and 7 (6%) of them in Virovitičko-Podravska County. 5 (4%) respondents each work in Požeško-Slavonska and Primorsko-Goranska counties. Vukovarsko-Srijemska County had 3 (3%) respondents, and Dubrovačko-Neretvanska County, Koprivničko-Križevačka and Šibensko-Kninska County had 2 (2%) each. One respondent (1%) answered that he operates in Bjelovarsko-Bilogorska and Krapinsko-Zagorska counties.

Firefighters in the Republic of Croatia can work in different institutions and associations. Most often, these are public fire brigades and voluntary fire brigades, which are also reflected in the research results. Most of the respondents work in Public Fire Brigades, a total of 58 of them, which makes up 50% of the respondents. After that, a large part of the respondents work in Voluntary Fire Brigades, a total of 54 of them (47%). Other respondents work in the Central Fire Department, 2 of them (2%), and 1 respondent (1%) each work in the City Fire Department and the Municipal Fire Brigade.

Out of 116 respondents, most of them had up to 5 years of experience, a total of 35 of them (30%). Thirty-one respondents (27%) had work experience of 10 to 20 years. 28 (24%) participated in the category of 5 to 10 years of work experience, and 13 (11%) respondents had 20 to 30 years of experience. Respondents with more than 30 years of work experience participated the least, a total of 9 (8%).

Education for firefighting is based on the principle of lifelong education. It is divided into qualification acquisition and informal education. The acquisition of qualifications is carried out by the State Fire Service School in cooperation with the Croatian Fire Service

Association, following the statute and the law regulating adult education. Out of 116 respondents, a total of 79 of them have obtained a firefighting qualification, which is 68%. 36 respondents (31%) do not have the qualification, and 1 person (1%) is in the process of education.

3.2. Attitudes and experiences of firefighters in technical interventions with an emphasis on electric vehicles

Technical interventions in traffic are very common, especially in fire brigades that cover the highway area. The first question in this group was related to the frequency of automotive technical interventions on an annual basis. Most respondents participate in 1-5 such technical interventions per year, a total of 54 of them, which is 47%. Furthermore, 31 respondents (27%) answered that they participate in 6 to 15 technical car accidents per year. Fifteen respondents (13%) claim that their number of interventions per year is over 15, while 16 respondents (14%) claim that they have never participated in such an intervention.

To the question that reads: "Do you use any of the applications to help with technical interventions (e.g. Euro RESCUE)?", the majority of respondents answered No, a total of 73 of them (63%). 43 respondents answered yes (37%). Of the respondents who answered with 'Yes', 81% are members of the Public Fire Brigade, while only 8 respondents are from Voluntary Fire Brigades, which makes up 19%. We remind you that Euro RESCUE is a very useful application for smartphones that provides answers and key information about the technical characteristics and schematics of the car.

Following the Rulebook on the program of training and development of firefighting personnel [14], most Croatian firefighters undergo training for technical interventions, which is confirmed by 83 respondents (72%) who declare that they have undergone them. A minority, i.e. 33 respondents (28%) still declare that they did not undergo training for technical interventions.

In addition to training and further training, firefighters can take various courses/training [15]. To the question: "Have you received training in which you worked with electric vehicles?", 34 respondents (29%) answered Yes, while the majority, 82 of them (71%), still answered No. Of the 34 respondents who answered positively, 25 of them (74%) belong to the Public Fire Department. Nine respondents who confirm the thesis with training in which they work with electric vehicles perform their activities in one of the Voluntary Fire Brigades, and they make up a total of 26%.

In addition to taking organized training and further training, firefighters can also educate themselves about extinguishing and rescuing electric vehicles. They can do this by reading professional literature, watching educational videos, or listening to the experiences of fellow firefighters from all over the world. The Internet and the easy availability of data enable very fast acquisition of knowledge in contemporary specific areas. Out of 116 respondents, 62 of them (53%) answered that they educate themselves about turning off electric cars and rescuing them, which is very positive. Furthermore, 54 of them (47%) answered that they do not do it anyway.

Electric car fires are very dangerous, especially since there is no perfected, precisely defined technology for their suppression. Fortunately, such fires are very rare. In the conducted research, the majority of respondents, 108 of them (93%), did not encounter interventions with electric vehicles in their work. 8 of them (7%) state that they encountered such interventions.

To the question: "Do you know any firefighting equipment that would help you with interventions on electric vehicles?", most of the respondents answered No, or simply left it blank, a total of 85 of them (73%). Some of the respondents mentioned several types of firefighting equipment. Most of the respondents, 12 of them (10%), singled out the "Emergency Plug" [9] for simulating the charging of an electric vehicle (it prevents the victim in the vehicle from accidentally and suddenly moving forward or backward, which can be very dangerous). Furthermore, the respondents indicated that they thought that powder (a total of 5 respondents), foam (a total of 3), containers (3 respondents), a fire blanket (2 respondents), and "Rosenbauer Battery Extinguishing System Technology" (BEST) (4 respondents) would help them. Respondents also provided one answer each: thermal camera, injection nozzle, Holomatro, "ColdCut" excavator, grounding devices, "Vetter E-Vehicle Isolation System" (EIS), electrician's gloves and cooling nozzle shield.

To the question about attitudes about one's competence for interventions with electric vehicles, answers were offered in the form of a Likert scale where 1 indicated "completely incompetent" and 5 "very competent". Most respondents, 44 of them (38%), chose the number 3, which indicates the middle of competence. The fewest respondents are considered "very competent", a total of 4 (3%).

Fear is a normal phenomenon, especially when dealing with something unknown and unexplored such as interventions with new substances and devices. Interventions with electric vehicles are very rare, and Croatian firefighters have almost no experience with the aforementioned. Despite this, according to the research results, we can almost say that the level of fear of Croatian firefighters is very low. Most respondents point out that they do not feel fear at all, as many as 39 (37%). Furthermore, 35 respondents (30%) decided on the middle on the scale of assessing their fear, and the least of them, i.e. 4 respondents (3%), pointed out that they feel very great fear.

As a follow-up to the question about attended training for interventions with electric vehicles, a question was asked about the desire of firefighters to continue attending them. Most respondents, i.e. 109 (94%) expressed their desire to attend the training. Six respondents (5%) declared that they were not sure whether they would like to attend this type of training, and 1 (1%) respondent answered negatively.

To the last question, which reads: "Do you consider training for interventions with electric vehicles useful for the future?", 111 (96%) respondents answered "Yes", 3 (2%) respondents answered "I am not sure", while 2 (2%) respondents answered that they did not consider it useful.

Based on the results of this research and the set hypotheses, we can conclude that H1 is confirmed because 71% of the examined firefighters did not participate in training for working with electric vehicles; H2 was confirmed because even 93% of the examined firefighters did not participate in interventions with electric vehicles; H3 is confirmed because 96% of respondents confirm the mentioned thesis about the usefulness of conducting training for intervention on electric vehicles; H4 was confirmed, because out of 116 respondents, a total of 43 declare that they use applications for assistance in technical interventions, and of these, 35 are members of the Public Fire Brigade; and finally, H5 was confirmed, because out of a total of 34 respondents who received some kind of training in which they worked with electric vehicles, 74% of them belong to

Public Fire Brigades, and 26% to one of the Voluntary Fire Brigades. A summary of indicators and confirmation of hypotheses is given in Table 1.

Table 1: A summary of indicators and confirmation of hypotheses

Label	Hypothesis	Total	Confirmed
H1	did not undergo EV training	71%	Yes
H2	did not participate in interventions with EV	93%	Yes
H3	they consider the training useful	96%	Yes
H4	PFB uses applications more often	81% PFB 19% VFB	Yes
H5	PFB attends training with EV more often	74% PFB 26% VFB	Yes

EV = electric vehicles; PFB = Public Fire Brigade; VFB = Voluntary Fire Brigades

4. CONCLUSION

Through this research, the previous literature related to the topic was analyzed. She states that the number of fire interventions with electric cars is very small compared to conventional cars with internal combustion. But with the increase in the number of electric cars on the roads and their aging, it is evident that the number will grow. Research with relevant data will only be possible when the number of electric vehicles and their average age reaches the approximate number of other vehicles. The literature also confirms that lithium-ion batteries are a key source of concern during interventions. One of the biggest problems is certainly inconsistent firefighting tactics, which results from insufficient experience due to relatively new technologies.

Exploring the attitudes and experiences of firefighters regarding interventions with electric vehicles provided a deeper understanding of the specific challenges and needs in this area. The findings of the research point out that Croatian firefighters do not have enough experience in working on interventions with electric vehicles, but they are regularly prepared through training and development, either formally or in their arrangement. Despite their inexperience, they are not afraid and believe that researching the mentioned topic is useful for the future.

Effective coordination between firefighters and other emergency services, as well as cooperation with vehicle manufacturers, is vital to ensure safety during interventions on electric vehicles. This work provides a starting point for further research that could explore the technical and practical aspects of interventions in more depth, as well as the development of firefighter-specific protocols. Given the rapid advancement of electric vehicle technology, continuous adaptation of intervention methods and training will become essential to ensure the safety of firefighters and the effectiveness of interventions in the future.

REFERENCES

[1] Bin Ahmad, M.S.; Pesyridis, A.; Sphicas P.; Mahmoudzadeh Andwari, A.; Gharehghani, A.; Vaglieco, B.M.: 'Electric Vehicle Modelling for Future Technology and Market Penetration Analysis, *Front. Mech.* **Vol. 8** (2022) ISSN 2297-3079

[2] Dennis, A.C.:'Electric Vehicle Batteries: Past, Present, and Future', *Electrochem. Soc. Interface*, **Vol. 31** (2022.) No. 3, pp. 63-68

[3] Shareef, H.; Md Mainul, I.; Azah M.: A review of the stage-of-the-art charging technologies, placement methodologies, and impacts of electric vehicles, *Renewable and Sustainable Energy Reviews*, **Vol. 64** (2016), pp. 403-420.

[4] Hrvatski sabor: Zakon o vatrogastvu, Službeni dokument Republike Hrvatske, NN 125/2019, *Available from* www.zakon.hr/z/305/Zakon-o-vatrogastvu *Accessed:* 2023-08-02

[5] Popović, Ž.; Purgar, S.; Knežević, D.; Blaha, J.; Holjević, N.; Kopričanec-Matijevac, Lj.; Fišter, S.; Petek, J.; Karlović, J.; Čuješ, K.; Vuk, M.; Posavec Ž.; Županćić, I.: *'Priručnik za osposobljavanje vatrogasnih dočasnika i časnika*', Hrvatska vatrogasna zajednica, ISBN 953-6385-16-3, Zagreb, (2006.)

[6] Vlada Republike Hrvatske: Pravilnik o standardnim operativnim postupcima, Službeni dokument Republike Hrvatske, NN 44/2022, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/full/2022_04_44_552.html *Accessed:* 2023-08-22.

[7] Vlada Republike Hrvatske: Pravilnik o programu osposobljavanja i usavršavanja vatrogasnih kadrova, Službeni dokument Republike hrvatske, NN 61/1994, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/1994_08_61_1105.html *Accessed:* 2023-08-22

[8] Hrvatska vatrogasna zajednica: Tečaj "Tehnike spašavanja u prometnim nesrećama", *Available from* https://hvz.gov.hr/vijesti/184 *Accessed:* 2023-08-24

[9] Total Safety Solutions: Official site: Emergency Plug, *Available from* https://www.emergency-plug.com/ *Accessed:* 2023-08-24

FIRE EFFECTS ON INVASIVE PLANTS IN THE AREA OF FOREST ADMINISTRATION KARLOVAC

Marko Ožura[1], Nina Popović[1], Zrinka Mesić[1]

[1]Karlovac University of Applied Sciences, Trg J. J. Strosmayera 9, Karlovac, Croatia
(marko.ozura@vuka.hr)

Abstract: The number of invasive plant species continues to grow in Europe and poses a risk to biodiversity by spreading rapidly into new ecosystems. Invasive plants also cause significant damage to economics and human health. Fire is known to facilitate the invasion of many invasive plant species. This research is aimed to understand a possible relationship between wildfires and the prevalence of invasive plant species. The research has been conducted in the fire affected forests in the area of Forest Administration Karlovac. Data analysis and recent field visits in 2023 revealed weak association between burnt areas and the spread of invasive plant species. Fire did not lead to an increase in the pace of invasion into burned areas, primarily due to its frequency. Results from our study will help in monitoring of impact of invasive plant species on studied sites during the postfire years.

Keywords: Invasive alien plant species, wildfire, forestry, Karlovac County

1. INTRODUCTION

Invasive alien plant species (IAS) are species with a broad environmental tolerances and, in many cases, spread rapidly into new ecosystems through different introduction pathways, for example along infrastructure corridors (e.g. roads, railways, canals). This study investigated the influence of open space wildfires on the rate of IAS spread, considering that the burned area becomes a suitable area for the development of invasive plants.

Fires can quickly and dramatically change the landscape and alter the competitive balance within the biotic community [1,2,3]. Fires consume plant biomass, which increases the availability of light and reduces the consumption of soil nutrients, thus increasing invasion potential during at least the first few postfire years [2]. The study has been conducted in the fire affected forests in the continental part of Croatia, where fires occur repeatedly every ten years consuming an average area of 100 ha.

2. RESEARCH AREA AND ANALYSIS OF FIELD DATA

The research was carried out in the period of October and November 2023 in the area of Duga Resa Forestry, in the fire affected forest economic units „Bosiljevac“ (3381.66 ha) and „Perjasica“ in SW part of Karlovac County. The study site was affected by fire in 2012, 2019 and 2022, which burned an area of approximately 500 ha. The fire spread from agricultural areas to areas of young forests. The possible directions of IAS expansion and the proportion of the area covered by surrounding pastures and unrestored forests were recorded using an unmanned aerial vehicle and georeferenced images.

Besides recent field visits of burnt surfaces in 2023, data analysis also included field data from test plots of 10 km^2, located near burned areas of state forests stands. Data we used from these test plots were collected within the project “Mapping of alien species and invasive alien plants, development, completing and testing of the monitoring program“, which was conducted by Oikon Ltd. – Institute of Applied Ecology in 2020.

Figure 1: Map of the researched area

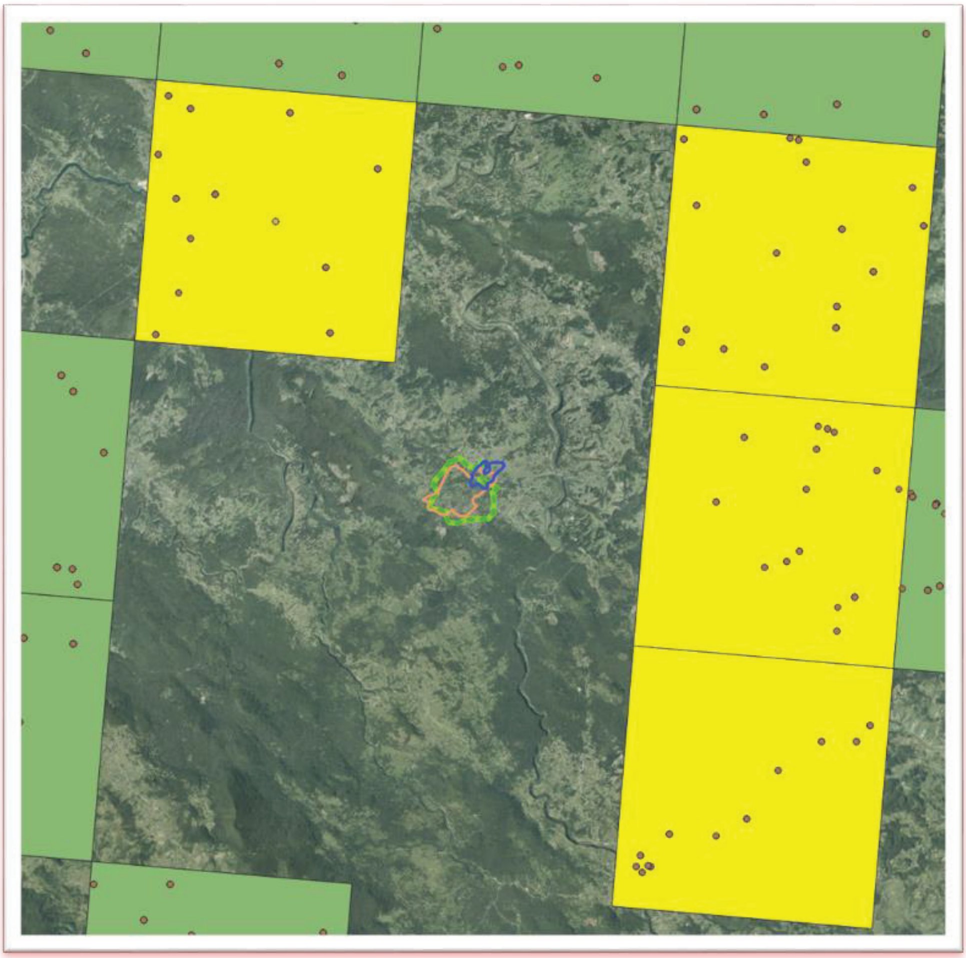


Figure 2: Marked burnt area and test plots for comparison (Oikon Ltd)

3. RESULTS

After field research and comparison with data from the project conducted by Oikon Ltd. (Table 1.), we gained unexpected results. Although the assumption was a large spread of IAS plants, as previously observed in burnt areas of these lowland forests in postfire period on three occasions in 2012, 2019 and 2022, no similar pattern of invasion was recorded.

Analysis of recent field data revealed weak association between burnt areas and the spread of invasive plant species. Fire did not lead to an increase in the pace of invasion into burned areas, primarily due to its frequency, so the IAS could not spread either by seed or vegetatively, and also due to the large coverage with fern *Pteridium aquilinum*. Large areas covered with fern represent degraded habitat of Epimedio-Carpinetum betuli/ht. 1938./Borh.1963., Melanpyro-Quercetum petraeae-subass. Quercetosum cerris/Pelcer1984., Querco petraeae- carpinetum illyricum var. Fagus sylvatica/Horvat 1937.. Some of the most common alien invasive plant species that were recorded in unburnt patches of the study site are: *Bidens frondosa* L., *Erigeron annuus* (L.) Pers., *Phytolacca americana* L, *Robinia pseudoacacia* L. and *Solidago* sp..

Table 1: Recorded species of invasive alien plants on test plots [6]

Plot 1 - 10kmE476N248	Plot 2 - 10kmE476N247	Plot 3 - 10kmE476N246	Plot 4 - 10kmE474N248
Erigeron annuus (L.) Pers.	*Reynoutria xbohemica* Chrtek et Chrtková	*Ambrosia artemisiifolia* L.	*Ambrosia artemisiifolia* L.
Robinia pseudoacacia L.	*Solidago gigantea* Aiton	*Conyza canadensis* (L.) Cronquist	*Conyza canadensis* (L.) Cronquist
Ailanthus altissima (Mill.) Swingle	*Ambrosia artemisiifolia* L.	*Erigeron annuus* (L.) Pers.	*Erigeron annuus* (L.) Pers.
Helianthus tuberosus L.	*Bidens frondosa* L.	*Phytolacca americana* L.	*Robinia pseudoacacia* L.
Panicum capillare L.	*Conyza canadensis* (L.) Cronquist	*Bidens frondosa* L.	*Solidago gigantea* Aiton
Phytolacca americana L.	*Datura stramonium* L.	*Galinsoga parviflora* Cav.	*Sorghum halepense* (L.) Pers.
Solidago gigantea Aiton	*Phytolacca americana* L.	*Robinia pseudoacacia* L.	*Amaranthus retroflexus* L.
Phytolacca americana L.	*Erigeron annuus* (L.) Pers.	*Lepidium virginicum* L.	*Galinsoga ciliata* (Raf.) S.F.Blake
Panicum capillare L.	*Galinsoga parviflora* Cav.	*Reynoutria japonica* Houtt.	*Solidago canadensis* L.
Conyza canadensis (L.) Cronquist	*Sorghum halepense* (L.) Pers.	*Echinocystis lobata* (Michx.) Torr. et Gray	*Galinsoga parviflora* Cav.
Sorghum halepense (L.) Pers.	*Asclepias syriaca* L.	*Galinsoga ciliata* (Raf.) S.F.Blake	*Parthenocissus quinquefolia* (L.) Planchon
Artemisia verlotiorum Lamotte	*Helianthus tuberosus* L.	*Sorghum halepense* (L.) Pers.	*Ailanthus altissima* (Mill.) Swingle
Epilobium ciliatum Raf.	*Amaranthus hybridus* L.	*Parthenocissus quinquefolia* (L.) Planchon	*Euphorbia maculata* L.
Bidens frondosa L.	*Robinia pseudoacacia* L.		*Solidago gigantea* Aiton
Paulownia tomentosa (Thunb.) Steud.	*Echinocystis lobata* (Michx.) Torr. et Gray		*Veronica persica* Poir.
Sorghum halepense (L.) Pers.	*Ailanthus altissima* (Mill.) Swingle		
Galinsoga parviflora Cav.	*Epilobium ciliatum* Raf.		
Epilobium ciliatum Raf.	*Echinocystis lobata* (Michx.) Torr. et Gray		
Phytolacca americana L.			

4. CONCLUSION

Forest fires or fires of vegetation or open space fires are caused mainly by human action [4, 5].

On the one hand, depopulation and the abandonment of arable land led to succession of natural habitats and significant accumulation of dead fuel, which increased the risk of fires, thus increasing invasion potential in the research area. On the other side, due to depopulation and lack of human activity (agriculture, livestock breeding) and traffic in that area, spreading of alien invasive plant species did not occur. Invasive plant species were recorded on the edges of the main roads and settlements, because the most common introduction pathway for IAS spreading is through human activity and traffic.

Results from our study will help in monitoring of impact of invasive plant species on human and natural resources of studied sites during the postfire years.

REFERENCES

[1] Stipaničev, D.; Štula, M.; Krstinić D.; Šerić, Lj.; Jakovčević, T.; Bugarić, M.: Advanced automatic wildfire surveillance and monitoring network, *VI International Conference on Forest Fire Research,* D. X. Viegas (Ed.), (2010)

[2] Brooks, M.; Lusk, M.: *Fire Management and Invasive Plants: a Handbook*. United States Fish and Wildlife Service, Arlington Virginia, (2008) 27 pp.

[3] Upravlja li se dobro potporom EU-a za sprječavanje štete i obnavljanje šuma nakon štete od požara i elementarnih nepogoda? http://eca.europa.eu

[4] Ožura, M.; Rodman, K.; Gašparac, M.; Drvar, I.: Analiza vegetacije nakon požara u šumskom ekosustavu - primjer g.j. Trepča, *Zbornik radova 53. hrvatski*

i 13. međunarodni simpozij agronoma, Rozman, V.; Antunović, Z. (ur.)., str. 71-75, Vodice, Poljoprivredni fakultet Sveučilišta Josipa Jurja Strossmayera u Osijeku, (2018)
[5] Kisić, I.; Bogunović, I.; Delač, D.; Barčić, D.: Požari otvorena prostora u Republici Hrvatskoj – pojava, učestalost i suzbijanje. Hrvatske vode, 31 (124), (2023)
[6] Oikon: Project "Mapping of alien species and invasive alien plants, development, completing and testing of the monitoring program", (2020)

ANALYSIS OF THE GAS CRISIS IN RAB

Željka Potočnjak[1], Maja Trečić[1], Zvonimir Matusinović[1]
[1]Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA

Abstract:

This paper analyzes the gas crisis that occurred in Rab on June 24, 2019. It focuses on the complete course of events, potential consequences and the reaction of the Rab Voluntary Fire Company (VFC). The incident began at 17:08 with a report of the smell of gas, which prompted VFC Rab members to go to the field and check the situation. Measuring instruments registered a high concentration of gas and research identified an underground propane-butane gas tank owned by the hotel as the source of the crisis. The rupture of the gas pipeline connecting the tank to the hotel resulted in the release of gas into the ground. VFC Rab firefighters with their legitimate actions, successfully limited the movement of gas and took measures to protect citizens, aware of the danger posed by propane-butane due to its low explosive limit. They continuously monitored the situation, irradiated internal openings and sewage systems, and used overpressure devices to get the gas out of the ground, thereby ensuring the safety of people in the dangerous area. This paper investigates the potential consequences for the environment and the local population and highlights the role and effectiveness of VFC Rab in solving this crisis situation.

Keywords: leak, propane butane, crisis, Rab, VFC Rab

1. INTRODUCTION

During the 2019. tourist season, a significant leakage of liquefied petroleum gas (LPG) propane-butane occurred which spread through the municipal infrastructure into part of the historic core of the City of Rab, specifically in its oldest section known as Kaldanac. This area contains three restaurants, a hotel, two cafes, a hair salon, the courthouse, the Harbour Master's Office, the Geodetic Administration, a souvenir shop, a religious building, a real estate agency, and five residential buildings. [1]

LPG infiltrated all the aforementioned establishments.

2. LIQUEFIED PETROLEUM GAS PROPANE-BUTANE

Liquefied petroleum gas (LPG) is a mixture of liquefied hydrocarbons derived from oil refining which are gases with a density 1.5 times that of air under standard conditions (p=101 325 Pa, T=293,15 K) and transition to a liquid state under increased pressure.

It has very widespread use as an energy source in industry and households and also as a substitute for more expensive fuels in automobiles.

Liquefied petroleum gas primarily consists of propane (C_3H_8) or butane (C_4H_{10}), and it is most often a mixture of both gases. Since liquefied petroleum gas is colorless and odorless, and poses a potential hazard when leaking, special additives (e.g. ethanethiol or tetrahydrothiophene) are added to give LPG a smell, thereby facilitating the detection of leaks.

The Safety Data Sheet (SDS) provides exhaustive information about the chemical hazard, including environmental hazards, as well as precautionary measures.

The flammability (explosiveness) limits indicate the ratio of air to gas mixture at which ignition (explosion) is possible. There is a lower explosive limit (LEL) and an upper explosive limit (UEL) which depend on the gas composition, pressure, and temperature.

An explosion can occur if a concentration of 1.9 % (LEL) to 9.5 % (UEL) vol. % of natural gas in a mixture with air is formed, along with the presence of thermal energy as the ignition source.[2]

3. LEAKAGE OF LIQUEFIED PETROLEUM GAS (LPG)

A leakage of liquefied petroleum gas (LPG) poses a significant risk due to its high flammability and potential to cause asphyxiation. Upon detecting an LPG leak, the first step is to identify the source using the odorant added for easier detection or visual cues such as white mist or frost around joints and pipes. Immediate evacuation of all individuals from the affected area is required establishing a safety zone and disconnecting all ignition sources, including electrical devices, to prevent potential explosions. Natural ventilation, such as opening windows and doors, can aid in the dispersion of the gas while explosion-proof fans are employed for accelerated removal.

After evacuation and securing the area, the leak must be isolated and stopped. Shutting off the main valves on tanks or systems where the leak occurs is critical and temporary sealing can be achieved using rubber stoppers, clamp bands or similar tools. Safety equipment such as protective gloves, goggles, and respirators should be used and specialized emergency tools should be ready for deployment.

Once the leak is contained, the gas concentration in the air is verified using portable detectors ensuring that it remains below the lower explosive limit (1.9 vol. % for LPG). Residual gas is removed through continued ventilation until detectors indicate zero concentration. Post-incident system inspection is essential to determine the cause of the leak and perform necessary repairs along with thorough system cleaning.

If exposure to the gas occurs, first aid measures include moving the person to fresh air for inhalation or rinsing affected areas with cold water if contact occurs with skin or eyes. Exposure to high gas concentrations can cause headaches, drowsiness, or asphyxiation.[3]

3.1. Incident Report – Day I

On June 24, 2019. at 17:07 hours, the Fire Operations Center (FOC) Rab received a report of a gas odor in an apartment on the third floor of a residential building at Put Kaldanca 4. The on-duty shift was immediately dispatched to the address. Upon arrival, the shift supervisor detected a gas odor on the third floor and was unpleasantly surprised to learn that no gas was used as a fuel in the building. At 17:15 hours, an explosive mixture with a concentration of 9 vol. % was detected in the building. Further inspections revealed the presence of propane-butane gas above the upper explosive limit (UEL) (16 to 20 vol. %) in the water and sewer shafts.

The wider area was immediately cordoned off, and the evacuation of that part of the city was initiated. Simultaneously, firefighters attempted to locate the gas leak source, but all large storage tanks in the vicinity showed normal conditions. Gas supplies to consumers were being shut off, pressure gauges on tanks were read and measures to prevent an explosion were undertaken, including opening shafts and ventilating. During the night, the source of the gas leak was not identified although it was indicated that a significant quantity was involved. It is important to note that there is no gas network on the island of Rab; LPG is used as a fuel in tanks or cylinders.[1]

3.2. Leak Source Identification – Day II

On the morning of June 25, 2019, the presence of gas was detected over an even wider area compared to the previous night, and the source of the leak remained unidentified. It was determined that the largest gas storage tank in the vicinity, an underground tank with a capacity of 5 m^3 belonging to Hotel Arbiana, showed no leakage upon measurement, nor did any other gas users, including nearby restaurants. Nonetheless, the fire safety inspector ordered the emptying of Hotel Arbiana's tank, and the gas supplier was contacted to perform this task. The inspector assumed that the problem lay with the hotel's tank, as there were no other tanks or major gas users in the vicinity.

Upon the arrival of the gas supplier's road tanker from Zagreb, the supplier's employees first filled the liquid-phase supply pipeline with gas-phase LPG determining that the gas phase had completely leaked. Subsequent testing with nitrogen revealed that the supply pipeline from the tanker connection to the storage tank was damaged causing a leak of the liquid phase during the tank filling. It was confirmed that the last filling of the tank took place in the evening hours of Saturday, June 22, 2019. and there had been four previous fillings during June.

During the tank emptying at 16:00 hours, a meeting of the Civil Protection Headquarters commenced and this information was communicated to the Headquarters immediately after the meeting began. Further measures focused on continuous gas concentration measurements and ventilating the shafts. Given the scale of the incident and the affected area, the intervention leader requested equipment from the Public Fire Department of Rijeka for which a vehicle from the Volunteer Fire Department Rab was dispatched.

Specifically, water-driven positive pressure fans which do not generate sparks, were requested to ensure safe ventilation of the buildings.[4]

The gas supplier and certain members of the Civil Protection Headquarters suggested to the intervention commander to fill all water and sewer shafts with water to prevent the gas flow into unknown directions, but this proposal was rejected to avoid disrupting the established gas escape routes. Instead, the gas was allowed to exit at known points where it was ventilated with continuous concentration measurements over a wider area.

Gas was also detected in the telecommunication ducts (DTK network). KD Vrelo d.o.o. was engaged to place balloons and seal off the spread of gas through sewer shafts outside the cordoned area. Using a special vehicle, a sewer jet was used to draw the gas toward the pumping station with the aid of a water curtain. The DTK ducts were flushed using a fire hose and the ducts with higher gas concentrations were filled with water to displace the gas back into the sewer system. Gas presence was still detected in the water shafts. Measurements showed explosive concentrations inside the pump station machinery room which was still energized. Consequently, a CO_2 fire extinguisher (5 kg) was discharged into the machinery room, reducing the propane-butane gas concentration and the station was de-energized.[1]

3.3. Decontamination of the Area and Continuous Measurements – Day III

During this period, the pumping station intermittently energized (using manually operated pumps) to prevent sewage spillage in the wider area of the city port, provided there was no risk of ignition or explosion of the gas mixture. Gas inflow into the wells (lowest points) was reduced in the evening hours. Therefore, a decision was made to accelerate the gas inflow by starting to displace propane-butane with water. For this purpose, a section of the connecting fitting piece linking the underground gas tank and the damaged liquid phase supply pipeline was removed. The fitting piece was handed over to the police with an explanation of the intention, after which a connection for a "C" firefighting hose was installed. The fitting piece was cut and a prefabrication, reducer, nipple, and coupling for the "C" firefighting hose were mounted on it. Thus, water pressurization of the damaged liquid phase pipeline commenced, flowing through the damage and into the ground, following the same path as the leaked propane-butane liquid phase. Special dye, used by sanitation workers for detecting leaks in sewage pipes, was added to the water. The dye appears at points where water exits, attempting to trace the "path" of the propane-butane gas.

Power disconnection on Bishop Draga Street from HEP was requested during soil and well flushing. In the evening hours, due to high gas concentration in the storm drainage well at the Arbiana Hotel parking lot, the MSA DVD-a Rab measuring device sensor completely failed, rendering the device inoperable. Immediately during the same evening, an additional measuring instrument was requested from the Rijeka Fire Department which was delivered to Rab the same evening. Measurements during the night detected the presence of flammable mixture at a height of 1 meter above the ground level on Bishop Draga Street.[1]

3.4. Decontamination of the Area and Continuous Measurements – Day IV

On June 27, 2019. measurements indicated the presence of gas in all shafts and a flammable mixture at a height of 1 meter above ground level in Biskupa Draga Street. Water saturation was conducted in all shafts to elevate the gas for ventilation in Biskupa Draga Street. Due to the detection of a larger quantity of gas in front of the court, cadastre, and harbor master's office, these institutions were evacuated. HEP cut off the power supply for a part of the city—Kaldanac area—overnight (from 01:00 to 05:30 hours) to attempt to remove larger quantities of gas from the sewer system in a major night operation. The operation was conducted at night to avoid the presence of passersby and resulted in the gas being lifted out of the sewer and dispersed with water fans toward the sea surface, confirming the strategy's validity.

Morning activities focused on controlled gas sedimentation into the sewer system with continuous concentration measurements and both natural and forced ventilation. Afternoon measurements on June 27, 2019. showed a renewed increase in gas quantities in the sewer. The intervention leader proposed treating the sewer with medium-density foam which would fill the entire volume of sewer pipes and push the gas toward the pumping station from where it could be more easily ventilated towards the open sea. The Civil Protection Headquarters requested the engagement of a utility company's tanker truck to implement this plan.

Implementing this method achieved an additional benefit by creating a Venturi effect with the STP nozzle at the shaft, allowing the gas to fill the foam bubbles. A large gas inflow was indeed found at the pumping station. Water fans ventilated the pumping station which was disconnected from the power supply. Due to the detected flammable mixture on the road along King Petar Krešimir IV's coast, the police closed that part of the city. The gas overflowing from the pumping station into the outdoor space was dispersed with water fans towards the sea surface. Mooring boats was prohibited in the declared danger zone along the coast. After treatment, no gas presence was detected through measurements, the foam was flushed with water and repeated measurements showed no gas traces in the sewer after foam treatment.[1]

3.5. Decontamination of the Area and Continuous Measurements – Day V

On June 27, 2019. in the early morning hours, gas pockets were still detected in the DTK sewer system while the sanitary sewer showed no gas presence after foam treatment. From noon, an external expert from the company "ATEST MAG" from Karlovac began measurements, confirming explosive gas concentrations in the DTK network, the parking lot of Hotel Arbiana (10 vol. %), and the building of the hairdressing salon. The rental of four X-am series multi-detectors from Drager Safety d.o.o. was arranged which were immediately put into use. Due to the use of the hydrant network, the water supply pressure dropped, leading to the arrival of two tanker trucks from State Reserves for relief.[1]

3.6. Decontamination of the Area and Continuous Measurements – Day VI

During the night and morning, measurements continued, showing 0 vol. % readings. At 07:30, the shafts were closed, and water injection into the damaged gas pipe was stopped. After two hours, measurements showed explosive gas concentrations in Hotel Arbiana and the basement of a residential building while no detections were found in the DTK infrastructure, sewer system and water shafts. One tanker truck was withdrawn. At 17:00, the external expert from "ATEST MAG" confirmed explosive concentrations at several locations which were treated with water. The damaged pipe was re-pressurized with water. Night measurements and water saturation of public areas continued along with well pumping.[1]

3.7. Decontamination of the Area and Continuous Measurements – Day VII

Throughout the night, morning, and afternoon, frequent measurements were conducted using Drager and MSA portable detectors. No gas concentrations were recorded. Starting from 12:00, the shafts were repeatedly closed, and water injection into the ruptured gas pipeline was halted. Due to the weight of the shaft covers (approximately 100 kg), 30 pieces of construction anti-slip wooden lining were supplied in collaboration with the municipal company and a local construction firm to facilitate easier opening later.

At 16:00, measurements indicated explosive gas concentrations detected by both devices within the basement of a residential building. Subsequently, the presence of gas was also recorded in the sprinkler system cabinet of Hotel Arbiana and around the chapel. The basement of the residential building began continuous ventilation with positive pressure fans powered by water from the Directorate for Commodity Reserves vehicle until the end of the day. The water in the basement well was frequently emptied multiple times using a centrifugal fire pump after it was confirmed safe to do so. Following several emptyings, no gas presence was recorded in the sprinkler system cabinet of Hotel Arbiana or around the chapel.

At 17:00, water injection into the ruptured gas pipeline resumed, and a small amount of water was periodically added to the sprinkler system cabinet. These measures resulted in occasional higher gas concentrations being recorded in the basement of the residential building, with gas entering the space both from the well and along the water pipe. Higher gas concentrations were recorded at the water meters on the street adjacent to the residential building, but below both alarm thresholds (below 50% of the LEL). No gas concentrations were detected at other measuring points. Measurements were logged in a table according to the time of measurement and the measuring location, as done on previous days.

Throughout the night of June 30, 2019 / July 1, 2019, measurements continued at all locations, with continuous ventilation of the residential building's basement and periodic emptying of the well of water, which frequently accumulated to capture the gas mixture. At that location, gas was released from the ground and ventilated using water fans outside the building. [1]

3.8. Decontamination of the Area and Continuous Measurements – Day VIII

From 02:00, measurements on the devices (MSA and Drager) showed 0.0 ppm of gas. The shafts were covered with boards throughout the monitoring. At 12:30, the excavation of the damaged gas pipeline section began carried out in cooperation with the utility company and with a protective water jet. The damaged section of the pipeline was handed over to the criminal police for expert analysis. From 19:00, the external expert from "ATEST MAG" conducted measurements, finding a concentration of 0.5 vol. % in one DTK shaft. Pressurized ventilation continued and other shafts were opened for natural ventilation. No gas presence was detected through the night.[1]

3.9. Decontamination of the Area and Continuous Measurements – Day IX

During the night and morning, pressurized ventilation of the DTK shaft with the previously measured gas concentration of 0.5 vol.% was performed. Other shafts, buildings and the pumping station were naturally ventilated. Frequent measurements did not detect gas presence at any location. After 30 hours of continuous measurements without gas detection, the intervention concluded. Monitoring was conducted for the next 7 days, particularly in the shafts at the Hotel Arbiana parking lot and the excavation site of the pipe. Control was additionally performed by the specialized company ATEST MAG d.o.o. and the intervention was planned to be repeated in case of heavy rainfall.[1]

4. CONCLUSION

The incident involving the leakage of liquefied petroleum gas (LPG) underscores the seriousness and complexity of managing hazardous gas systems, emphasizing the importance of a prompt and coordinated response from firefighting units. Firefighters from VFC Rab promptly identified signs of LPG leakage, enabling swift action. Identification and isolation of the leakage source by closing main valves were crucial in preventing further gas spread and potential escalation.

Evacuation of the affected area played a pivotal role in ensuring the safety of those present, while the establishment of a safety zone and the shutdown of all ignition sources eliminated the risk of explosion. Utilization of natural and forced ventilation, including explosion-proof fans, facilitated safe reduction of gas concentrations below the lower explosive limit, ensuring gas dispersion from pits and other enclosed spaces.

During the intervention, firefighters from VFC Rab used appropriate protective equipment such as gloves, goggles and respirators, ensuring their own safety. Continuous monitoring of gas concentration in the air using portable detectors was crucial for assessing the area's safety. These measurements ensured that the area could only be declared safe once gas readings showed zero concentration.

After stopping the leakage and reducing gas concentration, a system inspection followed to determine the cause of the leakage and perform necessary repairs. This step was essential for ensuring long-term system safety and preventing similar incidents in the future.

VFC Rab firefighters' adherence to protocols for managing LPG leakage, including evacuation, ventilation, isolation of the leakage source, use of protective equipment and continuous gas concentration monitoring, enabled effective control of the situation. This reduced risks to human lives and property, highlighting the importance of readiness and expertise in responding to hazards associated with liquefied petroleum gas. Through a coordinated and informed approach to all aspects of the incident, firefighters ensured safety and minimized potential damage.

REFERENCES:

[1] Dobrovoljno vatrogasno društvo Rab: Izvještaj s intervencije 051/00112/2019

[2] Ina Industrija nafte d.d..: Sigurnosno - tehnički list Ukapljeni naftni plin propan - butan smjesa, smjesa obogaćena propanom, autoplin, *Available from* https://www.ina.hr/wp-content/uploads/2020/01/Ukapljeni_naftni_plin_propan_butan_smjesa_izdanje_9.pdf *Accessed:2024.03.15.*

[3] LP Gas Safety: Guidelines for Good Safety Practice in the LP Gas Industry. (1998). Kenija: UNEP, *Available from* https://wedocs.unep.org/handle/20.500.11822/30155 *Accessed: 2024.03.15.*

[4] Stožer Civilne zaštite grada Raba: Zapisnik sa VI. sjednice Stožera civilne zaštite Grada Raba od 2.7.2019.; Rab, 2019.

[5] Portal Rab danas: Rapski vatrogasci bdiju nad svojim gradom, *Available from* https://rabdanas.com/index.php/vijesti/item/3928-rapski-vatrogasci-bdiju-nad-svojim-gradom *Accessed: 2024.03.15.*

FIRE ON HYBRID VEHICLES

Maja Trečić[1], Željka Potočnjak[1], Zvonimir Matusinović[1]
[1]Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA

Abstract:

Hybrid vehicle fires are a safety challenge and require a thorough analysis to understand the causes, consequences and preventive measures. This scientific paper investigates hybrid vehicle fires with a focus on identifying potential risks, mechanisms of thermal overheating and spontaneous ignition, as well as protection and intervention strategies. Through a review of relevant literature, case analysis and simulations of fire scenarios, various aspects of fires on hybrid vehicles are considered. It also explores innovative technologies and fire prevention strategies that can be applied to reduce risks and ensure the safety of passengers, drivers and firefighters. The aim of this paper is to provide a comprehensive overview of the fire problem on hybrid vehicles and to propose guidelines for further research and safety improvements in this domain.

Keywords: *Fire, hybrid vehicles, safety, preventive measures, fire intervention*

1. INTRODUCTION

In the past few decades, hybrid vehicles have become essential in reducing greenhouse gas emissions and dependence on fossil fuels. However, as the number of hybrid vehicles on the roads increases, there is a growing need for a thorough understanding of their specific safety risks, especially in the context of fire incidents. Fires in hybrid vehicles present unique challenges due to the combination of conventional engines and high-voltage batteries used for energy storage.

The causes of fires in hybrid vehicles can vary, including thermal overheating, short circuits, mechanical damage, and manufacturing defects. The complexity of these systems necessitates a detailed analysis to understand the mechanisms leading to spontaneous ignition and to develop effective preventive measures.

2. TECHNICAL REQUIREMENTS

Hybrid vehicles contain a significant amount of flammable materials, primarily the energy system (battery and fuel) and plastic components. The mass of polymers used in current automobiles ranges from 100 to 200 kg which is greater than the mass of gasoline (less than 50 kg).[1]

Regarding the battery, since a lithium-ion battery contains various flammable materials, its thermal burning capacity is influenced by its chemistry, packaging, capacity, and state of charge (SOC).[2] Generally, the thermal burning capacity of such batteries is approximately an order of magnitude smaller than that of gasoline. The thermal energy released from a battery fire, which includes internal thermal runaway during thermal runaway within the battery and flames sustained by flammable gases injected from the battery, is much greater than the electrical energy stored in the battery. As shown in Figure 1, a battery fire can release 5 to 10 times more energy than the stored electrical energy.[1]

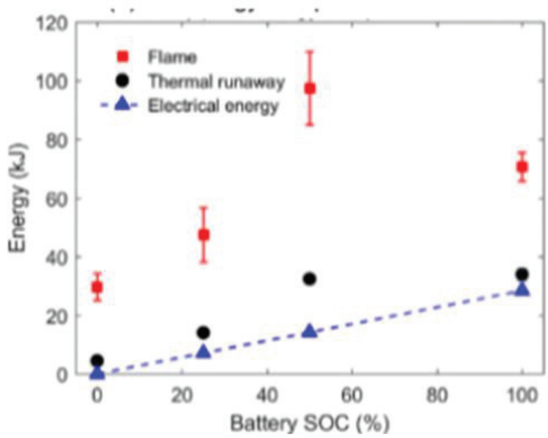


Figure 1: Battery energy release [1]

2.1. Heat Release Rate (HRR)

HRR (or fire power) is the most important parameter for characterizing fires and is also the most critical. Unlike the heat of combustion or the total heat released from a fire, HRR is a better indicator of fire intensity and hazard. It is defined as the variation of thermal power in the combustion reaction, expressed in kW, calculated in relation to the fuel, ventilation conditions, and depending on the geometric characteristics of the material. It can also be defined as the burning rate since one kW is equivalent to one MJ/s. The higher the peak value of the curve, the greater the burning rate. The reference HRR curve for vehicle combustion is a curve developed considering experimental results and is shown in Figure 2.[3]

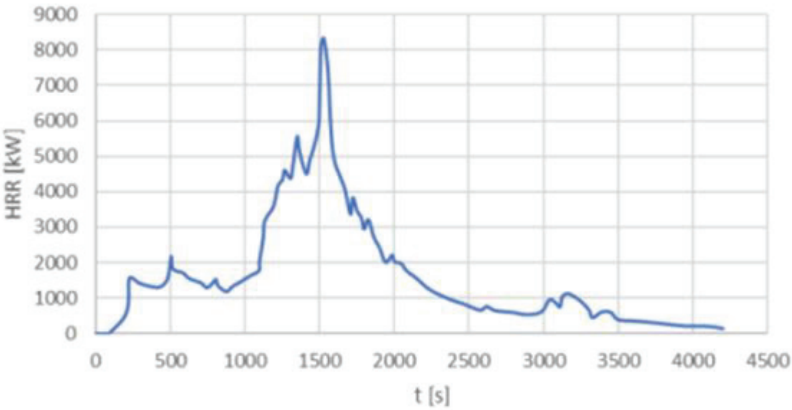


Figure 2: HRR for vehicle combustion [1]

The curve rises to a peak slightly exceeding 8000 kW, reached at approximately 1500 seconds.

2.2. Smoke and Toxicity

Lithium-ion battery fires can emit toxic smoke upon combustion. The smoke produced from these fires may contain a range of harmful chemicals, including carbon monoxide (CO), hydrofluoric acid (HF), hydrogen cyanide (HCN), and various metal oxides. Inhaling smoke from lithium-ion battery fires can cause severe health issues, including lung damage, eye irritation, and chemical burns on the skin and eyes. [1] Besides smoke, the heat generated by this technology can also release toxic fumes from the materials used in the battery. Combustion of lithium can release highly toxic lithium hydroxide fumes while combustion of the electrolyte used in the battery can release hydrofluoric acid fumes. The toxicity of HF and its derivative, hydrofluoric acid, is well documented. These gas emissions vary between manufacturers and types of electric vehicles, with the size and chemistry of the LIB influencing potential gas emissions.[3]

2.3. Factors and Causes of Fires in Hybrid Vehicles

Fires in hybrid vehicles can be triggered by various factors specific to the technology combining internal combustion engines and electrical components. The most common causes include:

Thermal Overheating of Batteries:

Lithium-ion batteries, frequently used in hybrid vehicles, are prone to overheating due to intensive use, charging errors, or failures in the cooling system. Overheating can lead to thermal runaway, a process where the battery suddenly releases energy in the form of heat, potentially causing a fire. Thermal runaway is a significant risk as it occurs rapidly and can have catastrophic consequences for the vehicle and its surroundings.[3]

Short Circuits and Electrical Failures:

High-voltage electrical systems in hybrid vehicles are susceptible to short circuits, which can arise from damaged cables, poor connections, or faulty components. Short circuits can cause sparking, potentially igniting flammable materials within the vehicle. Electrical failures can result from inadequate maintenance, manufacturing defects, or external influences.[3]

Mechanical Damage:

Collisions or other mechanical damage can puncture battery cells or damage electrical components, leading to fires. Mechanical damage can also compromise the integrity of the cooling system, increasing the risk of battery overheating. Structural integrity of components is crucial for maintaining the safety of the vehicle's electrical systems.[3]

Manufacturing Defects:

Design or manufacturing defects can cause failures in batteries or electrical systems. Such issues may include poor soldering, inadequately insulated cables, or other faults in the manufacturing process that increase the risk of fire. Ensuring quality control during production is critical for minimizing these risks.[1]

Poor Maintenance:

Irregular or improper maintenance can result in the accumulation of dirt, dust, and moisture in the vehicle's electrical components. These conditions can increase the risk of electrical failures and short circuits. Regular maintenance and inspection of electrical systems are essential for preserving vehicle safety.[1]

External Heat Sources:

Extreme external conditions, such as high ambient temperatures, can place additional stress on the battery cooling system, causing overheating. Parking vehicles near flammable materials or heat sources can also increase the risk of fire. Proper planning of parking spaces and consideration of environmental conditions can help mitigate these risks.[3]

Chemical Instability of Materials:

Lithium-ion batteries use electrolytes and other chemical components that are flammable. Instability of these materials can lead to spontaneous ignition, especially if batteries are used outside their optimal operating parameters. Understanding chemical stability and proper management of batteries is crucial for reducing the risk of fires.[4]

2.4. Prevention

To ensure the safety and reliability of hybrid vehicles, careful consideration of design, construction, and the use of high-quality materials is crucial. Adequate insulation of high-voltage components and robust design are key factors in reducing the risk of short circuits and overheating. Additionally, the implementation of effective cooling systems for batteries and electrical components plays a significant role in preventing overheating.

Advanced Battery Management Systems (BMS) are vital for monitoring the state of batteries and preventing thermal runaway by controlling voltage, temperature, and load. Regular vehicle maintenance is also critical for early detection of potential issues that could lead to fires, including checking the condition of electrical systems and inspecting high-voltage batteries.[3]

Temperature control of high-voltage components is essential to prevent overheating and serious problems such as thermal degradation of batteries or self-ignition. Integrating advanced safety systems, such as smoke detectors and automatic fire suppression systems, allows for rapid detection and suppression of incipient fires, thereby reducing damage and risk to passengers and personnel.

Educating personnel on the safe handling of hybrid vehicles, including proper procedures for dealing with high-voltage systems and using fire safety equipment, is key to preventing incidents and minimizing risks. The quality of vehicle construction, using high-quality materials resistant to high temperatures and electrical sparks, is crucial for reducing the risk of fires and ensuring vehicle reliability and safety.

Finally, regular monitoring and adherence to the latest regulations and safety standards in the automotive industry are essential for compliance and the implementation of best practices for fire prevention in hybrid vehicles.[5]

2.5. Extinguishing Fires in Hybrid Vehicles

The firefighting protocol for extinguishing fires in hybrid vehicles in the Republic of Croatia (RH) is adapted to the specific challenges posed by the electrical systems and batteries of such vehicles. When faced with a fire in a hybrid vehicle, firefighters must first ensure their own safety by assessing the situation and identifying potential electrical risks, such as the danger of electric shock or battery explosion. It is important to disconnect the vehicle's power supply if possible to reduce the risk of further issues with the electrical systems.[6]

Next, firefighters should identify the type of battery in the vehicle to adjust their approach and extinguishing techniques. If the fire has affected the battery, it is crucial to cool it to prevent further overheating and potential rupture, which can be achieved by applying water or specialized cooling agents.

When extinguishing the fire, firefighters should use fire extinguishing agents specifically formulated for electric vehicles, such as specialized extinguishers or agents designed for lithium-ion batteries. It is important to properly disperse the agent towards the source of the fire or the battery, taking into account potential electrical risks.

After extinguishing the fire, continuous monitoring of the situation is crucial to ensure that there is no re-ignition or other issues. Ongoing observation allows for quick responses to potential hazards and ensures the safety and protection of firefighters and other participants.

It is important to note that the firefighting protocol may vary depending on local regulations, equipment and firefighter training. Therefore, it is essential for firefighting services to regularly conduct training and be familiar with the latest protocols and techniques for extinguishing fires in hybrid vehicles.[3]

2.5.1. F-500 Encapsulator Agent

The F-500 Encapsulator Agent is a specialized fire suppressant used in various fire scenarios, including those involving hybrid vehicles. Its chemical composition allows for effective fire suppression by reducing the surface tension of water, cooling the fire and preventing re-ignition.

The exact chemical formulation of F-500 is not always fully disclosed due to intellectual property protections by the manufacturer. However, its primary components include: surfactants (chemicals that lower the surface tension of water, allowing better penetration of the liquid into combustible materials), polymers (which help create a protective layer on the surface, cooling it and preventing fire re-ignition), and cooling additives (substances that enhance the liquid's ability to absorb heat and rapidly cool the surface).

F-500 has the capability to encapsulate combustible particles, which helps in reducing fuel vaporization and prevents its contact with oxygen. It effectively absorbs heat from the fire, rapidly lowering the temperature and preventing the fire from spreading. Surfactants enable F-500 to penetrate combustible materials, including oils and fuels, extinguishing fires in otherwise hard-to-reach areas. The inhibition of chemical reactions reduces the rate of the reactions that sustain the flame, thereby effectively extinguishing the fire. It also helps in reducing smoke emission and toxic gases, improving safety for firefighters and other individuals present.

F-500 is particularly useful for extinguishing fires in hybrid vehicles due to its ability to efficiently cool battery modules and electrical components. Its formulation ensures safe use on electrical fires, reducing the risk of electric shock and further damage.

F-500 is typically mixed with water in recommended ratios, depending on the type of fire, and then directed at the flame source or the hottest part of the fire. For battery fires, continuous cooling is essential to prevent re-ignition.[7]

3. RECENT HYBRID VEHICLE FIRE IN CROATIA

The most recent hybrid vehicle fire in Croatia occurred on June 23, 2024. on the A3 motorway. The vehicle was completely burned. The incident involved extinguishing a lithium-ion battery fire which required a specific approach due to the complexity of extinguishing such batteries and the possibility of re-ignition after initial suppression. During the intervention, firefighters wore protective masks due to the release of toxic gases during battery combustion.

The intervention was classified as moderately severe. Although the hybrid vehicle had a battery, its size was not as large as that of fully electric vehicles, which somewhat, simplified the extinguishing process. After the vehicle was extinguished, firefighters monitored it to the disposal site and further inspected it using a thermal camera to ensure there was no risk of re-ignition. Fully electric cars can have batteries weighing between 400 to 500 kg, whereas the battery in this hybrid vehicle weighed 50-60 kg, significantly affecting the duration and complexity of the intervention.

The Croatian Firefighters Association is currently working on forming a task force to develop detailed guidelines for extinguishing fires in electric and hybrid vehicles. The aim of this group is to establish the best firefighting tactics, disposal procedures and communication with other relevant entities to ensure safety during such interventions.

This incident on the A3 motorway underscores the importance of specialized procedures for extinguishing fires in hybrid and electric vehicles and highlights the need for continuous education and preparation of firefighters to effectively manage such situations. In the future, the task force of the Croatian Firefighters Association will play a key role in standardizing protocols for interventions on vehicles with high-voltage batteries, ensuring safety and reducing the risk of potential fires.[8]

4. CONCLUSION

Given the increasing number of hybrid vehicles on the road, understanding the specific safety risks associated with these vehicles is crucial. Fires in hybrid vehicles present a unique challenge due to the combination of conventional engines and high-voltage batteries, necessitating thorough analysis and the development of preventive measures.

The technical requirements for the safety of hybrid vehicles encompass various aspects, including thermal characterization of fires, smoke and toxicity, and factors and causes of fires. Understanding heat release rates, smoke characteristics, toxic gases, and fire causes is essential for developing effective preventive measures.

Preventing fires in hybrid vehicles is vital for ensuring the safety of drivers, passengers and personnel. This involves careful design, the use of high-quality materials, the implementation of efficient cooling systems, and advanced battery management systems. Regular vehicle maintenance and monitoring the temperature of high-voltage components are also critical to preventing fires.

In the event of a fire above mentioned, it is important to apply appropriate firefighting protocols tailored to hybrid vehicles. This includes ensuring the safety of firefighters, identifying the type of battery and using specialized fire suppression agents. Monitoring the situation after extinguishing the fire is crucial to prevent re-ignition and ensure complete safety.

Finally, continuous alignment with the latest regulations and safety standards, along with regular training of firefighting personnel on modern firefighting techniques and agents, is key to ensuring the safety and reliability of hybrid vehicles in everyday use.

REFERENCES:

[1] Matteo, Di Silvia: Fire risk of electric vehicles in confined spaces; Politecnico di Torino, Torino 2023. *Available from* https://webthesis.biblio.polito.it/secure/26081/1/tesi.pdf, *Accessed: 2024.03.21.*

[2] La Scala, A., Sabba, M.F., Foti, D.: Fire Hazard of Electric Vehicles in Enclosed Structures, Politecnico di Bari, Bari, 2023. *Available from*: https://www.researchgate.net/profile/Armando-La-Scala/publication/365722079_Fire_Hazard_of_Electric_Vehicles_in_Enclosed_Structures/links/63e389edc002331f72624f2b/Fire-Hazard-of-Electric-Vehicles-in-Enclosed-Structures.pdf, *Accessed 2024.03.20.*

[3] Dorsz, A., Lewandowski, M.: Analysis of Fire Hazards Associated with the Operation of Electric Vehicles in Enclosed Structures, Energies 2022. *Available from*: https://www.researchgate.net/publication/357236873_Analysis_of_Fire_Hazards_Associ

ated_with_the_Operation_of_Electric_Vehicles_in_Enclosed_Structures *Accessed 2024.08.20.*

[4] The fire protection research foundation: Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results, Bowie, 2013. *Available from:*

https://www.energy.gov/sites/prod/files/2014/02/f8/final_report_nfpa.pdf. *Acessed: 2024.03.24.*

[5] International fire and safety journal: Thermal Runaway in Batteries – What are the Dangers? *Available from:* https://internationalfireandsafetyjournal.com/thermal-runaway/, *Acessed: 2024.03.24..*

[6] The State of Electric Vehicle Firefighting: 2023**,** *Available from*: https://tft.com/the-state-of-electric-vehicle-firefighting-2023/, *Acessed: 2024.03.24..*

[7] Šarić, M: požar električnog vozila, završni rad, Veleučilište u karlovcu, Karlovac, 2020. *Available from:* https://zir.nsk.hr/islandora/object/vuka:1628/datastream/PDF/view, *Accessed: 2024.03.25.*

[8] Glas Slavonije: Izgorjelo hibridno vozilo na autocesti, *Available from:* https://www.glas-slavonije.hr/553073/8/Izgorjelo-hibridno-vozilo-na-autocesti, *Accessed: 2024.06.25.*

STATISTICAL ANALYSIS OF WILDFIRES IN CROATIA: APPLICATION OF DATA FROM THE GLOBAL WILDFIRE INFORMATION SYSTEM (GWIS)

Maja Trečić[1], Nikola Radolić[2] Ivan Štedul[3], Manuela Žakula[4]

[1] Karlovac University of Applied Sciences, J. J. Strossmayera 9, Karlovac, Croatia, maja.trecic@student.vuka.hr

[2] Karlovac University of Applied Sciences, J. J. Strossmayera 9, Karlovac, Croatia, nikola.radolic@student.vuka.hr

[3] Karlovac University of Applied Sciences, J. J. Strossmayera 9, Karlovac, Croatia, ivan.stedul@vuka.hr

[4] Karlovac University of Applied Sciences, J. J. Strossmayera 9, Karlovac, Croatia, manuela.zakula@vuka.hr

Abstract: *This paper presents a statistical analysis of wildfires in Croatia using data from the Global Wildfire Information System (GWIS). The analysis covers the recent years, focusing on spatial and temporal patterns of wildfire frequency and intensity. The study examines key factors contributing to the occurrence of wildfires in different regions of Croatia and analyzes seasonal variations and trends. The results identify areas with the highest fire risk and provide insights into possible causes. Additionally, the paper discusses the potential of GWIS data in enhancing early warning systems and wildfire risk management in Croatia.*

Keywords: *Wildfires in Croatia, Global Wildfire Information System (GWIS), statistical analysis.*

1. INTRODUCTION

Wildfires represent a significant ecological, economic, and social challenge in many parts of the world, including Croatia. In recent decades, the frequency and intensity of wildfires have increased substantially due to a combination of climate change, human activities, and natural factors. In Croatia, where forests are an essential part of the national landscape and ecosystem, wildfires can cause lasting damage not only to the environment but also to local communities and the economy.

Recognizing the severity of this issue, the Government of the Republic of Croatia supplemented the existing document and, with changes, adopted a document titled "Disaster Risk Assessment for the Republic of Croatia" [1] in March 2024. This document emphasizes that "reducing disaster risk is of exceptional importance for individuals, communities, states, and the entire world. Disasters, regardless of their origin, can have serious consequences for people's lives, the economy, infrastructure, and the environment. To prevent the creation of new or reduce existing disaster risks, it is necessary to manage risks more effectively. Timely planning and preparation contribute to reducing the impact of disasters and help ensure safety, business continuity, and strengthen community resilience."

Additionally, in their paper "The Role of Civil Protection Headquarters in Open Space Fires,"[2] authors Miličić and Đurić highlighted the complexity and unpredictability of open space fires, noting that "open space fires, due to their nature, unpredictability, frequency, and potential consequences, represent an increasingly serious risk. In serious and complex situations that fires can cause, the operation of the civil protection system, upon which human lives and property depend, must also be taken seriously." They further warn that the lack of coordinated action plans often leads to improvisations, which, while sometimes successful, often depend on fortunate circumstances and the participants' immediate resourcefulness. To enhance effectiveness in combating these fires, the authors stress the importance of "well-coordinated collaboration between the civil protection headquarters, the firefighting command, higher-level headquarters, and other local government units," which is achieved through joint exercises and education.

In this context, understanding the spatial and temporal patterns of wildfires becomes crucial for effective risk management and the coordination of emergency services. Utilizing advanced technologies for data collection and analysis, such as the Global Wildfire Information System (GWIS), allows for precise monitoring and analysis of wildfires at both global and regional levels, providing essential information for disaster risk reduction and improving operational plans and responses of the civil protection system.

This paper aims to provide a detailed statistical analysis of wildfires in Croatia using GWIS data. It will explore the spatial distribution of fires, temporal trends, and key factors influencing their occurrence.

2. INPUT DATA FOR ANALYSIS

This analysis obtained data on wildfires in the Republic of Croatia from the GWIS[3] Country Profile application. This application provides an overview of wildfire trends, seasonality, and the spatial distribution of fires and burned areas at the country and sub-country levels for all countries worldwide. The application allows users to access detailed data, including visualizations such as charts and maps, which display key statistical characteristics of wildfires.

The data used in this study covers two distinct periods. The first dataset spans from 1991. to 2021., while the second covers 2002. to 2023. These datasets provide comprehensive insights into the number of fires, total burned areas, and the spatial and temporal variations of wildfires across these different timeframes. The statistical analysis includes calculating averages, and standard deviations, and identifying seasonal and annual trends. The methodological approach involves descriptive analysis of the number of fires and burned areas and examining the relationship between these variables.

The data and tools used for this analysis are freely accessible via the GWIS Country Profile application, available at the following link: https://effis.jrc.ec.europa.eu/static/country.profile/. This application provides easy access to relevant data and visualizations, making it a valuable resource for researchers and decision-makers.

3. RESULTS AND ANALYSIS

Between 1992. and 2021., the number of wildfires in the Republic of Croatia and the area affected by them varied significantly. From Figure 1. it can be seen that the largest burned area was recorded in the year 2000., with a total of 68.171 ha of forest burned. In contrast, the smallest burned area was in 2014., when only 188 ha were affected by fire.

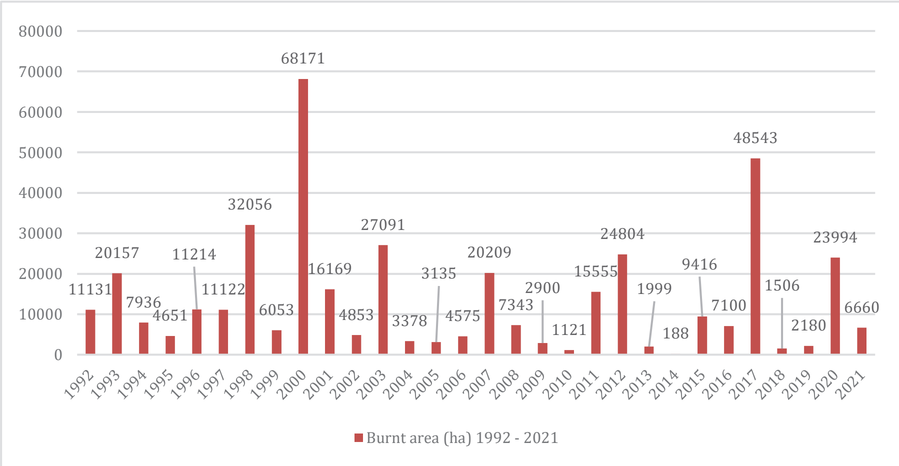


Figure 1 Burnt area (ha) 1992. – 2021. in Croatia [3]

When looking at the number of fires over the same period in Figure 2., a similar pattern emerges. The highest number of wildfires was also recorded in 2000, with a total of 706 fires, while the lowest number occurred in 2014, with only 43 fires. Generally, the data shows a correlation between the number of fires and the total burned area – in years with a higher number of fires, there was also a larger burned area, while in years with fewer fires, the damage was significantly lower.

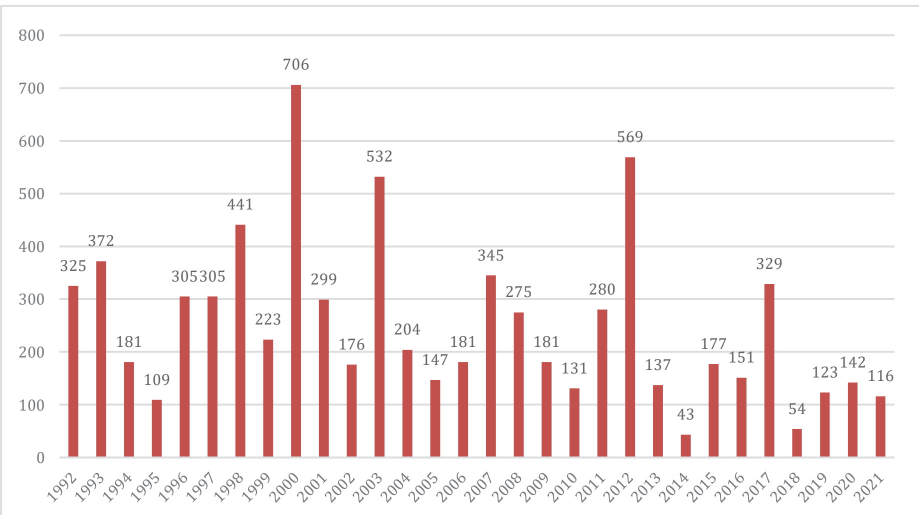


Figure 2. Number of fires by year 1992. – 2021. in Croatia

The average number of wildfires per year during the observed period was 252, with a standard deviation of 155 fires. The average area burned annually was 13.507 ha, but it is important to note that the standard deviation is quite high, at 2.758 ha, indicating significant variability in the burned area across different years.

These trends are illustrated in Figure 1. and Figure 2. which clearly show the relationship between the number of fires and the extent of the affected area.

3.1. REGIONAL ANALYSIS

To provide a more detailed regional analysis of wildfires, a comparison of average burned areas by county in the Republic of Croatia was conducted for the period from 2002. to 2023. To ensure comparability between counties of different sizes, the average burned area (in km²) was divided by the total area of each county. This method allowed for a proportional representation of wildfire occurrence, taking into account the size of each territory.

The results show that the largest burned areas were recorded in the Dubrovnik-Neretva County, followed by the Šibenik-Knin and Split-Dalmatia counties. These three coastal counties are known for being more exposed to wildfires, particularly during the summer months when high temperatures and drought periods occur.

In contrast, the counties of Koprivnica-Križevci, Krapina-Zagorje, and Varaždin recorded zero burned areas during the observed period, which can be attributed to their continental location and lower exposure to open-area fires.

These results are illustrated in Figure 3., which clearly shows the differences in wildfire occurrence among counties.

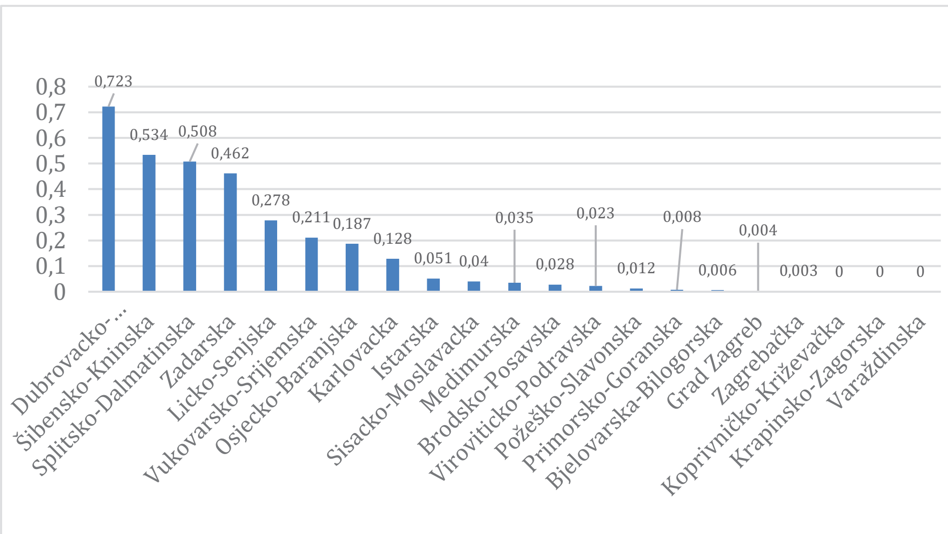


***Figure 3**. Average burned area (ha)/region area (km^2) in Croatia (2002. – 2023.)*

The connection between geographical characteristics and fire risk is further supported by the study[4] "Multicriteria Analysis of Fire Risk in the Split-Dalmatia County", which highlights that forest fires in the Split-Dalmatia County frequently occur during the tourist season, causing significant damage to the environment, tourism, and the economy.

Figure 4. presents the average number of wildfires per county from 2002 to 2023, adjusted for the area of each county (in km²). This approach provides a clearer comparison of wildfire frequency across different regions.

Interestingly, the highest wildfire frequency was observed in Lika-Senj County, followed by Vukovar-Srijem and Osijek-Baranja counties. This result is somewhat surprising, given that the counties with the largest burned areas—Dubrovnik-Neretva, Split-Dalmatia, and Šibenik-Knin—are ranked lower in terms of the number of fires, occupying 5th, 7th, and 8th place, respectively.

This discrepancy suggests that, while coastal counties experience fewer but larger-scale fires, some continental counties, such as Lika-Senj, Vukovar-Srijem, and Osijek-Baranja, face a higher frequency of smaller wildfires. The results highlight the different dynamics of fire occurrences across regions: coastal counties are more prone to catastrophic fires that affect large areas, likely due to environmental conditions such as strong winds and dry vegetation during the summer, while continental regions might experience more frequent but smaller-scale fires.

These findings suggest that fire prevention strategies should be tailored to specific regional characteristics. For coastal counties, emphasis should be placed on controlling large fires, while in continental regions, efforts could focus on reducing the frequency of smaller, recurring fires.

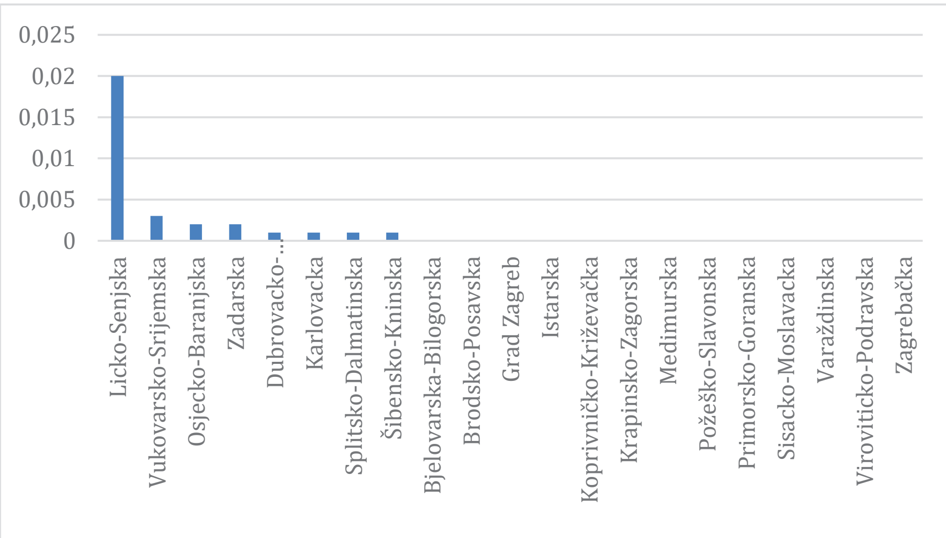


Figure 4. Average number. of fires/region area (km^2) in Croatia (2002. – 2023.)

3.2. SEASONAL PATTERNS

Figure 5. illustrates the average burned area (in ha) by month over the period from 2002. to 2023. The data reveal a distinct seasonal pattern, with the highest concentration of wildfires occurring in two key periods: early spring and mid-summer.

The spring season, particularly February, March and April, sees a notable increase in wildfire activity, with March recording the peak in burned areas. This rise in early spring can be attributed to dry vegetation and climatic conditions favorable for fire spread. May, however, shows a sharp decline in fire activity, with negligible burned areas during this period.

The second peak occurs in the summer months, especially in July and August when high temperatures and drought conditions lead to an increased risk of large-scale wildfires. These months consistently show the largest burned areas, corresponding with the dry Mediterranean climate along the coastal regions.

As the year progresses, the number of burned areas steadily declines, with autumn and early winter months (September to December) showing significantly lower fire activity. By December, wildfire occurrence becomes almost negligible, reflecting the wetter and cooler conditions typical of that season.

This seasonal distribution underscores the importance of focusing fire prevention efforts in the early spring and summer months when the majority of fire damage occurs.

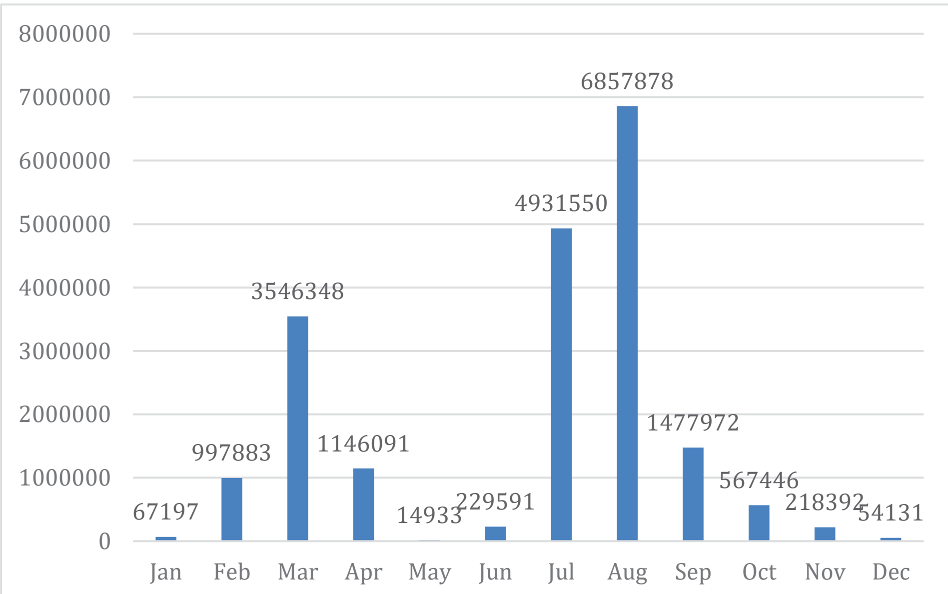


Figure 5. The average burned area (in ha) by month over the period from 2002. to 2023. in Croatia.

3.3. COMPARISON WITH OTHER EUROPEAN COUNTRIES

A comparative analysis, shown in Figure 6., presents the 20 European countries with the highest ratio of burned areas to land size (in hectares per square kilometer). Ukraine, Portugal, and Moldova top the list, while Croatia is ranked 19th. Despite being included in this group, Croatia shows a relatively lower impact of wildfires compared to many other countries.

Several factors contribute to Croatia's favorable position. The country benefits from an efficient firefighting and civil protection system, particularly in coastal regions where fires are most frequent. Strong preventive measures, including fire risk education and the maintenance of forest areas, help reduce the occurrence and spread of fires. Additionally, Croatia employs modern technologies for early fire detection, such as satellite monitoring and drone surveillance, which enable quicker responses.

Geographical diversity also plays a role. While the coastal Mediterranean region is more prone to wildfires, the continental parts of the country experience more rainfall, reducing fire risks. Croatia also benefits from international cooperation within the EU's civil protection mechanisms, ensuring rapid support during severe wildfire events.

Countries with a burned area-to-land ratio lower than 0.1 were not included in the analysis.

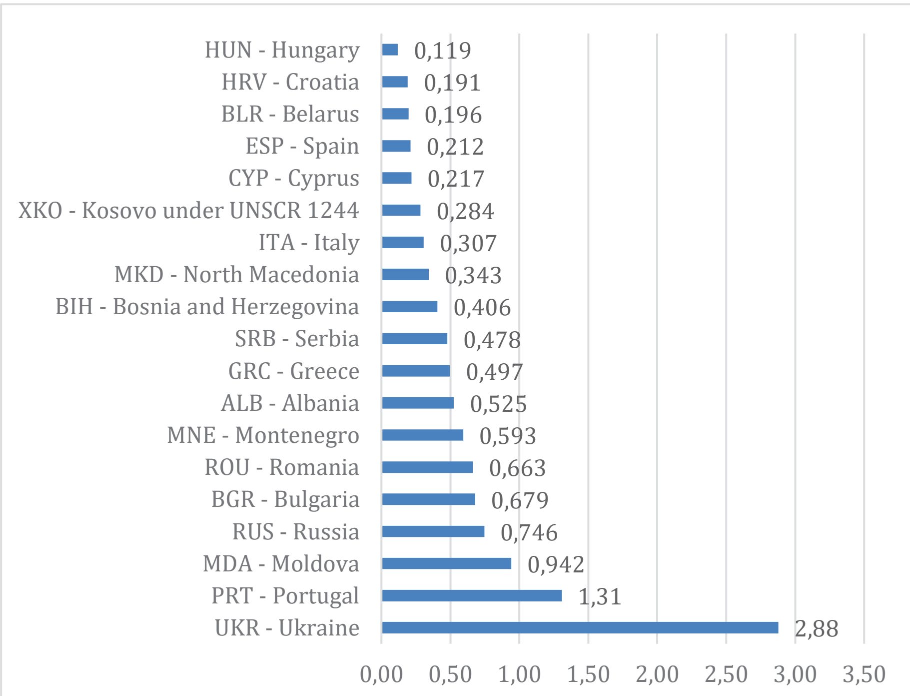


***Figure 6**. Average. burned area (ha)/region area (km^2) (2002. – 2023.)*

4. CONCLUSION

This analysis of wildfire trends in Croatia, supported by data from the Global Wildfire Information System (GWIS) and comparisons with other European countries, highlights the significance of effective wildfire management strategies. The data show that while Croatia experiences regular wildfires, particularly in the coastal regions, the overall impact, in terms of burned area per square kilometer, is relatively lower than in many other European countries.

Several factors contribute to Croatia's resilience to wildfires, including a well-organized firefighting and civil protection system, effective preventive measures, and the use of modern technologies for early detection and monitoring. Additionally, the geographical diversity between the Mediterranean and continental parts of the country plays a role in mitigating the spread of fires. International cooperation, particularly within the framework of the EU's civil protection mechanisms, further enhances the country's capacity to respond to severe wildfire incidents.

However, the data also show the importance of continuous improvement. The trends in burned areas and the number of fires suggest that wildfire risks remain significant, especially during the summer months. The regional differences in the frequency and severity of fires, as observed in various counties, underline the need for tailored regional strategies that address the specific fire risks of each area.

In conclusion, while Croatia has made substantial progress in managing wildfires, ongoing adaptation of fire prevention and response strategies, coupled with the use of advanced technologies and international collaboration, will be essential for mitigating the increasing wildfire risks posed by climate change and other factors.

REFERENCES

[1] "Procjena rizika od katastrofa za republiku Hrvatsku." https://civilna-zastita.gov.hr/hrvatska-platforma-za-smanjenje-rizika-od-katastrofa/80 (6.7.2024)

[2] A. Miličić and D. Đurić, "Uloga stožera civilne zaštite kod požara otvorenog prostora," *Conference proceedings 12th international scientific and professional conference "CRISIS MANAGEMENT DAYS 2019,"* pp. 104–114, 2019.

[3] "GWIS Global Wildfire Information System," https://gwis.jrc.ec.europa.eu/apps/country.profile/overview/ADM0/HRV.

[4] A. Netolicki, T. Blažević, and A. Antolović, "Multicriteria Analysis of Fire Risk in the Split-Dalmatia County," *https://hrcak.srce.hr/kig*, vol. 11, no. 17, 2012, Accessed: Jul. 05, 2024. [Online]. Available: https://hrcak.srce.hr/file/127940

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

SAFETY RISKS AND EXTINGUISHING FIRES OF ELECTRIC VEHICLES

Ivan Vrabec[1]; Anđelko Mihok[2]; Zvonimir Matusinović[3]

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, ivan_vrabec@hotmail.com
[2] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, amihok93@gmail.com
[3] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA, zvonimir.matusinovic@vuka.hr

Abstract: *Electric vehicles (EVs) mark a significant step forward in eco-friendly transportation, but they come with their own set of risks, as evidenced by EV fire incidents. This article delves into the causes, including battery cell flaws and external damage, which lead to thermal runaway and ignition. It also compares the frequency of EV fires to that of traditional vehicles, showing a lower rate but significant challenges due to lithium-ion battery properties. Additionally, it addresses the emergency services' response, the intricacies of managing EV fires, and the environmental repercussions of such events. The piece further investigates advancements in battery technology and materials that improve safety, as well as regulatory efforts to prevent and manage these occurrences. It concludes by considering the future impact on EV adoption and industry standards.*

Keywords: *Electric vehicles, fire, firefigting equpiment, environment, emergency response*

1. Introduction

Electric vehicles (EVs) are gaining popularity as a sustainable alternative to traditional combustion engines, but they come with their own set of risks, notably the potential for fires. While EV fires are less frequent than those in internal combustion engine vehicles, they can be particularly challenging due to the nature of lithium-ion batteries. These batteries can experience thermal runaway, a condition where increasing temperatures cause a self-sustaining series of reactions, leading to intense and difficult-to-extinguish fires.[1]

The introduction of EVs into the mainstream has necessitated a new approach to fire safety. Firefighters face unique challenges when dealing with EV fires, including prolonged burning and the risk of re-ignition due to the batteries' design and construction. The chemical exposure risks to first responders and the environment are also significant concerns that need addressing.[1]

Research and development of the battery design are ongoing to improve the understanding of EV fire dynamics, which will lead to more effective firefighting tactics and enhanced safety measures. This includes studying the burning characteristics of EVs, the thermal

and chemical exposures during fires, and the effectiveness of various fire suppression tactics.

As the adoption of EVs continues to rise, it is crucial to continue this research to ensure the safety of both the public and emergency responders and to maintain the momentum towards cleaner transportation. The introduction to electric vehicle fires sets the stage for a comprehensive discussion on these critical issues, highlighting the importance of preparedness and innovation in this evolving field.

2. Fire of the electric vehicles

EV fires are a point of concern due to the unique risks they pose. The core issue lies in the lithium-ion batteries that power these vehicles. Unlike traditional gasoline fires, lithium- ion fires can reach extremely high temperatures and are notoriously difficult to extinguish. This is because the batteries contain a flammable electrolyte that can ignite under certain conditions, such as physical damage, electrical short-circuiting, or overheating.

Firefighting efforts for EV fires require specialized knowledge and equipment. Traditional methods, such as using water or foam, may not be effective and can even be dangerous if not applied correctly. Firefighters often need to use large amounts of water to cool the batteries and prevent re-ignition, which can be a lengthy and resource-intensive process.

Despite these challenges, it’s important to note that EV fires are relatively rare. Studies suggest that the incidence of fire in EVs is significantly lower than in vehicles with internal combustion engines.[2] The advancement in battery technology and safety mechanisms continues to reduce the risk of fires. For instance, manufacturers are developing more stable battery chemistries and incorporating advanced Battery Management Systems (BMS) to monitor and prevent conditions that could lead to fires

3. Safety risks

Fires in electric vehicles powered by lithium-ion batteries pose two main dangers to emergency responders. First is the risk of **electric shock** from exposure to high-voltage connections in a damaged battery. Second is the risk that damaged cells in the battery will experience uncontrolled increases in temperature and pressure, known as **thermal runaway**, which can lead to venting and combustion of toxic gases, cell rupture and release of projectiles, and battery reignition/fire.[1]

The risks of electric shock and battery reignition/fire arise from the energy that remains in a damaged battery – known as **stranded energy**.[1]

3.1 Electric shock

The human body is an electrical conductor; if it contacts an energized source of electricity, current will flow through it. The body's resistance – its ability to reduce an electric current – varies from person to person and according to whether the skin is wet or dry, among other things. To protect occupants, bystanders interacting with injured persons, and emergency responders from electric shock, safety standards require electrically isolating the high-voltage battery system from the vehicle's chassis. If a crash damages the electrical isolation system, a person who touches the vehicle (or an exposed connector) can become part of the high-voltage circuit and suffer serious injury or death.[1]

3.2. Thermal runaway

Thermal runaway is a chemical process that produces heat (an exothermic reaction); the heat increases the rate of the reaction, which further increases the temperature and escalates the process. Thermal runaway can spread from one battery cell to many cells, in a domino effect. The originating cause of thermal runaway is generally short-circuiting inside a battery cell and a resulting increase in the cell's internal temperature.

Fire and explosion can result when cells go into thermal runaway. The flammable solvent in the electrolyte can ignite if exposed to high temperatures or electrostatic sparks.

A recent study identified four primary hazards of thermal runaway:

(1) venting of toxic and flammable vapors from the electrolytic solvent, through pressure-relief devices or holes in the battery casing
(2) combustion of vapors ejected from the flammable electrolyte solvent
(3) localized overpressure
(4) rupture of the cell casing and release of projectiles if pressure-relief devices are absent or fail.

Secondary hazards identified in the study were release of toxic and corrosive chemicals, ignition and burning of combustible parts of the vehicle, asphyxiation of vehicle occupants from toxic gases vented by the battery, and electric shock to occupants, first responders, or maintenance personnel from exposure to high-voltage conductors if electrical insulation and isolators melt or burn. Flammable gases released from a damaged battery constitute the most significant fire threat, according to study.[1]

3.3. Stranded energy

If a high-voltage battery is damaged, energy remains inside any undamaged battery modules and cells, with no path to discharge it. That stranded energy can cause a high-voltage battery to reignite multiple times after firefighters extinguish an electric vehicle fire. Emergency responders have no way of measuring how much energy remains in a damaged battery.

Electric vehicles are always equipped with emergency cut loops; low-voltage wire loops that first responders can safely cut to disconnect the high-voltage system from the rest of the vehicle. Severing the cut loops will isolate high-voltage power inside the battery, thereby protecting the rest of the vehicle.

Manufacturers have developed tools to drain the high-voltage batteries in their vehicles, but the tools, which require a specialist to operate, are usually specific to the vehicle and work only on an intact battery.[1]

4. Extinguishing fire of electric vehicles

Extinguishing an electric car fire involves a specific set of procedures due to the unique characteristics of lithium-ion batteries.[2] Here's a step-by-step guide based on the latest information:

Safety First: Ensure the safety of all individuals by establishing a secure perimeter around the vehicle. **Cut Off Electricity**: If possible, disconnect the battery from the electrical system to stop the flow of electricity, **Cooling the Battery**: The primary method to extinguish an electric car fire is to cool the battery cells directly, **Avoid Firefighting Foam**: Traditional firefighting foams are ineffective against electric car fires, **Wait It Out**: In some cases, if the battery box is intact and there are no exposures, **Use Appropriate Extinguishers, Continuous Monitoring**: Even after the fire appears to be out, continuous monitoring is necessary, **Professional Cleanup**: Due to the hazardous materials involved, a professional cleanup crew should handle the aftermath.

It's crucial for emergency responders to receive specialized training in handling electric car fires to effectively manage these incidents and minimize risks to themselves and the public.[3]

4.1. Fire container

Not only in case of a malfunction but also in the event of an accident the batteries of an electric vehicle can catch fire. A special feature is that the accumulator starts to burn off automatically after only a few moments above a critical ignition temperature. Due to the high heat development as a result of such a fire, salvage and extinguishment is extremely difficult.

If a lithium-ion battery catches fire once, the source of the fire must be cooled by an enormous amount of water (more than 100 000 L). The batteries cause one big difficulty when it comes to cooling them: since they are so well encapsulated the water cannot be brought close enough to the cells to achieve a sufficient cooling effect; the emergency services on our roads will also have to face this problem. The solution is to flood the vehicle in a special container rather than simply extinguishing it by conventional means.[5]

4.2. Fire blanket

Fire blanket is the most efficient way to isolate and extinguish car fires, even in electric vehicles. Any car fire is dangerous and toxic. A car fire in a gas station, road tunnel, car park or passenger ferry can be a disaster. Fire Blanket enables us to contain the flames, smoke and toxic fumes in a car fire in seconds. It's the only solution that can effectively handle fires in electric vehicles, until better solution is available.[6]

4.3. Recover-e-bag

This system offers a straightforward and effective solution for managing electric vehicles post-fire. Designed to conform to the contours of various car models, it ensures minimal water usage while being equipped for extinguishing purposes. As a portable and cost-efficient alternative to traditional roll-off containers, this system allows for easy vehicle entry and elevation, making it ideal for use in confined spaces such as underground parking and small yards. Once the vehicle is secured within the system, it can be safely transferred to a tow truck. The system also captures and contains any runoff water, facilitating proper disposal and mitigating environmental impact. Its compact design allows for effortless transportation and storage, rendering it an optimal choice for fire departments, towing services, auto repair shops, and car dealerships.[7]

5. Real life situation

The advantages of electric cars compared to conventional ones are clear to everyone, as well as the obvious disadvantages. Because when a fire breaks out on the "electricity", it is extremely difficult to put it out. Firefighters regularly struggle to put out electric car fires. Numerous innovations are applied, from special blankets to specific extinguishing materials, but the classic "water method" still prevails. If it is not possible to submerge the car in a tank with water, then the vehicle must be watered abundantly and cooled. And this can take a long time, which means that the water consumption will be many times higher than in the case of extinguishing a fire on an "ordinary" car. This is also confirmed by the event, when firefighters from the town of Pine Level in the USA, received a call at around 11 p.m. A Tesla Model Y was in a traffic accident, which then caught fire. The driver escaped from the car in time and saved himself, while the vehicle, despite the quick arrival of the firemen, was completely burnt. Extinguishing the fire took more than an hour, and the firefighters used over 135,000 liters of water. This is at least 36 times more than what is needed to put out a fire on an ordinary car. For the sake of comparison, this is the amount of water that an average family of four consumes during the year. In their post, firefighters emphasized that "electric vehicle fires are uncommon and present unique challenges and dangers for firefighters" because vehicles can "reignite hours or days after being extinguished." At the same time, temperatures higher than 2500°C are created. It was noted that the smoke from these burning electric cars contains hydrogen fluoride and hydrogen chloride. Both are toxic and require firefighters to wear special protection.[4]

6. Conclusion

In conclusion, the phenomenon of electric vehicle (EV) fires, while a rare occurrence, underscores the need for specialized knowledge and preparedness in handling such emergencies. The unique challenges posed by lithium-ion battery fires require a departure from traditional firefighting techniques, demanding innovative approaches and continuous education for first responders. As the automotive industry shifts towards electrification, the safety protocols and emergency response strategies must evolve in tandem to address the potential risks associated with these advanced power systems. The example of the ignition of an electric car given in this paper confirms that the huge amounts of water is used to extinguish electric car and that fires of electric vehicles present a great danger for for firefighters because vehicles can reignite hours or days after being extinguished. This paper has highlighted the importance of ongoing research, technological advancements in battery safety, and the development of effective firefighting methods to ensure public safety. Ultimately, the collective efforts of manufacturers, policymakers, and emergency services will be pivotal in fostering a safe and sustainable transition to electric mobility.

REFFERENCES

[1] National Transportation Safety Board, *Safety risks to emergency responders from lithium-ion battery fires in electric vehicles*, available from https://www.ntsb.gov/safety/safety-studies/Documents/SR2001.pdf, accessed 2024-06-09.

[2] Gas vs. Electric cars fires, available form https://www.autoinsuranceez.com/gas-vs-electric-car-fires/, accessed 2024-06-09

[3] Fire Rescue 1, *Electric vehicle fires: where waiting game wins*, available from https://www.firerescue1.com/electric-vehicles/articles/electric-vehicle-fires-where-the-waiting-game-wins-f934UedqIpVqc1k2/, accessed 2024-06-10.

[4] Tesla fire,. available from https://dnevno.me/kola%C5%BE/-/za-gasenje-pozara-na-tesli-potrosili-vise-od-135-000-litara-vode-31-12-2023-13-29-07, accessed 2024-10-06

[5] Open Source Lab, *The Red Boxx - a Bathtub for cars,* available form https://opensourcelab.dfki.de/the-red-boxx-a-bathtub-for-cars/, accessed 2024-06-10.

[6] Bridgehill, *Car fire blankets*, https://bridgehill.com/fire-blankets/car/, accessed 2024-06-11

[7] Weber rescue, *Recover-e-bag*, https://www.weber-rescue.com/en/feuerwehr/zusatzausruestung/glasmanagement-und-sicherungssysteme/recover-e-bag.php, accessed 2024-06-11

[8] Žakula Manuela, Krin Snježana*, Istraživanje postupaka gašenja požara na električnim vozilima*, Sigurnost magazine - number 65; pages 255-267, published 2023

[9] Žakula Manuela, Krin Snježana, Marjan Šarić, *Extinguising fire in electric vehicles*, 7th International Scientific Conference On Safety Engineering Fire, Environment, Work Environment, Integrated Risk; 17th International Conference on Fire And Explosion Protection, pages 86-93, published 2021.

8

SOCIAL AND HUMANISTIC ASPECTS

WHAT MOTIVATES VISITORS TO VISIT HUNTING LODGE MULJAVA? – VISITOR MOTIVATION, SATISFACTION, LOYALTY AND SUSTAINABLE DEVELOPMENT

Tihana Cegur Radović[1], Dijana Benko[2], Lora Vucelić[3]

[1]Karlovac University of Applied Sciences, Trg I. G. Kovačića 9, Karlovac, Croatia, tcradovic@vuka.hr
[2]Hrvatske šume d.o.o., Put Davorina Trstenjaka 1, Karlovac, Croatia, lovacki-dom-muljava@hrsume.hr
[3]Istrabenz plini d.o.o, Pristanište podbok 3, Bakar, Croatia, lruzic1809@gmail.com

Abstract

The purpose of this paper is to determine the impact of visitor motivation and satisfaction on their loyalty to visit Hunting Lodge Muljava. The goal was to investigate the relationship between visitor motivation, satisfaction and loyalty. An analysis of the recent literature on the topic of the visitor motivation, satisfaction and loyalty was performed. Empirical research was conducted on a convenience sample of 113 visitors of Hunting Lodge Muljava on April 30· 2022. Descriptive and multivariate statistics were used in the data analysis. The data analysis was performed using the software package IBM SPSS Statistics version 29. The results of this research analyse the relationship between the visitor motivation to visit Hunting Lodge Muljava, their satisfaction and loyalty as well as possible sustainable development in the future. Furthermore, this research is useful for hotels and hospitality management in order to improve the quality of their services and offer to different target groups of visitors and possible sustainable development in the future.

***Keywords**: visitor motivation, satisfaction, loyalty, sustainable marketing, sustainable development*

1. INTRODUCTION

Muljava is a hunting lodge located on the hills of Petrova gora. It is an ideal place for rest and recreation. It provides accommodation in eights rooms with a total of 27 beds. It is well known for its gastronomic offer of game dishes, grilled and skewered dishes, seasonal dishes and forest fruit desserts. Throughout the years it has received numerous awards for its quality. In the last few years, the Hunting Lodge Muljava also offers catering services [1]. Hunting Lodge Muljava is investing in employee education, energy efficient materials and green transition. Furthermore, its plan is to increase accommodation capacity and the number of staff.

Empirical research of the motives, satisfaction and loyalty of visitors on the Hunting Lodge Muljava was conducted on a convenience sample on April 30 2022. The research goal was the attitude of the Hunting Lodge Muljava visitors, their motives to visit, satisfaction with the Hunting Lodge Muljava products, services and content offer as well as their loyalty.

The research questions were:

1. What is the most common visitor motivation to visit the Hunting Lodge Muljava?
2. What are visitors most satisfied with in the Hunting Lodge Muljava?
3. Is there a relationship between visitor motivation for coming to the Hunting Lodge Muljava and their satisfaction?
4. Is there a relationship between visitor motivation for coming to the Hunting Lodge Muljava and their loyalty?
5. Is there a relationship between the visitor satisfaction with the Hunting Lodge Muljava and their loyalty?

Based on the research questions, here are the following hypotheses:

H1: The most common visitor motivation for visiting the Hunting Lodge Muljava is special events.

H2: The visitors of the Hunting Lodge Muljava are most satisfied with the staff of the Hunting Lodge Muljava.

H3: There is a positive relationship between the visitor motivation and their satisfaction with the Hunting Lodge Muljava.

H4: There is a positive relationship between the visitor motivation and loyalty of visitors with the Hunting Lodge Muljava.

H5: There is a positive relationship between satisfaction and loyalty of visitors with the Hunting Lodge Muljava.

The results of this research analyze relationship between visitor motivation, satisfaction and loyalty of visitors to the Hunting Lodge Muljava. This result can help the management of the Hunting Lodge Muljava to improve the quality of their product, services and content for different target groups of visitors. The result can also help other hospitality and hotel management in their quality management. Data analysis was performed using software package IBM SPSS Statistic Version 29.

2. LITERATURE REVIEW

Motivation is an indispensable factor of customer behaviour [2]. It steers and directs customer behaviour [3]. Understanding the visitors' motive for visiting an event represents a key concept in creating offer for visitors and personalizing that offer to suit their needs as well as in building the loyalty of visitors [4]. Measurement of visitor motivation is the key to satisfied visitors. It attracts more visitors, predicts future demand and creates new products, services and experiences that meet the visitors' needs and demands [5]. There are differences in visitors' motivation according to the visitor type, specifically between foreign, daily and local visitors [6].

Many authors have shown interest in examining the motivation – satisfaction relationship. Satisfaction is the outcome of subjective evaluation whether the selective alternative meets or exceeds expectations [7]. Satisfaction has a positive influence on the visitors' post-purchase behaviour such as recommendations and intention to revisit [8]. Loyalty is defined as repeat purchase behaviour and is characterised in terms of repurchase intentions, WOM communications and recommendations [9]. Satisfied visitors may revisit a place and recommend it to others [10].

3. FINDINGS

To achieve the purpose and goal of the paper, an empirical study was conducted on a convenience sample of 113 respondents. The sample description based on gender, age, main reasons for coming to the Hunting Lodge Muljava are shown in Table 1. Scales from previous studies were used and translated to the Croatian language. The attitudes of the respondents were measured using a Likert scale for evaluating attitudes ranging from 1 to 7 (1- completely disagree, 7- completely agree). Visitor motivation was measured using a Likert scale created by Uysal et al. (1993) with 15 variables [11]. The satisfaction of the visitors and sharing experiences through social networks was measured using a Likert scale created by Bounincontry et al. (2017) with 10 variables [12] and loyalty was measured using a scale by Kim et al. 2010 [13], Kim et al. 2015 [14] with 3 variables regarding future visit and recommendations. All the variables with arithmetic mean, mode and standard deviation are shown in Table 2. There were also two open questions "What do you thing should be improved in the offer of the Hounting Lodge Muljava?" and "How can the Hounting Lodge Muljava develop in the future?".

Table 1 shows sample structure of respondents.

Table 1: Sample structure (N = 113)

Characteristics	Total	
GENDER	N	**%**
Female	68	60.2
Male	45	39.8
AGE		
18-25	6	5.3
26-35	10	8.8
36-45	43	38.0
46-55	28	24.8
56-65	23	20.4
NUMBER OF PREVIOUS VISITS		
This is my first time	23	20.4
Only once before	16	14.2

Three visits	14	12.4
Four visits	44	38.8
I have been visiting for a long time	16	14.2
HOW DID YOU FIND OUT ABOUT THE HUNTING LODGE MULJAVA?		
Social networks	23	20.4
Jumbo posters	3	2.7
Brochures	3	2.7
Other (word of mouth)	84	74.2

Source: Research results

The sample structure shows that more women (60.2 %) then man (39.8 %) participated in the survey. The respondents were mainly middle-aged people from 36 to 45 years of age (38 %). The majority of the visitors visited the Hunting Lodge Muljava four times (38.8 %) and they mostly heard about the Hunting Lodge Muljava from other people (74.2 %).

Table 2 shows variables from the questionnaire and descriptive statistic with Cronbach alpha.

Table 2: Descriptive statistics and Cronbach alpha of variables

Item	Arithmetic Mean	Mode	St. dev.	Cronbach alpha
MOTIVES				**0.865**
1. To get away from the demands of life	**3.99**	**5**	**1.243**	
2. I enjoy its gastronomic offer.	**4.29**	**5**	**1.050**	
3. I was curious.	**3.58**	**5**	**1.328**	
4. To experience new and different things.	**3.93**	**5**	**1.067**	
5. To be with people of similar interests.	**4.12**	**5**	**1.059**	
6. I enjoy the crowd.	**2.98**	**3**	**1.458**	
7. It is stimulating and exciting.	**3.70**	**4**	**1.133**	
8. I enjoy in cultural and historical heritage.	**3.58**	**5**	**1.315**	
9. The Hunting Lodge Muljava is unique.	**4.11**	**5**	**1.080**	
10. I like the variety of things to see and do.	**3.98**	**5**	**1.035**	
11. I enjoy special events.	**4.44**	**5**	**0.844**	
12. I have been here before and have a good time.	**4.10**	**5**	**1.356**	
13. So I could be with my friends.	**4.39**	**5**	**1.047**	
14. I thought the entire family would enjoy it.	**4.36**	**5**	**1.111**	
15. I heard good things about the Hunting Lodge Muljava.	**3.90**	**5**	**1.414**	

SATISFACTION WITH THE OFFER AND CONTENT				**0.765**
16. Information about the Hunting Lodge Muljava.	**4.04**	**5**	**1.133**	
17. Gastronomic offer	**4.59**	**5**	**0.970**	
18. The ambiance of the restaurant	**4.66**	**5**	**0.607**	
19. Beauty of the environment	**4.65**	**5**	**0.652**	
20. Souvenir offer	**3.21**	**3**	**1.285**	
21. Events	**3.18**	**3**	**1.377**	
22. Cultural – historical heritage	**3.78**	**5**	**1.294**	
23. Entertainment for children	**3.42**	**5**	**1.368**	
24. Staff	**4.74**	**5**	**0.531**	
LOYALTY				**0.591**
25. I will participate in similar types of events in the future.	**4.29**	**5**	**.926**	
26. I will revisit the Hunting Lodge Muljava in the future.	**4.65**	**5**	**.654**	
27. I will recommend the Hunting Lodge Muljava to others.	**4.65**	**5**	**.654**	
28. I have shared my experience of the visit with others through social networks.	**3.83**	**5**	**1.395**	

Source: Research results

The arithmetic means of the variables of visitor motivation range from 2.98 to 4.44 and mode range from 3 to 5. The variable "I enjoy special events" has the highest score, and mode is 5. The values of standard deviation exceed 1, pointing to data dispersion except for the variable "I enjoy special events." The values of the arithmetic mean of satisfaction range from 3.18 to 4.74. Mode is 3 and 5. The highest score has the satisfaction with the staff of the Hunting Lodge Muljava. The mode is 5. The construct loyalty has values of arithmetic mean range from 3.83 to 4.65 and mode 5. The majority of the visitors will revisit and recommend the Hunting Lodge Muljava. Cronbach alpha coefficients are for construct visitor motivation 0.865, for satisfaction 0.765 and for loyalty 0.591.

Tabela 3: Pearson Correlation of constructs visitor motivation, satisfaction and loyalty with the Hunting Lodge Muljava

		MOTIVES	**SATISFACTION**	**LOYALTY**
MOTIVES	Pearson Correlation	1	.505**	.531**
	Sig. (2-tailed)		0,000	0,000
	N	113	113	113
SATISFACTION	Pearson Correlation	.505**	1	.429**
	Sig. (2-tailed)	0,000		0,000
	N	113	113	113
LOYALTY	Pearson Correlation	.531**	.429**	1
	Sig. (2-tailed)	0,000	0,000	

	N	113	113	113
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Research results

The results of the Pearson Correlation show that the satisfaction has a positive, moderate and significant relationship with visitor motivation (r = 0.505, p = 0.000), loyalty has positive, moderate and significant relationship with visitor motivation (r = 0.531, p = 0.000) and loyalty has positive and significant moderate relationship with satisfaction (r = 0.429, p = 0.000).

4. DISCUSSION AND CONCLUSION

The purpose of this research is to determine the impact of visitor motivation and satisfaction on their loyalty to visit the Hunting Lodge Muljava. The five research questions and five hypotheses were set. Empirical research was carried out. It has been established that the most common visitor motivation for visiting the Hunting Lodge Muljava are different special events. The arithmetic mean is 4.44 and mode 5. This confirms the first hypothesis H1. The second hypothesis H2: The visitors of the Hunting Lodge Muljava are most satisfied with the staff of the Hunting Lodge Muljava. is also confirmed. The arithmetic mean is 4.74 and mode is 5. This information confirms the theory that people are one of the most important factors of the quality of service. The hypotheses H3, H4, and H5 were also confirmed. There is a positive, moderate and significant relationship between visitor motivation and satisfaction (r = 0.505, p = 0.000) which confirmed hypothesis H3, visitor motivation and loyalty (r = 0.531, p = 0.000) which confirmed hypothesis H4 and satisfaction and loyalty (r = 0.429, p = 0.000) which confirmed hypothesis H5.

During the research there were some limitations. The research depended on weather conditions. There were also limitations regarding the visitors who visited the Hunting Lodge Muljava. There are different attitudes from tourists, visitors who visited the Hunting Lodge Muljava from other part of Croatia and locals. Also, the big crowd during the research had a negative effect on respondents. Most of them refused to fill in the questionnaire. The future research must be conducted longitudinally in terms of different events on the Hunting Lodge Muljava and different target groups. There are also different attitudes regarding tourists, visitors and locals which need to investigate. The research result can help managers develop marketing strategies and tactics to create some new facilities and experience of different events. Also, there is a need for some new quality products and services in the Hunting Lodge Muljava.

The research analysis has also found that the visitors want more facilities for children, increase in the number of accommodation capacities, renovated paths and roads and more employees in order to reduce the crowdedness. The visitors suggested development in the direction of expanding the existing facilities, increasing marketing activities and the visibility of the Hunting Lodge Muljava. The research analysis confirmed that visitors return to the Hunting Lodge Muljava and recommend it to others. They also share their visit experience through social networks. The Hunting Lodge Muljava has been placed on the tourist and gastronomic map not only of the Karlovac County but also the entire area of continental Croatia. They do that with hard work and engagement of its employees.

Reconstruction of the existing and construction of a new building is a part of new sustainable development strategy of the Hunting Lodge Muljava. The future plan of the Hunting Lodge Muljava are 4-star room categorization end ecological label. Through the arrangements of the existing building, in addition to the arrangement of 7 new rooms, it is possible to arrange the interior of the restaurant, improve energy efficiency of the building, replace the necessary installations and modernize the building. The design of the lamella structure, a longitudinal building that follows the layers of the terrain, fits into the existing environment with minimal interventions in environment. The lamella structure building is compact, cut into the hill, with a green roof with the natural vegetation. With its dimensions and designs it allows more space for different purposes which expand to tourist offer, such as wellness, a conference hall, additional restaurant areas and others.

The reconstruction of the existing building and the construction of an additional new one offers the possibility of obtaining an environmental label. The environmental label represents a key step towards sustainable development of the Hunting Lodge Muljava. This way the Hunting Lodge Muljava shows its commitment to environmental protection and the community. The benefits of ecological labels are numerous like reducing ecological footprint, saving in the consumption of water, energy and other resources, reducing waste and adapting sustainable practices in the procurement of food and other products that contributes to the economic efficiency of the business. Internationally recognized environmental labels attract visitors who appreciate ecologically conscious hospitality and accommodation facilities.

REFERENCES

[1] Hrvatske šume; *Availabe from* https://www.hrsume.hr/index.php/hr/turizam/nai-objekti/muljava *Accessed* 2024-06-10

[2] Mahika, E.-C.; Rădulescu, R.; Aluculesei, A. - C.: The Behaviour of Romanian Tourists Regarding the Attendance at Festivals", *Procedia Economics and Finance*, Vol. 23, (2015), pp. 1239-1244, ISSN: 2212-5671, doi:10.1016/s2212-5671(15)00345-7

[3] Iso-Ahola, S. E.: *The Social Psychology of Leisure and Recreation*, Dubuque, IA: William C. Brown, (1980)

[4] Lončarić, D.; Cegur Radović, T.; Skendrović, P.: Who attends Christmas Markets and why? Analysis of visitor structure and motivation for attending two Christmas Markets in Croatia, *Econviews*, Vol. 20 (2020), No.1. pp. 101-114, e-ISSN 1847-2206

[5] Albayrak, T.; Caber, M.: Examining the relationship between tourist motivation and satisfaction by two competing methods, *Tourism Management*, Vol. 69 (2018), pp. 201-213, e-ISSN: 1879-3193

[6] Matheson, C. M.; Rimmer, R; Tinsley, R.: Spiritual attitudes and visitor motivations at the Beltane Fire Festival, Edinburgh, *Tourism Management*, Vol. 44 (2014), pp. 16-33, e-ISSN: 1879-3193

[7] Kim, Y. G., Suh, B. W., Eves, A.: The relationships between food-related personality traits, satisfaction, and loyalty among visitors attending food events and festivals,

International Journal of Hospitality Management, Vol. 29, No. 2 (2010), pp. 216-226, e-ISSN: 1873-4693
[8] Caber, M., Albayrak, T., Ünal, C.: Motivation-based segmentation of cruise tourists: a case study on international cruise tourists visiting Kușadasi, Turkey, *Tourism in Marine Environments*, Vol. 11, No. (2/3) (2016), pp.101-108, e-ISSN: 2169-0197
[9] Lee, M. S.; Chou, J. N.; Lin, Y.: The research of the relationship among service quality, relationship quality and customer loyalty in leisure farms, *Journal of Agricultural Economics*, No. 8 (2006), pp. 125 – 168, e-ISSN:1477-9552
[10] Tanford, S., Jung, S.: Festival attributes and perceptions: A meta-analysis of relationships with
satisfaction and loyalty, *Tourism Management*, Vol. 61 (2017), pp. 209-220, e-ISSN: 1879-3193
[11] Uysal, M., Gahan, L., Martin, B.: An Examination of event motivations: A case study, *Festival Management & Event Tourism*, Vol. 1, No 1, (1993), pp. 5-10, ISSN 1065-2701
[12] Buonincontri, P., Morvillo, A., Okumus, F., Van Niekerk, M.: Managing the experience co-creation process tourism destinations: Empirical findings from Naples, *Tourism Management*, Vol. 62, (2017), pp. 264-277, e-ISSN: 1879-3193
[13] Kim, Y. G., Suh, B. W., Eves, A.: The relationships between food-related personality traits, satisfaction, and loyalty among visitors attending food events and festivals, *International Journal of Hospitality Management*, Vol.
29, No. 2 (2010), pp. 216 – 226, e-ISSN: 1873-4693
[14] Kim, H., Woo, E., Uysal, M.: Tourism experience and quality of life among elderly tourists, *Tourism Management*, Vol. 46, (2015), pp. 465-476, e-ISSN: 1879-3193
[15] Mahika, E.-C., Rădulescu, R., Aluculesei, A.-C.: The Behaviour of Romanian Tourists Regarding The Attendance at Festivals, *Procedia Economics and Finance*, Vol. 23 (2015), pp. 1239-1244, ISSN: 2212-5671, doi:10.1016/s2212-5671(15)00345-7

WHAT IS THE RISK?

Tatjana Čumpek
Senior Advisor of Civil Protection, email: tcumpek@mup.hr

Abstract: „Risk comes from not knowing what you are doing." *Although there is a simple formula for assessing risk, we are more prone to broad theorizing, that becomes a burden instead of a guide.Each local community or company or household best assesses environmental hazards (risks). They also know best their capacities, level of preparedness and ways of mitigating the consequences.That is why all instructions for risk assessment should be understandable, short and encourage the self-observation of changes in the environment.Here I am appealing for the additional engagement of employees in the local community, as well as individuals for the benefit of community and households. This makes you and your community more resilient. In the event of major accidents and disasters, when local capacities are insufficient, assistance will be provided by the national level of civil protection with state forces and capacities.*

Keywords: *risk, assessment, community, resilience*

1. Risk assessment approach and methodology

Increasing exposure to negative anthropogenic impacts has generated a whole range of approaches to risk analysis. From initial comprehensive preparedness measures to evaluation and preparedness for potential risks according to the standard for risk management - ISO 31000. Managing risks means ensuring improvements and defined risk reduction goals. By measuring efficiency, we will see the improvements achieved. ISO 31000 is a guideline that describes a generic risk management process for all areas of application. The instructions that we can use from this standard refer to the risk management process:

1. Determining the context - communication and consultation of stakeholders,
2. Risk identification;
3. Risk analysis;
4. Risk evaluation - evaluation and processing
5. Monitoring and reviewing the risk we are preparing for

The second standard ISO 31010 provides risk calculation methods applicable in different spheres and involves multidisciplinary teams. This 31010 standard is an integral concept that, in addition to assessing the profession, includes experience, science, or extrapolation of data and predictions from scientific studies.

The term that unites the interaction of science and prediction we call an educated guess. The standard does not ignore communication with the population (community at risk - CAR) or the incorporation of previous experiences. The history of events that we publish as a "return period" is now modeled according to recent changes in the environment, regardless of whether they are caused by the human factor or changes in nature.

When the context of the expected risk is determined, prevention, preparedness and risk reduction measures are initiated.

The measures taken must be co-created, that is, the result of a joint consensus of the profession, science and the population of the community exposed to risk. Only in this way are the measures sustainable and compatible, i.e. adapted to the community and environmental conditions.

1.2 Cost-effectiveness of risk reduction

Observe, evaluate and prepare in a way that guarantees personal safety and community safety with measures appropriate to your income.

The risk reduction approach, ALARP (As low as reasonably practicable), is described as an approach that assesses the relationship between risk exposure and the application of "reasonably acceptable" risk reduction measures. Affordability is nothing but the attitude towards cost growth. It is not difficult to conclude that the stronger economies of developed countries will be able to allocate more (RP - reasonably practicable) for risk reduction, while less developed and populous countries are forced to accept exposure to more disastrous risks. The ALARP concept is oriented towards risk reduction investments and includes both positive and negative risks. An essential element of risk assessment is uncertainty, that is, the variable of risk probability. Precisely because of this uncertainty, investment results will increase the negative effects against the positive ones.

We should see these negative and positive effects as positive and negative risks. It is not possible to prepare for all unexpected and uncertain situations, but by understanding the risks, we can prepare acceptable mitigation measures. It is this attitude that can help us to use the negative effects of risk and turn them into positive effects of risk.

Julian Talbot [1] comments on ALARP as a traditional risk management approach that is good for negative risks, however the ISO 31000 definition of risk includes both positive and negative effects of risk. Talbot believes it is time to phase out the ALARP approach entirely.

That's why the newer approach - As high/low as reasonably practicable (AHLARP) is being mentioned more and more often. This risk assessment model emphasizes positive effects (as high), which should be as high as possible in relation to the invested funds and risk reduction. The moment when the positive effects outweigh the negative is marked by the acronym RTP - Risk Tipping Point according to Malcom Gladwell's theory [2]. AHLARP sets the optimal boundary between risk/resource/performance. In this case, the proportionality of the invested funds and the acceptability of the consequences of the risk is achieved by wise investment. It is based on the assumption that with initially wisely invested and relatively small funds, we can achieve more than unlimited investment and spending of additional resources. There is a limit beyond which further investments do not contribute to significant risk reduction. The relationship between investment and benefit, which should be proportional, is now growing only on the investment side, while the effects, or benefit, are stagnating.

This limitation opens another possibility - we learn to build resilience (personal, collective, company).

AHLARP's program is "Prudent Investments". As it is impossible to prepare an adequate response to all risks, each risk should be realistically predicted, researched, evaluated, consider effects and possible responses. We should learn from risk. In other words, the first in the process of learning and quality risk assessment should be crisis management. They should be the first in acquiring and disseminating knowledge.

Although the term positive risk sounds like an oxymoron, let's recall the aphorism attributed to Georg E.P. To Box: "All models are wrong, but some are useful".

Positive risk is generated from analyzes of existing and expected risks. By evaluating the circumstances, threats and capacities, as well as the experiences that exist in the near and far environment, we learn about the best mitigation measures. Knowledge excludes panic reactions, which are most often the cause of wrong decisions and harmful consequences.

We approach positive risk in order to use, improve, share and accept it.

A negative risk is one that endangers us or prevents realization. We strive to: avoid, mitigate, redirect or accept negative risk.

1.3 A reasonable investment in risk reduction

Should the strongest operational forces, such as the army, be engaged in cleaning construction materials or removing snow from Split's riva? Should military helicopters rescue tourists on Velebit? Should the small Municipality of Civljane buy too extensive Risk Assessments and Civil Protection Plans for its 171 inhabitants? (prescribed by the Law on Civil Protection)

The Croatian legislative framework in the field of civil protection specifies the scope and content of documents that are appropriate for national risks. Here, municipalities are facing an obligation for which they have neither professional nor administrative capacity, so they are forced to buy documents on the market from agencies licensed by the Civil Protection Directorate.

Although the Law and regulations speak of "major accidents and disasters", we transferred the obligation to the municipalities as if a major accident or disaster can only affect one municipality!? However, when we talk about national or regional risk (which was the intention of the EU) - then we need a more comprehensive document. And that document must be a product of science and expertize with respect for local experiences and specific community knowledge. Based on that knowledge and analysis, it is possible to prepare capacities for response. Thus, we will establish an optimal ratio between risk as a challenge to the community and an adequate community response.

When we talk about risks and the way we perceived them in the Republic of Croatia - both segments are missing. There is a lack of networking expert analyzes and local experiences, as well as cost-benefit analysis (CBA). The institution responsible for the civil protection system (DUZS - RCZ) has never done a cost-benefit analysis. In 2005, as a spokesperson - head of Public Relations of DUZS, I made a SWOT analysis, so research and CBA were a logical continuation. Based on the principle of the ratio of costs and benefits, an analysis of the civil protection system in the Republic of Croatia for the period 2005 – 2021, was made for the first time. The results of the research were published as a professional paper in the Proceedings of the "Crisis Management Days

2022" of the University of Applied Sciences, Velika Gorica, under the title "Civil Protection Deliberation" [3] . Along with the analysis of the previous effects of civil protection, in that paper I propose three necessary measures: 1. deliberation; 2. decentralization and 3. deregulation. Deliberation - considering experiences from major accidents in which the citizens themselves reacted the fastest by providing help with their own capacities, as well as due to a series of crisis volunteering projects financed with European money. Every local self-government has a significant capacity of volunteers who are neglected in the Civil Protection Plans. Of the volunteers, only the volunteer firefighters (DVD), the Mountain Rescue Service (HGSS) and the Red Cross are mentioned.

Decentralization, because the state level does not perceive or recognize the experiences and capacities of local self-governments, and extensive regulations, inappropriate to local circumstances, unnecessarily burdens local budgets, so that deregulation is the only logical but also necessary postulate.

As my work in the Proceedings was published in English, I received an offer from abroad to publish a book of professional works. The book was published under the title "Croatia between political centralization and European democracy" [4] . We can only hope that this book, even though it is in English, will point out to someone the omissions so far and be a useful guide (but also corrective) to the functional - now already the third law on civil protection (the first - in 2004 and the second - in 2015).

2. European risk approach and disaster risk reduction

In order to achieve the objectives of the resilience of the European area, the peculiarities of individual regions (broader picture) are considered and instructions are given to the members for assessing national risks. Thanks to these instructions, coordinated action, exchange of experiences and the establishment of good practices are achieved. Institutionally, the EU civil protection architecture as well as the provision of aid is organized through the Directorate General for European Civil Protection & Humanitarian Aid Operations (DG ECHO) [5] , which was established in 1992 as an expression of the European solidarity with the population affected by accidents.

In addition to the highlighted basic principles and values, ECHO also acts as crisis management. It monitors and assesses the situation in the area of possible and current crises and supports the national capacities of the members. The goal is to standardize member practices and assess risks in a way that everyone can understand, so that we act in a coordinated manner and recognize risks that can spill over borders. Therefore, there is increasing emphasis on a regional approach, raising the level of preparedness, exchanging information and good practices.

In order to harmonize approaches and actions, the European Commission issues directives (or guidelines) that order member states to achieve goals in a certain area for the benefit of the entire EU area. First - the Risk Assessment and Mapping Guidelines [6] for assessing national risks and the second - Risk Management Capability Assessment Guidelines [7] for assessing national capacities. They even give an overview of tools, give examples of good practice from member countries (Netherlands, France) but also from countries outside the EU (New Zealand) whose risk approaches should be followed because they have achieved an optimal population protection system and a high level of resilience.

Increasing exposure to weather extremes, due to climate change, requires action without administrative obstacles, so members are directed to an integrated risk management approach. Based on the EU Civil Protection Mechanism Decision of January 2014, members committed to implementing a range of disaster prevention measures, including sharing information and assessing their risk management capacities (at the national or appropriate sub-national level every three years).

The Organization for Economic Co-operation and Development (OECD) has recommended simple methods for risk assessment with an emphasis on raising public awareness. The Decision states that each member state should assess its ability to manage risk according to "technical, financial and administrative capacities at the national or appropriate sub-national level".

3. CONCLUSION

What is risk? It can be a threat or an opportunity.

All EU documents (decisions, guidelines) clearly state that the goal of risk assessment is "achieving a common understanding of risk", which means that research and risk assessment must not remain at the level of an administrative obligation archived in the institution. Every resident, every association and every volunteer should know what the profession has said about the risks and what measures their local community has prepared. We saw this synergy only after the disaster, and we should have practiced it much earlier. We grow together.

Regions (Asia) and risk-exposed countries (India) for a long time have been developing a community-wide risk management called Community-based Disaster Risk Management (CBRDM) [8]. CBDRM is a process in which the community identifies, analyze, monitors and assesses risks with the aim of reducing vulnerabilities and strengthening the necessary capacities. In layman's terms, this approach is "tailor-made" and is applied according to weather peculiarities, terrain characteristics and the living conditions or customs of the inhabitants.

Their experiences (ibid.) show that the involvement of the community results in enthusiasm in the acceptance of activities, dissemination of knowledge and generally better solutions thanks to the whole spectrum of ideas and innovations. They conclude that no one understands the local circumstances, capacities and constraints better, and no one is more interested in improving local disaster response capabilities than the residents of the area themselves.

This is resilience formula - resilience that has become a dominant social construct.

REFERENCES

[1] Julian Talbot, Available from: https://www.juliantalbot.com/post/alarp-vs-ahlarp, Accessed: 2017.

[2] Malcolm Gladwell "The Tipping Point" How Little Things Can Make Big Difference, Little Brown&Co. Boston 2000. ISBN 0-316-34662-4. Gladwell describes the "tipping point" as a turning point, i.e. a moment in which small actions or ideas at the right time, in the right place and with the right people trigger

big changes. It is the moment when an action or an idea becomes a trend and spreads like wildfire.

[3] Čumpek, T. : Civil protection deliberation", *Conference proceedings 2022.* p.102-119 ISSN 2706-3720, Available from https://dku.hr/wp-content/uploads/2024/01/DKU-2022-conference-proceedings-v3.pdf

[4] Čumpek, T.: *Croatia Between Political Centalization & European Democracy*, 2023. Eliva Press SRL, ISBN 978-9999313063, Available from: https://www.amazon.sg/CROATIA-Political-Centralization-European-Democracy/dp/B0CPGWMFYF

[5] European Civil Protection and Humanitarian Aid Operations, Available from: https://civil-protection-humanitarian-aid.ec.europa.eu/index_en

[6] Risk Assessment and Mapping Guidelines, Available from: https://ec.europa.eu/echo/files/about/COMM_PDF_SEC_2010_1626_F_staff_working_document_en.pdf

[7] Risk Management Capability Assessment Guidelines, Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015XC0808(01)&from=HU

[8] Summary report of a webinar attended by more than 200 experts, Available from: https://nidm.gov.in/pdf/trgReports/2021/November/Report_18November2021sk.pdf, accessed August 2022.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

ANALYSIS OF SOCIO-DEMOGRAPHIC CHARACTERISTICS OF INJURIES AT WORKPLACE FOR THE 2022 YEAR IN SERBIA

Ivana Ilić Krstić[1], Danijela Avramović[1] & Anica Ranđelović[1]
[1] Faculty of Occupational Safety, Čarnojevića10, Niš, SERBIA,
ivana.ilic@znrfak.ni.ac.rs

Abstract: *This study carefully studied the socio-demographic features of industrial injuries that occurred in Serbia in 2022. Technical suggestions were provided for the best approaches to enhance safety and health at work in particular social sectors based on the categorization of the severity, locations, causes, body parts, qualifications, age structure, and organizational characteristics of injuries.*

Keywords: *safety and health at work, socio-democratic characteristics, workplace injuries.*

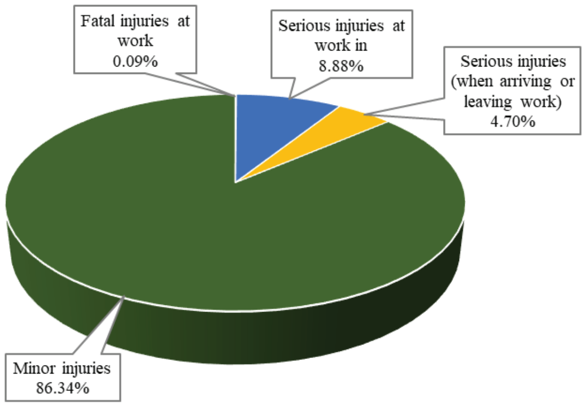
1. INTRODUCTION

A healthy working environment is one of the prerequisites for employees' overall health. The assertion that "the quality, and especially the 'poor quality' of the working environment strongly affects the health and well-being of employees" was made in relation to this statement [1]. The assertion that "dignified work is safe work" (Safety and Health at employment, n.d.) further emphasizes the significance of this notion. Nonetheless, data indicates that a worker in the globe passes away from an industrial illness or accident every 15 seconds (Decent labor is safe work, n.d.) [2]. Before, working conditions, procedures, the use of machinery, etc., posed a greater risk of physical harm to employees. However, the contemporary labor market also brings with it the emergence of psychosocial risks in a variety of forms, which have a much less obvious impact on employees' health and are not always simple to identify [3] [4]. This issue has also had an impact on the rise of occupational illnesses, which are more common than work-related injuries. According to Danny Pieters, the legislator may base their decision to grant special treatment in these situations on the fact that the employer with these injuries typically pays a higher contribution rate and/or in order to provide victims of these injuries with more favorable benefits [5]. When specific restitution rules will be used in this sense will also rely on the meaning of these terms.
The definition of "injury at work" varies depending on the national legislation that governs this term [6]. In some laws, it is also required that the injury occurred during working hours; in others, it must have occurred while carrying out work-related responsibilities; and in many laws, it encompasses injuries that may happen while making the regular commute from home to work or from work to home [7]. Generally speaking, though, the initial idea has been greatly developed throughout time. The term "injury at work" refers to an injury that occurs during a routine trip from the apartment to the place of employment and vice versa, i.e. on the way undertaken for the purpose of performing official duties or starting work. This definition is found in the Law on

Pension and Disability Insurance [8] [9]. It also includes an injury that is spatially, temporally, and causally related to the performance of work for which the person is insured or work for which he is not distributed but performs in the interest of the employer where he is employed.

2. ANALYZING SOCIO-DEMOGRAPHIC CHARACTERISTICS OF OCCUPATIONAL INJURIES

Employers filed 12 692 reports on work injuries to the Administration, in accordance with the guidelines in Article 7 of the Rulebook regarding the format and content of the report form on occupational disease and injury [10]. Graph 1 displays the number of workplace injuries broken down by severity.



Graph 1: *Injuries at work in relation to the severity of the injury*

Workplace injury data was analyzed using a manner consistent with the ESAW. The Administration analyzed a total of 1 138 work-related injuries (11 fatal and 1 127 serious work-related injuries) that occurred in 2022 at the workplace. Serious injuries that occurred when arriving and leaving work are not the subject of this analysis. The data was analyzed and presented in tabular and graphical form using the following categories:
1) Activity of the employer;
2) Number of employees;
3) The sex of the injured person;
4) Age of the injured person;
5) Qualification level;
6) Work environment;
7) Work process;
8) Specific physical activity;
9) Source of injury;
10) Contact - way of injury;
11) Cause of injury;
12) Type of injury;
13) Injured body part;
14) Estimated number of lost calendar days.

2.1. Overview of workplace injuries by activity of the employer

Overview of injuries at work according to the employer's activity In 2022, the number of injuries at work according to the employer's activity is shown in Table 1. The highest number of injuries at work was recorded in the activities of the processing industry 289 (25.64 %) and transport and storage 100 (8.87 %).

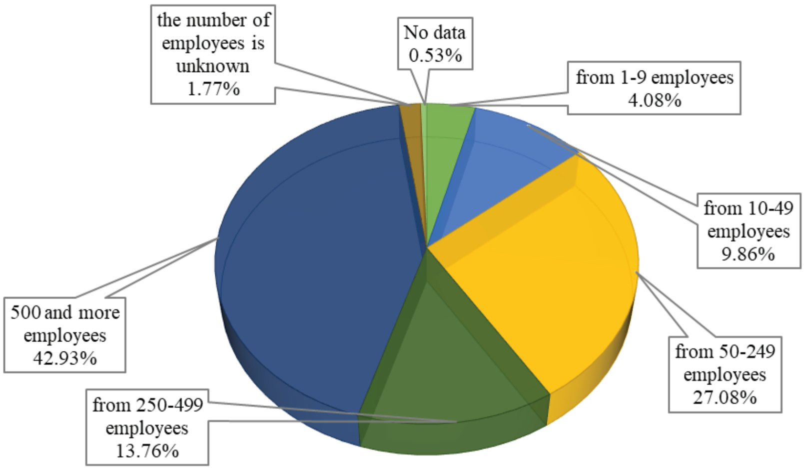
Table 1: Injuries at work according to the employer's activity

Activity and Occupation	No	%
administrative and auxiliary service activities	56	4.97
construction industry	74	6.57
household activity as an employer; activity of households that produce goods and services for their own needs	0	0
state administration and defense, compulsory social insurance	70	6.21
health and social protection	84	7.45
information and communications	15	1.33
education	69	6.12
other service activities	6	0.53
agriculture, forestry and fishing	92	8.16
real estate business	3	0.27
manufacturing industry	289	25.64
mining	27	2.40
traffic and storage	100	8.87
water supply, waste water management, control of waste removal processes and similar activities	45	3.99
supply of electricity, gas, steam and air conditioning	47	4.17
professional, scientific, innovative and technical activities	22	1.95
wholesale and retail trade, repair of motor vehicles and motorcycles	89	7.90
arts, entertainment and recreation	13	1.15
accommodation and food services	12	1.06
financial activities and insurance activities	13	1.15
No data	1	0.09
Total:	**1 127**	**100.00**

Source: Administration fir Safety and Health at Work. Report for 2022.

2.2. Overview of injuries according to the number of employees at the employer

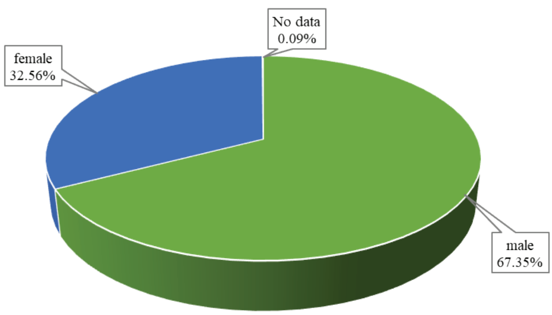
The number of injuries at work according to the number of employees at the employer is shown in Graph 2. The largest number of injuries at work occurred at employers with 500 or more employees, 484 (42.90%) and at employers with 50-249 employees, 305 (27.06%).



Graph 2: Injuries at work according to the number of employees at the employer

2.3. Overview of injuries at work according to the gender of the injured person

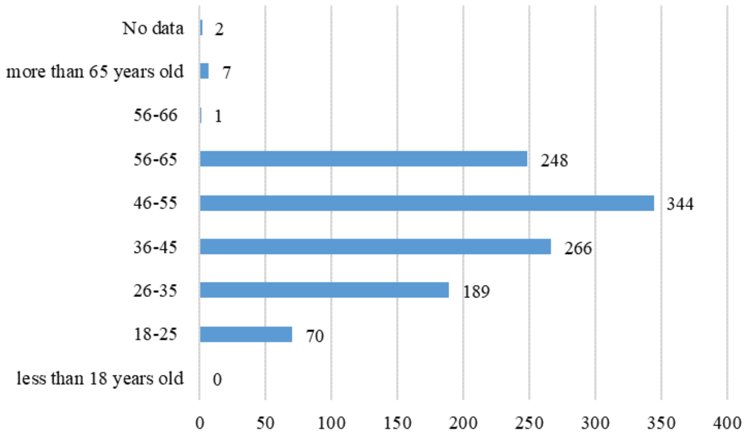
When it comes to work-related injuries by gender, men (759) experienced more work-related injuries than women (367), shown in Graph 3.



Graph 3: Injuries at work in relation to gender

2.4. Review of injuries at work according to the age of the injured person

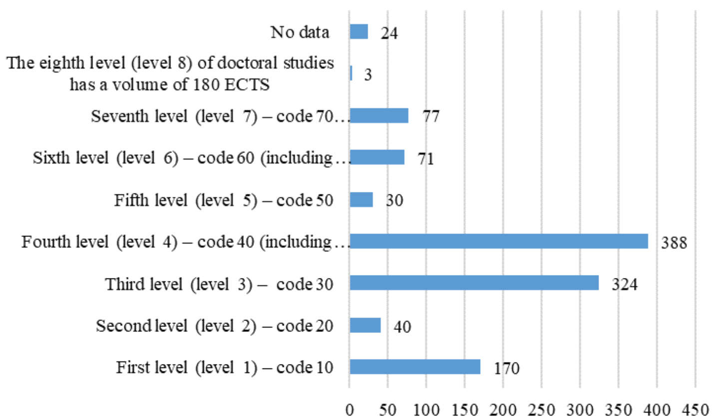
The number of work-related injuries according to the age of the injured person is shown in Graph 4. The largest number of work-related injuries occurred among employees aged between 46-55 years 344 (30.52%) and 266 (23.60%) among employees aged between 36-45 years.



Graph 4: Injuries at work according to the age of the injured person

2.5. Equations Review of injuries at work according to qualification level

When it comes to injuries at work in relation to the acquired level of qualification, the largest number of injuries occurred to persons with the acquired fourth level of education, (level 4) - four-year high school education 388 (34.43%) and persons with the third level of education, (level 3) - secondary professional education for three years, informal adult education for at least 960 hours of training 324 (28.75%), which is shown in Graph 5.



Graph 5: Injuries at work according to acquired qualification level

2.6. Overview of injuries at work according to the work environment in which the injury occurred

The number of work-related injuries according to the work environment in which the injury occurred is shown in Table 2. The work-related injuries in this table are shown for the corresponding groups and subgroups according to the adopted methodology. The largest number of work injuries in this category occurred in group 010 - industrial location 454 (40.25 %) and in group 040 - office, amusement park and miscellaneous 183 (16.24 %).

Table 2: Injuries at work according to the work environment in which the injury occurred

Occupational environment	**No**	**%**
no information	**7**	**0.62**
industrial location - not specified	**15**	**1.30**
location of production, factory and workshop	315	27.95
maintenance site and repair shop	31	2.75
a room used for storage, loading and unloading	68	6.03
other working environment not specified in group 010	25	2.22
construction site, construction, open-pit quarry and open-pit mine - not specified	**6**	**0.53**
construction site - construction of the building	32	2.84
construction site - demolition, alteration and maintenance of the building	21	1.86
opencast quarry, opencast mine, excavation and trench (including opencast mines and quarries)	32	2.84
construction site underground	0	0
construction site on/under water	0	0
construction site - in the middle of high pressure	0	0
other working environment not specified in group 020	5	0.44
agricultural zone, livestock breeding zone, fish breeding zone and forest zone - not indicated	**4**	**0.35**
cattle breeding zone	7	0.62
agricultural zone - surface crops	6	0.53
agricultural zone - cultivation of trees and shrub crops	5	0.44
forest zone	9	0.80
zone of fish farming, fishing and agriculture	0	0

vegetable garden, park, botanical garden and zoo	1	0.09
other working environment not specified in group 030	8	0.71
office, amusement park and miscellaneous	**8**	**0.71**
office, meeting room, library, etc.	37	3.28
educational institution (school, university, kindergarten)	45	3.99
small or large sales area	43	3.82
restaurant, recreation area and temporary accommodation (including museums, halls, stadiums, fairs, etc.)	24	2.13
other working environment not specified in group 040	26	2.31
health institutions - not indicated	**17**	**1.51**
health care facility, private hospital, nursing home	50	4.44
other working environment not specified in group 050	6	0.53
public space - not indicated	35	3.11
a space that is always open to public passage (highways, roads, parking spaces, station or airport waiting rooms, etc.)	97	8.61
means of transport for road and rail traffic, private or public (car, train, bus, etc.)	20	1.77
zones that are connected to public space but with limited access (access allowed only to authorized persons): railway, aircraft platform, zone next to the highway	11	0.98
other working environment not specified in group 060	16	1.42
at home, not specified	2	0.18
private house	4	0.35
communal areas of the building, extension and private family gardens	9	0.80
other working environment group not specified in group 070	3	0.27
sports zone - not indicated	2	0.18
indoor sports area - sports hall, gym, indoor swimming pool	10	0.89
open sports area - sports ground, outdoor swimming pool, ski slopes	7	0.62
other working environment not specified in group 080	0	0
aerial locations, elevated, excluding construction sites - not specified	0	0
raised - at a fixed level	1	0.09
raised - mast, pylon and hanging platform	1	0.09
in aviation	0	0
other working environment not specified in group 090	3	0.27

underground excluding construction sites - not indicated	0	0
underground - tunnel (road, train, subway)	0	0
underground - a mine	13	1.15
underground - drains/sewage	0	0
other working environment not specified in group 100	1	0.09
on/above water, excluding construction site - not specified	0	0
sea or ocean, on all types of vessels, ship platforms, boats, barges	0	0
lake, river or port, on all types of vessels, ship platforms, boats, barges	1	0.09
other working environments not listed in group 110, excluding construction sites	0	0
high pressure environment, excluding construction site - not indicated	0	0
high pressure environment - underwater (eg diving)	0	0
high pressure environment (chamber)	0	0
other work environment not specified in group 120, excluding construction site	0	0
other working environment that is not specified in the classification	31	2.75
No data	7	0.62
Total:	**1 127**	**100.00**

Source: Administration fir Safety and Health at Work. Report for 2022.

2.7. Review of injuries at work by type of injury

Injuries at work according to the type of injury are shown in Table 3. Injuries at work in this table are shown for the corresponding groups and subgroups according to the adopted methodology. The highest number of injuries at work according to the type of injury was recorded in the group - bone fracture 799 (70.90%).

Table 3: Injuries at work by type of injury

Type of injury	**No**	**%**
type of injury unknown or not indicated	**25**	**2.22**
wounds and superficial injuries	**8**	**0.71**
superficial injuries	7	0.62
open wounds	66	5.86
other types of wounds and superficial injuries	9	0.80
bone fracture	**579**	**51.38**
internal fracture	193	17.13

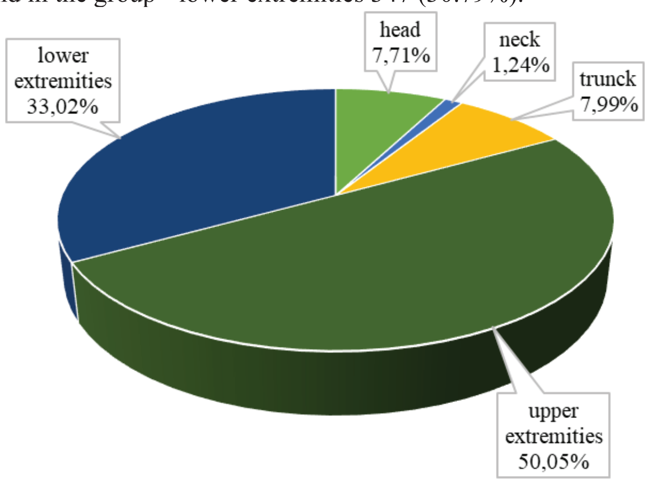
open fracture	15	1.33
other types of bone fractures	12	1.06
sprains, strains and sprains	**23**	**2.04**
dislocations and subluxations	15	1.33
sprains and strains	12	1.06
other types of dislocations, sprains and strains	10	0.89
traumatic amputation (loss of body parts)	**53**	**4.70**
concussion and internal injuries	**5**	**0.44**
concussion and intracranial injuries	11	0.98
internal injuries	10	0.89
other types of concussions and internal injuries	5	0.44
burns, burns and frostbite	**3**	**0.27**
burns and burns (thermal)	6	0.53
chemical burns (corrosion)	2	0.18
frostbite	0	0
other types of burns, burns and frostbite	1	0.09
poisoning and infections	**0**	**0**
acute poisoning	3	0.27
acute infections	0	0
other types of poisoning and infections	0	0
strangulation and suffocation	**0**	**0**
suffocation	0	0
drowning and non-fatal drowning	1	0.09
other types of strangulation and suffocation	0	0
noise, vibration and pressure effects	**1**	**0.09**
acute hearing loss	0	0
effects of pressure (barotrauma)	0	0
other effects of noise, vibration and pressure	0	0
effects of extreme temperatures, light and radiation	0	0
heatstroke and sunstroke	0	0
radiation effects (non-thermal)	0	0

low temperature effects	0	0
other effects of extreme temperatures, light and radiation	0	0
shock	0	0
shock after attack and threat	3	0.27
traumatic shock	1	0.09
other types of shocks	1	0.09
multiple injuries	**22**	**1.95**
other specific injuries not listed	**16**	**1.42**
No data	**9**	**0.80**
Total:	**1 127**	**100.00**

Source: Administration fir Safety and Health at Work. Report for 2022.

2.8. Review of injuries according to the injured part of the body

Injuries at work according to the injured part of the body are shown in Graph 6. Injuries at work in this table are shown for the corresponding groups and subgroups according to the adopted methodology. The most frequent injuries are in the group - upper extremities 526 (46.68%) and in the group - lower extremities 347 (30.79%).



Graph 6: Injuries at work according to the injured part of the body

3. CONCLUSION

With a system of clearly defined rights, responsibilities, and obligations, governments, employers, and employees actively contribute to the provision of a safe and healthy working environment. This is the national occupational health and safety culture. The prevention principle is accorded the utmost priority. Creating and sustaining a preventive culture in the field of occupational health and safety at the federal level requires making use of all available resources to increase public awareness, understanding, and comprehension of risks and hazards, as well as their mitigation and management. A quality piece of work has to be safe. Therefore, it is imperative that the ILO and its members take the initiative to promote workplace health and safety. To create the kind of cooperation necessary for the changes we want to see in order to create a culture of prevention in the field of occupational health and safety, we must cooperate with one another. This is the main reason for the significance of the reports, which are the outcome of annual countrywide monitoring of occupational injuries. The efforts resulting from this data collection and analysis make a unique contribution since they highlight the social activities that are least effective at raising each worker's degree of safety and health.

ACKNOWLEDGEMENTS
The work was financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contract No.451-03-66/2024-03/ 200148)

REFERENCES

[1] Jašarević, S. (2016) Serbia. Alphen aan de Rijn: Kluwer Law International BV.
[2] Lubarda, B. (2013) Radno pravo. Rasprava o dostojanstvu na radu i socijalnom dijalogu. Beograd: Pravni fakultet Univerziteta u Beogradu.
[3] Pap Đ., (2012), Stanje zaštite na radu u 2010. godini, Sigurnost, Zagreb.
[4] Sprčić M., (2013), Upravljanje rizicima, Sinergija, Zagreb.
[5] Pieters, D. (2006) Social security: an introduction to the basic principles, second edition – revised. Alphen aan den Rijn: Kluwer Law International.
[6] Bilban M., (2006), Ekonomski vidik poškodb pri delu, Delo in varnost, Volum 51, Ljubljana.
[7] Gilad B., (2009), Rano upozoravanje, HESPERIJAedu, Beograd.
[8] Kovačević, Lj. (2007) Normiranje socijalne sigurnosti u međunarodnom pravu. Magistarska teza. Beograd: Pravni fakultet Univerziteta u Beogradu.
[9] Uprava za bezbednost i zdravlje na radu, 2023. Izveštaj o radu za 2022. godinu. Beograd: Ministarstvo za rad, zapošljavanje, boračka i socijalna pitanja
[10] Inspektorat za rad. (2022) Izveštaj o radu Inspektorata za rad za 2021. godinu, Beograd, Ministarstvo za rad, zapošljavanje, boračka i socijalna pitanja.

NORMATIVE FRAMEWORK ON OCCUPATIONALSAFETY IN GREAT BRITAIN

Suan Islamović[1]; Nikola Findrik[2]; Fadil Islamović[3],

[1] Faculty of Law, University of Bihać, Džanića Mahala, Bihać, B&H, suan.islamovic@gmail.com

[2] Faculty of Law, University of Bihać, Džanića Mahala, Bihać, B&H, findrik_nikola@yahoo.com

[3] Faculty of Technical Engineering, University of Bihać, Irfana Ljubijankića, Bihać,B&H, fadil.islamovic@unbi.ba

Abstract: *All the peculiarities of the constitutional and legal structure, as well as the centuries- long nurturing of a distinctive legal culture based on Anglo-Saxon legal folklore are only some of the potential causes of the Great Britain's overall normative framework specificities. The field of health and safety at work is also not isolated in this context. Nevertheless, the British model of occupational safety stands out as one of the most functional in the world due to, inter alia, its roots in long- standing tradition and numerous functional specificities.*

Keywords: *working conditions, protection at work, occupational safety, criminal liability, Great Britain*

1. INTRODUCTION

The historical development of occupational health and safety protection in the United Kingdom of Great Britain and Northern Ireland (hereinafter: Great Britain) should be analyzed through the adequate spatial and temporal context, especially through the role of economic trends in the appropriate time periods. Without dwelling specifically on the period before the greatest conflict in the history of mankind, it is necessary to highlight the fact that the largest colonial power in the world had been a leader in the segment of introduction and implementation of appropriate institutes related to the protection of health and safety at work for decades (and even centuries), considering that the first historical roots of the tradition of safety at work date back to the 1800s. Great Britain emerged victorious from the Second World War, so it was reasonably expected that this country would be the leader of economic and other social changes on a global level. Nevertheless, conservative governments did not enable the 'external openness' of the British economy over the next few decades. It was only in the seventies of the last century that significant changes began to occur. These are primarily related to two basic factors: Great Britain became a member of the EU in 1973, while six years later Margaret Thatcher took power and introduced complete liberalization of British trade system. The Health and Safety at

Work Act 1973 was also adopted during this period, which is still the basic regulation governing the protection of health and safety at work in Great Britain. In that context, it is necessary to give a special review to this legal act in the first title of this paper. Also, within the first title, other national sources of law that directly regulate the occupational health and safety system will be presented. Second part of the paper potentiates the appropriate institutional specificities of the occupational health and safety system in Great Britain. These specificities make it authentic and one of the best on a global level.

2. LEGAL FRAMEWORK

Generally speaking, health and safety law in Great Britain is made up of acts of legislator (Parliament) and of regulations as statutory instruments. The backbone of the legal framework for health and safety at work in Great Britain is The Health and Safety at Work Act 1974 (hereinafter: HASAWA). Although there are other laws and by-laws that contribute to the realization of the principles set by HASAWA, it is clear that HASAWA also acts as a *sui generis* framework law whose principles must be fully followed by other regulations. In nomotechnical terms, HASAWA is consisted of four main thematic units: Occupational health, safety and welfare and the control of hazardous substances and certainatmospheric emissions (Part I); Service for medical counseling in employment (Part II); Building Regulations and the Building (Scotland) Amendment Act 1959 (Part III) and Miscellaneous and General (Part IV) [1].

The most significant and extensive part of HASAWA is Part I which comprehensively regulates safety and welfare in relation to workplace. In addition to the introductory provisions, the first thematic unit refers to general duties where the various provisions refer to the following specified duties (of): employers to their employees, employers and self- employed to persons who are not their employees, persons concerned with premises to persons other than their employees, persons who control certain premises in relation with harmful emissions into the atmosphere, manufacturers, employees at work, not to interfere with or misuse things that have been provided in accordance with certain provisions and notto charge employees for things that have been done or provided in accordance with certain specific requirements. Two very important conclusions can be drawn from the normative-dogmatic analysis of the provisions in question. The first conclusion refers to the fact that as a starting point for the creation and implementation of an adequate occupational safety framework, HASAWA emphasizes the obligations of the ‘contracting parties’, mainlyemployers and employees. The second conclusion refers to the preventive nature of these provisions. Namely, the prescribed duties have primarily a preventive effect aimed at minimizing or eliminating potential risks to health and safety at work. From the very beginning of the analysis, it is clear that the legislator had recognized that the duties of various subjects represent an initial basis for further regulation of the corresponding occupational safety institutes.

The second thematic unit of Part I regulates the system of supervision and control over the implementation of statutory obligations. In addition to the provisions related to the establishment of the Health and Safety Executive (hereinafter: Executive), the functions and powers of this institution are precisely regulated. Provisions governing the powers of the Commission to direct investigations and inquiries should be certainly emphasized.

Section 14 (2) stipulates that the executive authority under this section (at any time) has authority to "investigate and make a special report" or to "authorise another person to investigate and make a special report into any such matter". This provision prescribes the initial and most important Executive's power, considering that institutional framework of occupational health and safety in Great Britain successfully exists primarily due to the possibility of conducting *ad hoc* controls on the application of HASAWA and other laws or by-laws at any time. The second most important competence of the Executive is the approval of codes of practice as practical guidelines regarding realization of HASAWA's provisions. Article 16 (1) explicitly stipulates that the Executive can "approve and issue such codes of practice (whether prepared by it or not)" and "approve such codes of practice issued or proposed to be issued otherwise than by the Executive". These practical instructions are related to the most health and safety regulations, so it can be concluded thatthe occupational safety system in Great Britain practically cannot function without the Executive in terms of its powers' exercise. Regardless of all the above, it is evident that the culture of prevention plays a key role in the second thematic unit as well.

Compliance with the statutory provisions governing the protection of health and safety at work is an obligation of several subjects of labour law. *Vice versa*, non-compliance often raises the issue of civil, misdemeanor or even criminal liability. In that case, a subject can get verbal or written advice, get an improvement/prohibition notice or be prosecuted [2]. Article 17 is particularly important for criminal proceedings. It is stipulated that "failure on the part of any person to observe any provision of an approved code of practice shall not of itself render him liable to any civil or criminal proceedings". At the same time, it is emphasized that the provisions of the Codes of practice shall be admissible in evidence in criminal proceedings. Unless the contrary is proved, a document purporting to be a notice issued by the Executive or a code of practice which appears to the court to be the subject of such notice shall be deemed to be (the subject of) such notice. Finally, the third most important competence of the Executive relates to the creation of "adequate arrangements for the enforcement of the relevant statutory provisions", as prescribed in section 18. Powers of inspectors are detailed in section 20. In addition to analyzed competences of the Executive, the precisely prescribed authority of inspectors certainly confirms effective legal solutions that in a practical sense have both preventive and repressive effects. The list of inspectors' responsibilities is pretty much long, but it should be pointed out that for the purpose of carrying into effect any of the relevant statutory provisions, inspector may (at any reasonable) time enter any premises, make examination and investigation, take such measurements and photographs and make such recordings as he considers necessary, require any person whom he has reasonable cause to believe to be able to give any information, take samples of any articles or substances etc. In accordance with thesecompetencies, there is no doubt that inspectors are institutional aid in achieving the goals and principles set by HASEWA. Together with the Executive, inspectors have crucial competencies in the process of the relevant statutory provisions' enforcement. Once again, the culture of prevention comes to the fore while exercising these powers as well.

In addition to special provisions relating to agriculture which are treated separately by agricultural health and safety regulations, provisions as to offenses (Part I) have a particularly important role in the segment of misdemeanor regulation. The list of potential violations is elaborated in section 33. The last on the comprehensive list of offenses is a failure to comply with an order made by a court under section 42. In any case, HASEWA 'does not leave anything to chance'. A possibility of imposing solutions that would not be

in accordance with the letter and spirit of the most important statutory act in Great Britain is minimized. This intention of the legislator has both normative and logical justification. In the practical sense, it has obtained appropriate results. In addition to facilitating the inspections' practical organization, adequate cooperation with judicial authorities has also been achieved, which is of special importance in modern democratic systems. Without separate analysis of the remaining three HASEWA's thematic units which refer to The Employment Medical Advisory Service, Building Regulations, and Amendment of Building (Scotland) Act 1959 as well as Miscellaneous and General, it can certainly concluded that the core and most important unit od HASEWA is exactly Part I as a comprehensive normative framework for the protection of health and safety in the workplace.

Summa summarum, HASEWA emphasizes workplace security and general safety at work. Further to provisions of the HASEWA that refer to adequate training of staff, adequate welfare, safe working environment and other working conditions, it should be noted that there are also other legal sources aiming to adequately regulate health and safety at work in Great Britain. Workplace (Health, Safety and Welfare) Regulations 1992 do not only refer to safety at work, but also to suitable workplace in terms of all activities which are being carried within it: places for breaks, drinking water standards, walking routes etc. The Executive has also published a Code of Practice that specifically refers to the practical implementation of the Workplace Regulations 1992. Display Screen Equipment Regulations 1992 (amended 2002) provides a normative stronghold for the protection of workers who use PCs, laptops, tablets and smartphones for at least an hour in their daily worktime. Furthermore, the Personal Protective Equipment Regulations 2018 prescribes the standards of employees' protection from significant risks related to dangerous work environment through key segments. Management of Health and Safety at Work Regulations 1999 is a legal act of a preventive nature that emphasizes the individual responsibility of employees during the assessment and adequate control of risky activities within the framework of the employment relationship. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013, which correspond to the Management of Health and Safety at Work Regulations 1999, refer to the formal reporting of the death, injury or illness in the workplace. Finally, the list of the acts owned or enforced by Executive is very specific, especially when taking into account the year of their adoption. Many of these acts were adopted in the twentieth century, while and Explosives Act was adopted in 1875. When it comes to the first-mentioned category, the following could be highlighted: Employment of Women, Young Persons, and Children Act 1920, Factories Act 1961, Mineral Workings Offshore Installations Act 1971, Mines and Quarries (Tips) Act 1969, Offices, Shops and Railway Premises Act 1963 etc. These acts are evidence of centuries-old continuity in the protection of health and safety at work in Great Britain [3].

3. INSTITUTIONAL SPECIFICITIES

The most important functional specificity of the institutional framework, which serves as a basis for practical activities for normative regulations' implementation is based on a simple formula: 'Those who create risk are the best for its control'. The Executive is the most significant national authority with the greatest responsibility in the field of

occupational safety and health in Great Britain. It is composed of 12 non-executive directors and over 3,200 staff of various professional profiles: inspectors, legal advisers, statisticians, economists, technologists etc. When preparing appropriate regulations and standards, Executive relies on internal experts and conducted research, as well as other external stakeholders who have a legal interest while preparing regulations, such as business managers and trade unions. Alongside of these responsibilities, the Executive very often conducts various types of inspections within its competence or publishes relevant publications and reports. In addition to unambiguously prescribed competences, which veryoften lead to unwanted situations in countries where this is not the case, it is most importantthat the Executive exercises its powers actively and acts as a key national authority in the application of the standards prescribed by HASEWA, as well as other laws and by-laws.

At the end of the last century, the current regulations allocated powers/competences in terms of control over the occupational safety and health system. With the support of the Executive Committee for Health and Safety of Northern Ireland, Executive has a central role in controlling the application of the HASAWA in industrial workplaces. Following on from this, less than 400 local authorities in England, Scotland and Wales have competences in implementing the legislation in shops, hotels, leisure industry and the like [4]. It is clear that the external inspection of occupational safety is carried out either by the appropriate regulatory bodies: Executive or local authorities. These types of controls do not need to be previously announced. Inspectors have the right to order measures *post festum*, i.e. after the inspection with the aim of improving the security situation in the company was performed. What is particularly significant, the first level of control is carried out internally by employees of the company who are experts in this field or external collaborators who are engaged by employers with the aim of ensuring the minimum standards of safety at work. Of course, these controls do not necessarily have to be previously announced, which makes the above-mentioned allocation of competences even more important. In accordance with the statutory provisions analyzed above, as well as the basis methodological postulates on the functioning of various types and forms of control, the culture of prevention is imposed as the main feature of the entire occupational safety system in Great Britain.

In the end, it is necessary to apostrophize several functional specificities that make the British occupational safety system authentic. These functional specificities are complementary to the statutory provisions. The legal basis for the education of workers in the field of occupational safety is the first and most significant specificity, which was later adopted by many national systems. This stipulates an employer's obligation to provide adequate funds and time for the education of the employees. Otherwise, employer could end up in the labor court. Therefore, according to the letter of the law, the financial costs are fully borne by the employer and these trainings should be carried out during working hours [5]. The second specificity refers to voluntary and free counseling in matters related to worker safety. As the reporting body for all serious accidents at work, the Occupational Safety and Health Office has implemented a voluntary program for occupational safety advisers. This system is based on the online platform named *Occupational Safety and Health Consultants Register* which provides the possibility of consultation and free advices to employers in matters of occupational safety. The third specificity concerns the provision of health care at work. Although it is not a legal obligation, many employers have made it possible to provide health care where this risk is adequately managed through professional services. This ultimately contributed to better promotion of workers' health and less abuse of absence from work [6].

4. CONCLUSION

Long-standing tradition and numerous normative and institutional specificities are the main reasons for the functionality of the authentic British occupational health and safety system. As a *sui generis* framework law, HASAWA is the most important piece of legislation which comprehensively regulates standards of safety and welfare in the workplace. The core and most important unit of HASEWA is Part I as a normative framework for the protection of health and safety. A legislator had recognized that the duties of various subjects represent an initial basis for further regulation of the corresponding occupational safety institutes. In this regard, the preventive nature is extended through other provisions of HASEWA. It is clear that the culture of prevention plays a key role in overall normative and institutional activities. HASEWA emphasizes workplace security and general safety at work, while other laws and sub-laws serve as 'extended arm' of this legal act. After analyzing the normative specificities of occupational health and safety regulations in Great Britain, few institutional peculiarities were emphasized in the second part of the paper. The most important fact is that Executive uses its competences actively and acts as a key national authority in the application of the standards prescribed by HASEWA, as well as other laws and by-laws. Other functional specificities are complementary to the statutory provisions and emphasize the culture of prevention through the education of workers, voluntary and free counseling and providing health care where this risk is adequately managed through professional services.

REFERENCES

[1] The Health and Safety at Work Act 1974, *Available from* https://www.legislation.gov.uk/ukpga/1974/37/contents *Accessed:* 2024-02-17.

[2] Health and Safety Executive: Health and safety at work, *Available from* https://www.hse.gov.uk/simple-health-safety/law/health-safety-law.htm#:~:text=If%20 you%20do%20not%20comply,be%20prosecuted *Accessed:* 2024-02-20.

[3] Health and Safety Executive: Acts owned and enforced by HSE, *Available from* https://www.hse.gov.uk/legislation/acts.htm *Accessed:* 2024-05-15.

[4] Health and Safety Executive: *A guide to health and safety regulation in Great Britain*, N/A, London, (2013), pp. 5-6.
[5] Islamović, S.: *Zaštita zdravlja i bezbjednosti na radu u pravu Evropske Unije*, master'sthesis, Sarajevo (2018), p. 65.
[6] Melvan, P.: *Njemačka je najuspješnije gospodarstvo u EU - kako tome doprinosi zaštita na radu*, interview with dr. Jaoch Breuer, Director General of the German Social Accident Agency, *Sigurnost*, 56 (2014) 4*, passim*.

OCCUPATIONAL HEALTH AND SAFETY COSTS ACCOUNTING

Dubravka Krivačić[1]; Silvija Špehar[2]

[1] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia, dubravka.krivacic@vuka.hr

[2] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, 47000 Karlovac, Croatia, silvijaspehar996@gmail.com

Abstract: *A part of the contemporary sustainability accounting is corporate health and safety performance. One performance dimension is the costs of occupational health and safety (OHS). Accounting of those costs implies recognition, classification and monitoring the costs of accidents at work and related injuries, costs of business downtime, compensations, etc., in order to prevent their future occurrence. Also, OHS costs accounting recognizes costs of health and safety management system, training and education of workers, preventive medical examinations, etc., in order to achieve better health and safety performance. It is therefore important to incorporate OHS costs into corporate management accounting, which facilitates their monitoring, analysis and interpretation. Related to this, the main goal of the paper is to provide an explanation of OHS costs accounting and provide reliable support to managers in deciding on investments in occupational health and safety.*

Keywords: *occupational health and safety, performance, costs, accounting*

1. INTRODUCTION

The continuous striving towards cost efficiency aroused the interest of managers in the occupational health and safety (OHS) costs. Identification and monitoring of OHS costs is necessary in order to more easily assess the risks for occurrence of costs arising from accidents at work, but also to plan costs that will contribute to improving health and safety at work and achieving benefits for all stakeholders. Understanding these costs is crucial for decision-makers to prioritize preventive measures, as well as to achieve financial benefits for their companies. Especially by monitoring the costs that arise as a result of accidents at work and related injuries, managers perceive the financial interest in investing in preventing their occurrence. If occupational accidents are prevented then these costs could be avoided. By quantifying overall economic effects of OHS, managers can better advocate for OHS in the processes of planning, organizing and controlling business activities. Consequently, companies are increasingly including OHS costs in their internal accounting systems, especially management accounting. The inclusion of OHS costs in management accounting enables their easier monitoring, analysis and interpretation, and further use for the calculation and reporting of OHS performance indicators in the context of sustainability accounting.

2. OCCUPATIONAL HEALTH AND SAFETY COST CATEGORIES

The information that is usually collected about occupational accidents is frequency of accidents, types of accidents, location of accidents, affected groups of workers, length of sick-leaves etc., which is then put in relation with number of employees, number of working hours etc. But when considering the issues of occupational accidents in an accounting context then the costs of accidents, the value that the company loses in the course of occupational accidents and the value that is created through prevention initiatives becomes of interest [1]. Through previous research various authors classify OHS costs in accordance with different criteria, but two fundamental groups of OHS costs are clearly distinguished: planned (targeted, preventive) costs versus unplanned (consequence, corrective) costs. Preventive costs are the result of a proactive approach to the OHS management and are aimed at preventing accidents at work and worker illnesses. They include investments in the safety of working conditions, protective equipment, education and preventive health examinations of workers, costs of managing OHS systems, etc. The costs incurred as a consequence of accidents at work and occupational diseases of workers represent the costs that were not incurred on purpose like preventive costs, but as a consequence of an adverse event. Corrective costs include the costs of overtime work due to the compensating the inured worker’s working hours, fines and compensation, as well as expenses arising from reduced productivity, frequent fluctuations of workers, their absenteeism, etc. The latter are also the costs that are the focus of most previous research (e.g. [2], [3], [4]). These costs are further divided into two subcategories: direct and indirect costs. European Agency for Safety and Health at Work under direct costs means health care costs, while indirect costs are those that are the result of productivity reduction associated with the occurrence of accidents at work [5]. The International Labor Organization under direct costs consider costs that arise due to business interruptions and absences of workers due to sickness, treatment and rehabilitation, higher insurance premiums, fines, etc., while indirect costs mean time spent in accident investigation procedures, training replacement workers or hiring new workers, costs due to a decrease in employee motivation, a decrease in the reputation of the company, etc. [6]. In addition to direct and indirect OHS costs a more comprehensive classification considers economic and non-economic OHS costs (depending on who bear them and whether they are expressed quantitively or qualitatively), internal or external costs (depending on whether the business entity bears them or not), fixed and variable costs (depending on their relationship to the number of work injuries and occupational diseases), as well as visible and invisible costs (depending on whether or are not accounted for) [7].

3. MEASURING OCCUPATIONAL HEALTH AND SAFETY COSTS

Measuring OHS costs involves assessing the financial impact of work-related accidents, injuries and illnesses. Different approaches and methods are developed to estimate OHS costs. These methods can be observed at the macroeconomic and microeconomic level. On the macroeconomic level a bottom-up model breaks down costs into direct costs, which include medical expenses, compensation and rehabilitation costs directly associated with accidents or illnesses; indirect costs which encompass lost productivity, absenteeism and reduced efficiency due to workplace incidents; and intangible costs which include pain, suffering and emotional distress experienced by affected individuals. By analysing each component of these costs, organizations can calculate the overall cost of OHS issues. The opposite of a bottom-up model, the top-down approach relies on estimating the costs of the work-related burden of disease. The total costs are estimated via the total burden of injury and disease and the estimated fraction that was caused by occupational factors [8]. The model is often based on DALYs (Disability-Adjusted Life Years), a measure of overall disease burden expressed as the number of years lost or lived with disabilities due to ill health, disability or early death [8]. The application of the bottom-up model determined that the total estimated economic burden of work-related injuries and diseases, including fatal and non-fatal cases, ranges from 2.9% to 10.2% of GDP, while the economic burden according to the top-down model, which is highly dependent on the applied monetization approach, ranges between 4.1% and 10.2% of GDP [8]. The global cost of work-related accidents and illnesses amounts to EUR 2 680 billion, which is 3.9 % of global GDP. By comparison, the European cost is EUR 476 billion, which, at 3.3 % of European GDP. The split of the costs between fatal and non-fatal cases globally and in the EU-28 is almost the same: each category accounts for approximately half of the total costs [9].

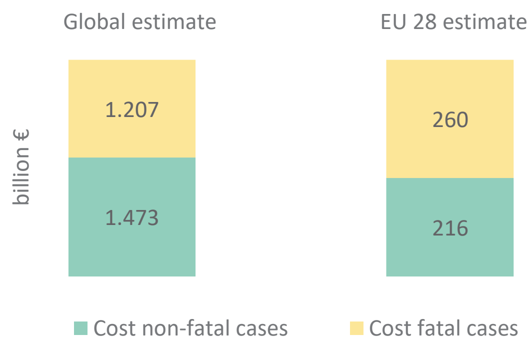


Figure 1: Cost of work-related accidents and illnesses globally and in the EU-28 [9]

At the microeconomic level, OHS costs are elements of management accounting consideration. Management accounting supports decision making processes in organizations by providing managers with relevant information, especially about different types of costs and expenses which is incurred in business. For health and safety-related issues, cost-based calculations dominate practice, and typical measures include cost per injury or the total cost of accidents [9]. Information on the health and safety investments (i.e. preventive costs) is usually well known, but the monetary value of the benefits is difficult to calculate. The same is the case with costs incurred as a result of work-related injuries and occupational diseases (i.e. corrective costs or expenses). The direct corrective costs of work-related injuries and occupational diseases are easier to calculate, given that they are immediately visible at the same time of the occurrence of the accident, while indirect costs appear with certain time lag and are difficult to predict and measure. Management accounting thus needs to implement appropriate costs evaluation methods which will help to measure and predict the occurrence of different types of OHS costs. These methods also have to include identification of non-financial outcomes, either of poor health and safety activities, or benefits created though contemporary OHS systems. The relevant management accounting methods include the Balanced Scorecard (BSC) approach, the payback period, the simple rate of return, and the benefit-to-cost ratio [9].

Because classical budgeting methods imply giving a monetary value for life or pain, which is questionable, some authors suggest to include non-monetary values in calculations, as the BSC approach implies. In that way it is possible to credit to safety benefits that are not directly based on the value of safety itself but are side effects of safety work [9]. As appropriate cost evaluation method some authors suggest Activity-Based-Costing method, according to which OHS costs are classified into controllable and non-controllable costs. It represent more management-oriented approach because of the focus on the internal costs and exclude social costs [1]. Depending on the applied cost estimation method, OHS costs should be included in the internal calculation according to the account groups and analytical accounts, which should be foreseen in the chart of accounts.

4. REPORTING ON OCCUPATIONAL HEALTH AND SAFETY

Just as it is responsible for protecting the health of its workers, by providing them with safe working conditions, company has to be accountable and provide relevant information about the measured indicators of OHS to all its stakeholders. An acceptable framework for providing information to stakeholders is sustainability reporting. In sustainability reporting companies focus on information about employees, community activities, consumers' satisfaction and responsibility towards the natural environmental. Information about employees inevitably includes measured indicators of OHS. The legal framework for sustainability reporting at the EU level is the Corporate Sustainability Reporting Directive [11], which implies the application of the European Sustainability Reporting Standards [12]. In order to meet the objective of the ESRS S1 – Own workforce, companies are required to report an explanation of working conditions, including health and safety indicators. Specifically, companies have to report on the extent to which its own workforce is covered by its health and safety management system and the number of incidents associated with work-related injuries, ill health and fatalities of its own workers. In addition, they have to disclose the number of fatalities as a result of work-related injuries and work-related ill health of other workers working on the undertaking's sites (ESRS, S1-14). Companies also can report about OHS in accordance with the Global Reporting Initiative (GRI) Standards, "the most dominant standards used around the world" [13]. GRI 403 Standard – Occupational Health and Safety is a topic-specific standard which includes disclosures on the management approach, for example about OHS management system, hazard identification, risk assessment, etc., as well as topic-specific disclosures such as workers covered by an OHS management system, work-related injuries and work-related ill health [14]. By acting responsibly and reporting on OHS in accordance with the aforementioned international standards, business entities contribute to the achievement of the Sustainable Development Goals (SDGs), adopted by the United Nations as a universal call to action, which among the other goals include also the goal of ensuring decent working conditions and economic growth [15]. On the other hand, information on the economic consequences of accidents at work and, conversely, about preventive investments in OHS, are the subject to consideration in the processes of internal reporting. Companies typically prepare information of OHS costs for their own internal use through management accounting. In general, such "internal information only rarely reaches the public domain and so relatively little tends to be known about it outside the organization itself" [16]. The difficulty that stakeholders have in obtain information about OHS performance is one of the reasons why organizations like EU OSHA emphasize on distinguishing lagging from leading indicators and their reporting to external users. Lagging indicators should include: injuries and work-related ill health in terms of Lost

Time Injury (LTI) and Lost Time Incident Frequency (Rate), production days lost through sickness absence, incidents or near misses (including those with the potential to cause injury, ill health, or loss), complaints about work that is carried out in unsafe or unhealthy conditions and the number of early retirements [17]. Although there is often a strong emphasis on the negative indicators, examples of positive lagging indicators are: the percentage of productive planned work days realised, the number of hours worked without lost time injury, the number of working days since the last accident and employee satisfaction [17]. Indicators that can be used to improve OSH management are leading indicators, examples of which are: the percentage of managers as well as workers with adequate OSH training, percentage of management as well as management-worker meetings wherein OSH is addressed, percentage of business partners evaluated and selected on the basis of their OSH performance, number of workplace inspections, number of OSH audits performed, percentage of OSH projects/activities that are finalised on time, etc. [17]. Leading indicators focus primarily on actions undertaken to prevent OSH problems. When looking at economic indicators it is useful to know how much the organisation invests in certain preventive actions, especially since financial resources are scarce and should be used efficiently. Investment in preventive activities have a positive impact on production. The indicator "return on prevention" is important to confirm that past OSH investments were cost effective and to facilitate future investments in OSH prevention. Useful also can be to quantify the costs associated with lost time injuries, the percentage of sickness absence translated into financial costs, the cost of hiring a temporary replacement or claims from insurers, etc. Key performance indicators are important for the effectiveness of the OSH management process because they provide valuable feedback, help to motivate managers and organisations to take action, are valuable for communication purposes and are also important for mainstreaming OSH management in business management, but should not themselves become an aim [17].

5. CONCLUSION

The basic conclusion of the research is that the issue of OHS should be viewed through all aspects of socially responsible business, including the accounting aspect. The issues of protecting health and safety of workers viewed in accounting context are the values that a company loses due to accidents and diseases, as well as the values that it creates through the implementation of preventive initiatives. Those values are consequently differentiated into planned and targeted costs and expenditures that result from accident and worker illnesses. When there is a creation of a liability and/or an outflow of money, regardless of the creation of the intended effects, it is a matter of expenses of the period, that is, of losses. They charge the accounting period in which they arose and directly affect the reduction of financial result of the business. On the other hand, investments that result in the protection of the health and safety of workers represent expenditures made with the aim of improving the social efficiency of the company on the issue of workers in the coming period. The reason for undertaking them is usually accidents or illnesses of workers that have already occurred, i.e. already incurred expenses for wages, expenses for organizing the replacement of the injured or sick workers, expenses due to delays in delivery deadlines, etc. However, there is no wrong moment for preventive initiatives, considering the business case for protecting the health and safety of workers, and deciding on the amount of investment. At the same time, it would be desirable to incorporate monitoring and reporting of the OHS costs into the management accounting system of the company. This would enable their continuous measurement, analysis and interpretation, and ensure up-to-date and reliable support for managers in deciding on investments and managing the aspect of protecting the health and safety of workers. Investments in health protection and safety at work, like any other investment, are profitable if they provide adequate returns to the company. Given that they prevent the occurrence of unplanned costs, i.e. expenses that are a consequence of harmful events and worker injuries, as well as disruption of the continuous flow of business processes, investments in the protection of worker health and safety are undoubtedly justified.

REFERENCES

[1] Rikhardsson, P. (2006): Accounting for Health and Safety costs: Review and comparison of selected methods, chapter in the book, Schaltegger, S., Bennett, M., Burritt, R. (eds.): Sustainability accounting and reporting, Springer, Dordrecht, Netherlands, pp 129 – 151

[2] Gibb, A., Drake, C., Jones, W. (2018): Costs of occupational ill-health in construction, Research funded by the Institution of Civil Engineers, https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Documents/Disciplines%20and%20Resources/Briefing%20Sheet/Costs-of-occupational-ill-health-in-constructionformattedFINAL.pdf

[3] Thiede, I., Thiede, M. (2015): Quantifying the costs and benefits of occupational health and safety interventions at a Bangladesh shipbuilding company, International Journal of Occupational and Environmental Health, 21, 2, p. 127-136

[4] Lebeau, M, Duguay, P. (2013): The costs of occupational injuries, Studies and Research Projects, Report R-787, The study was funded by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST), Montréal, Canada, https://www.irsst.qc.ca/media/documents/PubIRSST/R-787.pdf?v=2020-08-13

[5] EU OSHA (2014): Estimating the cost of accidents and ill-health at work: A review of methodologies, https://osha.europa.eu/en/publications/estimating-cost-accidents-and-ill-health-work-review-methodologies

[6] ILO (2006): International Labour Office, Committee on Employment and Social Policy, Occupational safety and health: Synergies between security and productivity, Geneva, https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/meetingdocument/wcms_110380.pdf

[7] Dorman, P. (2000): The economics of safety, health and well-being at work, InFocus Program on Safe Work, International Labour Organisation, http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_110382.pdf

[8] EU OSHA (2019): The value of OSH and the societal costs of work-related injuries and diseases, https://osha.europa.eu/sites/default/files/Value%20of%20OSH_and_societal_cost_workrelated%20injuries_and_diseases.pdf

[9] EU OSHA (2017): An international comparison of the cost of work-related accidents and illness, https://osha.europa.eu/sites/default/files/2021-11/international_comparison-of_costs_work_related_accidents.pdf

[10] Tappura, S. et al. (2015): A management accounting perspective on safety, Safety Science, Vol. 71, Part B, p. 151-159

[11]Corporate Sustainability Reporting Directive (CSRD), 2022/2464/EU

[12]European Sustainability Reporting Standards (ESRS), 2023/2772/EU

[13]KPMG (2022): Big shifts, small steps: Survey of Sustainability Reporting 2022

[14]GRI 403 (2018): Occupational health and safety, https://assets-global.website-files.com/6284e7575a119269975cab85/62a87f7a90e6bc3ede06585f_gri-403-occupational-health-and-safety-2018.pdf#page=8&zoom=100,0,0

[15]United Nations Development Programme (UNDP) (2024): https://www.undp.org/sustainable-development-goals

[16]Gray, R., Adams, C. A., Owen, D. (2014): Accountability, Social Responsibility and Sustainability: Accounting for Society and the Environment, Pearson, Harlow, UK
[17]EU OSHA (2024): https://oshwiki.osha.europa.eu/en/themes/key-performance-indicators

QUALITY MANAGEMENT SYSTEMS IN THE AREAS OF OCCUPATIONAL HEALTH AND SAFETY AND ENVIRONMENT USING FMEA METHOD FOR PATIENT SAFETY RISK MITIGATION

dr.sc. Elizabeta Krstić Vukelja, dipl.ing.stroj, univ.mag.admin.sanit.
[1] Dental Clinic Zagreb, Perkovčeva 3, Zagreb, HRVATSKA,

Abstract: *The processes of healthcare organization represent an integrated set of activities, the implementation of which is governed by the requirements of national regulations and internationally recognized standards related to quality, occupational safety and health and the environment. All three management systems require a risk management approach. The aim of this article is to present a comparison of the quality system with the occupational safety and environmental protection system through the application of national legislation with a focus on patient safety. By presenting the research on patient safety risks, the obtained results will provide evidence that the integration of all three management systems is necessary when it comes to the health organization. The application of the Failure Modes and Effects Analysis (FMEA) method will provide insight into the importance of identifying and managing risks.*

Keywords: *quality management, occupational health and safety, environment, patient safety, FMEA method*

1. INTRODUCTION

In the last years organizations have increase their concerns for implementing and certification according to at least one quality standard. When it comes to healthcare institutions, the problem was understanding what a process approach really is, given that the concept of process and even service has always been linked to production and industry. Following new trends in system quality management, occupational health and safety management, and environmental management, there is one question that arises concerning the possibility of combination all three systems into one single system with a common goal. A review of the literature [1-10] suggests that it is possible to establish an integrated management system that would include all three systems in one, the requirements of the ISO 9001 [1], ISO 14001 [2], and ISO 45001 [3], standards. However, the implementation of at least one management system requires a lot of financial investments, from education, implementation to periodic inspections, emphasizing that the implementation of any system is a voluntary choice of the employer with a view to long-term benefit. By studying the national legislation [4, 5], such as Law on the Quality of Health Care [4], the Regulation on Accreditation Standards and the regulation on health care quality standards and the way on their application [5], are particularly highlighted, which combine the requirements of all three systems into one, and their common goal is patient safety, emphasizing that the requirements of both regulations are mandatory, subjected to inspection control and in case of Act and Regulations violation, the health care institution can pay a fine.

The aim of this paper was to show, on the example of the Dental Clinic, that it is possible to integrate all three systems into one with one common goal, respecting the requirements of the national legislation, process approach and risk management using risk management making decisions. The application of the FMEA method will provide important data for identifying and managing risk.

2. COMPARISON OF THREE MANAGEMENT SYSTEMS

The analysis of each management system leads to the conclusion that the requirements of each of them are directed towards the focus group. The requirements of the quality management system, in accordance with the ISO 9001 standard [1], put the end customer in focus. The requirements of the environmental management system, according to the ISO 14001 standard [2], focus on the requirements of society and interested parties. The requirements of the occupational health and safety management system, in accordance with the ISO 45001 standard [3], focus on employees. The analysis of the national legislation requirements leads to the conclusion that they deal with the quality of health care with focus on patient safety, while the international accreditation standards for health institutions focus on risk management with the aim of saving lives [6]. Each standard and national regulation should increase processes competitiveness with the perspective on their impact on service quality, environment and occupational and health safety. Generally, all standards have an approach that is based on the ‘‘Plan-Do-Check-Act’’ (PDCA) cycle, and the management system requirements are categorized as following: general requirements, policy planning, implementation and operation, checking and corrective action, and management review. In this context, the paper discusses and debates factors affecting safety-quality integration in quality management systems, compliance requirements of 45001 occupational health and safety management standard and that of ISO 9001 (quality) and ISO 14001 (environment management standards).

2.1. The quality management system

With the adoption and implementation of the Health Care Quality Act and the Regulation on Health Care Quality Standards, all healthcare institutions are obliged to manage the health care quality requirements. They must approach management in a systematic way. They must establish an internal organization so that the roles, responsibilities, obligations, activities related to quality management are defined in such a way that all measures implemented by a healthcare organization are directed towards one common goal, which is patient safety. However, a safe patient is the ultimate outcome assuming that the prerequisites of a safe environment, safe procedure, safe health technology, and a safe worker are met. By reading the requirements of the ISO 9001 standard and the requirements of the standards in accordance with the Regulation on quality standards of health care, as well as the requirements of the accreditation standards, certain similarities could be observed. For example. The requirement number 4 of ISO 9001 expects that the organization is aware of the context in which it operates, that it is aware of the needs of its own workers, the expectations of interested parties, that it has defined the area of application of the quality management system and defined its own processes. Requirement number 5 of ISO 9001 talks about the commitment of the management and all employees towards the customer. On the other hand, standard number 2 of Regulation on Health Care Quality Standards requires from health care organization to be committed to patient safety, with the definition of a mechanism for recognizing and detecting the prevalence and severity of incidents that affect or threaten patient and staff safety.

Likewise, healthcare institutions must have a documented patient and staff safety system that includes the following procedures: Detection and reporting of unwanted events, Preventive and corrective actions, Defined procedure for risk reduction, Implementation of action plans, Continuous measurement to ensure the effectiveness of actions, Patient and staff safety assessment, Policy and practice of notifying patients and/or their families about unexpected adverse events, Defining Unexpected Adverse Events.

Requirement number 6 of ISO 9001 means defining measures to solve risks and opportunities, adopting quality goals and planning their achievement. On the other hand, standard number 1 of Regulation on Health Care Quality Standards requires measurement, monitoring and analysis of clinical and non-clinical procedures, through the establishment of measures that can detect deviations and identify problems, as well as identify both positive and negative outcomes and the effectiveness of actions taken to improve work and/or reduce risk. Farther more standard number 5 of Regulation on Health Care Quality states that a healthcare institution must have a general act that establishes measures, obligations and responsibilities.

Requirement number 7 of ISO 9001 refers to people, infrastructure, environment for process work, organizational knowledge, competences. The requirement of the international accreditation standard (literature) Module I states the requirement of management of staff, especially of Doctor of Dental Medicine, patient safety; Module III – deals with security measures of the entire infrastructure of the healthcare institution.

Requirement number 8 of ISO 9001 8 refers to operational planning and supervision, as well as the supply of production and services, which is again covered by all Regulation on Health Care Quality Standards. The requirement number 9 of ISO 9001 internal audit is also described in standard number 8 of Regulation on Health Care Quality Standards which imposes the obligation to carry out internal audits of its own procedures and the consequent application of corrective and preventive actions and verification of their effectiveness, and the healthcare institution must have a documented procedure for performing internal audit. The requirement number 10 of ISO 9001 deals with non-conformities and corrective measures - which is already described in standard number 9 of the Regulation on Health Care Quality Standards.

2.2. The occupational health and safety management system

Management of occupational health and safety is based on measures to eliminate or minimize risks for employees and other interested parties who could be exposed to risks for safety and health protection at work. The Law on Quality of Health Care provides an exact definition of what the safety of a health care procedure is. So, the focus is again on patient safety and measures to prevent the occurrence of diseases, injuries and other harmful unwanted events for the patient. At the same time, safety includes not only the safety of the patient, but also of healthcare workers and the healthcare procedure. In accordance with the requirements of the Regulation on healthcare quality standards, as well as the ISO 9001 standard, the healthcare organization must define healthcare quality indicators. One of the quality indicators related to patient and employee safety is a puncture incident. When it comes to puncture incident, it is very important to gather all the information about the workplace, the employee, the way the incident occurred, the cause of the puncture injury and the circumstances that led to the incident. To standardize this practice of reporting, handling before and after a puncture incident, procedures were adopted such as training plan for newly hired nurses, trainees and procedures for dealing with a puncture incident. By these procedures health care institution will easier handle all challenges of the risk behaviors and problems related to workplace environment.

2.3. Environmental management system

In a healthcare organization, the environmental management system includes all activities through which the healthcare organization proves its responsible behavior towards workers, patients and the wider community through the conscientious separation, sorting and storage of hazardous waste. The correct management of hazardous waste directly affects the risk of outpatient infections. Environmental management in terms of preventing the occurrence and spread of outpatient infections, hazardous waste management aims to achieve the so-called "Cleaner and safer health care" by ensuring the following "clean" principles: clean hands, clean practice, clean products, clean environment and clean equipment. In accordance with the requirements of the Law on Waste Management [7], the Regulation on Medical Waste Management [8] and the Law on the Protection of the Population from Infectious Diseases [9], Dental Clinic carries out the following activities: collection, sorting, storage and delivery of waste to an authorized trading company. Since it is a hazardous waste management system, it was necessary to define hazardous waste management processes, which entailed creating a documented record that included defining the areas of application, responsibilities, work tools, work accessories, competencies, and records of activities performed. The purpose of the documented records was, among other things, to define procedures for carrying out measures to prevent, control and monitor polyclinic infections. In that case Dental Clinic has adopted following procedures: procedures for cleaning and disinfecting workspaces, environment and equipment, procedures for keeping appropriate records of the activities carried out, procedures for maintenance of work resources, procedures for training of workers responsible for hazardous waste management, hazardous waste management procedure, and so on.

3. RESEARCH RESULTS OF A CONDUCTED SURVEY

With the intention of demonstrating the importance of managing patient safety, as the end user of the healthcare service, a survey was conducted at Dental Clinic with the aim to determine the number of patients with certain high-risk health conditions in everyday dental practice, who might require certain emergency interventions in case of the occurrence of so-called incident situations. Incident situation is determined as any event or circumstance that occurs during or in connection with the provision of healthcare and that could have caused, or has already caused, unintentional or unexpected injury, loss or damage. A subsequent analysis of collected data was carried out to represent all problems or nonconformities which may arise during the diagnostic and therapeutic procedure. The analysis of possible causes and consequences of all problems will show that within just one process different risks specific to all three management systems can be find. And this is way they need to be observed through an integrated management system.

The documentation that served the purpose when collecting data for this analysis included FDI health questionnaire, data obtained during dental therapy regarding suspicion on risky health conditions and data obtained after emergency intervention in the dental office. The research was conducted on a sample of 17,400 patients in three specialist departments (oral surgery, endodontics with restorative dentistry, oral medicine and periodontics, and dental prosthetics). A total of 2,146 at-risk patients were registered, i.e. every 8th patient was at risk during this study. The smallest number was recorded with infectious diseases 4.05% (HBV, HIV, AIDS, TB, MRSA). Then, patients with systemic diseases were the most represented, 77.31%. While patients with special needs were registered in 400 cases, of which 10.11% were uncooperative patients (conflict, dementia, PTSD) and 8.52% were patients with some physical disability. Incidents that can occur more often in the dental office are syncope, hypoglycemia, hyperglycemia, allergy, collapse, myocardial infarction, and epileptic seizure. These incidents can cause undesirable and even serious consequences such as falls, fractures, suffocation, etc. The risk of incident situations is greater when treating patients with various systemic diseases: cardiovascular, pulmonary, hematological and neurological diseases, asthma, epilepsy, diabetes and allergies. So, despite a good medical history and a questionnaire about the patient's health (which includes current illnesses and medications the patient is taking) and special precautions in planning the dental treatment of a high-risk patient, there is always a risk to the patient's safety. Due to the specificity of each of the listed conditions, it is necessary to strictly adhere to certain procedures before, during and after the dental procedure because the planned intervention can worsen the underlying illness. Such events require the immediate reaction of the entire dental team, therefore preparation and training, as well as a detailed plan of action, are extremely important success factors. A good knowledge of systemic diseases and a proper procedure will prevent a possible incident, and good communication, regular education in emergency situations will save human life.

3.1 Application of FMEA method in risk analysis in diagnostic-therapy procedure

During the risk analysis following phenomena were important when applying the FMEA method: the frequency of patients with risky health conditions, the level of knowledge and experience of medical staff in recognizing risky health conditions of patients, skills and speed in applying first aid in the event of an incident situation, availability and correct equipment for providing first aid, detailed and accurately completed FDI health questionnaire, valid laboratory tests, medical history, etc. During the diagnostic and therapeutic process, basic principles were always applied - checking medical documentation, statements about health, interview with patient. In accordance with this principle, control points are set so that the participants in the diagnostic and therapeutic process are sure that they have completed everything necessary previous activities before the actual therapy of the patient. Each step of the diagnostic and therapeutic process is defined by precisely defined roles and responsibilities and accompanying documentation.

In a concrete example of risk analysis during the diagnostic and therapeutic process, in the case of treating a high-risk patient, it is necessary to first gather information about the patient's health condition, his systemic diseases, years of life, the therapy he receives, etc. The detailed FDI health questionnaire is filled out by the patient personally, and additional clarifications and information are available on patient request from healthcare specialist. Some of the important questions in this questionnaire refer to the patient's statement if he is suffering from any disease, whether he has been treated in the last two years, whether he has been in the hospital in the last two years, what medications he is currently taking - intermittently all the time, whether he had problems with local or general anesthesia so far, is he allergic to any medication or something else, does he have problems with blood clotting, has he ever been irradiated on head and neck area, does he have any infectious disease, does he smoke, is he HIV positive, is he addicted to drugs, etc. Patient is responsible for the accuracy of these data, and doctor confirms with his signature that he has read the FDI document.

The Failure Modes and Effects Analysis (FMEA) was used to analyze risk management for OHS, environment and quality management under the integrated management system in the case of diagnostic therapy process. Dental Clinic has ISO 9001 certifications but has not OHS and environment certification and the integrated management system is well defined and implemented by national regulation considering health care quality.

For conducting FMEA risk analysis [10], a multidisciplinary team included three different dental specialists, three nurses, quality and risk manager, environmental and OHS specialist. The multidisciplinary team identifies and ranks the process failure modes. In conducting the prospective risk analysis, the first step is to describe the diagnostic therapeutic process according to occurrences of incidents situation. Once all possible failure modes are obtained, a severity (S) is assigned to the effect of the failure mode to reflect the seriousness of its occurrence. An occurrence (O) is assigned to the cause of the failure mode to reflect the probability of the failure mode occurring, and a detectability (D) is assigned to the cause of the failure mode to reflect the difficulty of detecting the cause or failure mode. Finally, the risk priority number (RPN) was calculated based on the severity, occurrence, and detectability as shown in equation:

$$RPN = S \times O \times D \qquad (1),$$

Details on the occurrence of failure, severity, and detection for OHS, quality and environmental risks are explained as follows [10]: occurrence for quality risk represents the probability of quality failure, for environmental risk represents the probability of hazardous events to the environment, for occupational and health risk represents the probability of injuries, professional deseases and dangerous events on work. Severity and detection for quality risk represents strenght of inpact of poor quality on the system and probability that it will be detected. Severity and detection for envirnmental risk represents the strenght of impact of hazardous events on the environment and the probablity thet it will be detected. Finally, severity and detection for occupational and health risk represents the strenght of the impact of all incidents on safety at work an the probability that they will be detected.

Table 1: Incident situation scale table: Occurrence (O), Severity (S), and Detection (D)

Score	O	S	D
10	Incident situation extremely high to occur	Hazardous without warning, the patient's life is endangered	Absolutely uncertainty to detect incident situation
9	Incident situation very high to occur on 1/10 patients	Hazardous with warning (procedures were not applied)	No existing measures for the problem detection, very remote
8	Incident situation high to occur on 1/50 patients	Major additional safety, medical, environmental, quality problem very high to occur	The detection problem is remote because it is done by the patient through complaints
7	Incident situation frequent occurs on 1/100 patients	Minor additional injuries, professional deseases and dangerous events on work problem high to occur	The problem detection is done by random checks
6	Incident situation moderate to occur on 1/500 patients	Procedure with moderate positive effect	The problem detection is low because it is done by yearly planned internal audit
5	Incident situation occurs occasionally on 1/1000 patients	Failure in applying organization's own internal rules, norms	The problem detection moderate because it is done by planned checking actions
4	Incident situation slightly to occur on 1/5000 patients	Very low effect on safety, quality and environment	The detection problem is moderately high (it is done at a later stage)
3	Incident situation has very slight chance to occur on 1/20 000 patient	Quality, safety, medical procedures with minor negative effect	The detection is high, and it is done using a control or checklist
2	Incident situation is very unlikely to occur on 1/100 000 patients	Quality, safety, medical procedures with very minor negative effect	The detection is very high

1	Incident situation extremely unlikely to occur	No effect on patient safety, quality, OHS and environment	The problem is almost certainly detected

In the case of the diagnostic and therapy process the assessment criteria have been established as shown in **Table 1**. A scale of 10 points is explained as follows: 10 represents the most possible in occurrence, the most serious in severity and least detectable and 1 is the least possible in occurrence, the least serious in severity and the most detectable. The team members of FMEA requested to provide their scales on evaluation of occurrence, severity, and detection for potential risks. With this method FMEA team have detected more than 143 risks. In this paper only few of them will be presented in **Table 2**. Since the analyzed risks deal with patient safety, every risk was evaluated as undesirable and unacceptable regardless of RPN.

Table 2: Identified Failure causes, Failure effects, Risk types and actions to reduce occurrence of failure

Risk Priority Number RPN	Failure mode	Failure Cause	Failure Effect	Risk type	Actions to reduce occurrence of failur
30	Risk patient is not recognized	Failure to apply knowledge, fatigue, speed, superficial assessment of the patient's condition with regard to systemic diseases	Risk to the patient's health - possible injury and impairment of bodily functions in circumstances that are contrary to the natural course of the patient's treatment, and which require additional treatment or which result in significant changes in the patient's condition,	Quality failure, OHS and the environment failure	Internl audit of medical documentation and competence Quality audit, work competence, work procedure, education, control Standard procedure for an epileptic seizure Standard procedure in a patient with vomiting stimulus Standard procedure for fainting Standard procedure for an HIV and hepatitis positive patient, etc.
90	Administering the wrong medication or the wrong amount of the appropriate medication	Wrong diagnosis or superficial assessment of the patient's condition with regard to systemic diseases	Adverse drug reaction Patient may receive incorrect medication, or incorrect dose	Quality failure, OHS failure	Audit of medical records and competence Quality audit, work competence, work procedure, training, control
81	In the case of an incident situation, the adopted procedure was not followed	Failure to apply knowledge, fatigue, speed, superficial assessment of the patient's condition with regard to systemic diseases	Sudden onset of infection, transmission of an infectious disease from staff to patient, from patient to staff, from patient to patient (HIV, hepatitis B and C, MRSA)	Quality failure, OHS failure, environment failure	Introduce incident procedures acquire and use equipment for incident situations Create an education and supervision plan review risks. Introduce a system of supervision and prof. control.

Risk Priority Number RPN	Failure mode	Failure Cause	Failure Effect	Risk type	Actions to reduce occurrence of failur
81	The roles of each staff member during emergency procedures are not defined	Lack of knwoledge, lack of procedures	Risk to the health of the patient, staff, and the environment	Quality failure, OHS failure, environment failure	Quality audit, work competence, work procedure, training, control
36	Unknown location of emergency equipment and medications	Lack of knwoledge, lack of procedures	Risk to the health of the patient	Quality failure, OHS failure	Quality audit, work procedure, training, control
45	The occured incident situation is not documented	Failure to apply knowledge, fatigue, speed, carelessness	Patient health condition complication, the risk of complaints and lawsuit	Quality failure	Instructions for handling in incident situations - documented record - the name of the patient and other participants at the scene of the incident - condition of materials and equipment -medicines that were used in PPP (providing first aid) -place, time and conditions in which the incident occurred

Risk Priority Number RPN	Failure mode	Failure Cause	Failure Effect	Risk type	Actions to reduce occurrence of failur
36	Resuscitation drugs (according to ACLS guidelines) have expired	Lack of knowledge, lack of procedure for medication management, carelessness, speed	Risk to the health of the patient	Quality failure, OHS failure	Instructions for the procedure for implementing anti-shock therapy Instructions for dealing with emergency situations with a description of the kit for emergency intervention
81	Automated External Defibrillator with Electrodes (AED) not serviced regularly, no battery, battery defective	The manufacturer's instructions are not followed, lack of knowledge, negligence	Risk to the health of the patient	Quality failure, OHS failure	Quality assessment and work procedures, training and control, records of regular inspection and maintenance

4. CONCLUSION

Management of an integrated system of quality, environment and safety must be a priority when it comes to a healthcare institution. The aim of the integration is risk management to reduce errors and unwanted events, the result is: patient safety, safer work process, safer workspace and equipment, satisfaction of employees and of end users. How to achieve this? By the cooperation of clinicians and experts for risk, quality and safety, by changing the culture of work, awareness of quality, setting common value systems, including the attitudes of individuals, habits and the behavior of people within the work organization, by taking a dominant position on striving for excellence.

REFERENCES

[1] International Organization for Standardization: *ISO 9001 International standard quality management systems-requirements,* Geneva, Switzerland, (2015)

[2] International Organization for Standardization: *ISO 14001 International standard environmental management systems- requirements with guidance for use,* Geneva, Switzerland, (2015)

[3] Internatiional Organization for Standardization: *ISO 45001 Occupational health and safety management systems Requirements with guidance for use, Geneva*, Switzerland (2018).

[4] Zakon o kvaliteti zdravstvene zaštite, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2018_12_118_2339.html, *Accessed:* 2024-05-10

[5] Pravilnik o standardima kvalitete zdravstvene zaštite i načinu njihove primjene, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2011_07_79_1693.html, *Accessed:* 2024-05-10

[6] AACI, *Available from* https://aacihealthcare.com/news/accreditation-standards-for-dental-organisations-under-revision/, *Accessed*:2024-05-10

[7] Zakon o gospodarenju otpadom, *Available from* https://www.zakon.hr/z/2848/Zakon-o-gospodarenju-otpadom, *Accessed*: 2024-05-10

[8] Pravilnik o gospodarenju medicinskim otpadom, *Available from* https://narodne-novine.nn.hr/clanci/sluzbeni/2015_05_50_989.html, *Accessed*: 2024-05-10

[9] Zakon o zaštiti pučanstva od zaraznih bolesti, Available from https://www.zakon.hr/z/1067/Zakon-o-za%C5%A1titi-pu%C4%8Danstva-od-zaraznih-bolesti, Accessed: 2024-05-10

[10] Zeng, S. X., Tam, C. M.: Integrating safety, environmental and quality risks for project management using FMEA method, *Engineering Economics*. Vol. (2015) No. 66, pp. 1
Available from
https://www.researchgate.net/publication/228556148_Integrating_Safety_Environmental_and_Quality_Risks_for_Project_Management_Using_a_FMEA_Method,

PROTECTION AND RESCUE SYSTEM OF THE REPUBLIC SERBIA

Zoran Marjanović[1]; Marija Mičović[2]; Aleksandar Terzić[3]
[1]Ministry of Defence Republic of Serbia
[2]Research associate, University of Criminal Investigation and Police Studies, Cara Dusana 196, 11080 Zemun, Belgrade
[3]Master of Political Science

Abstract: *One of the basic missions of civil defense in the Republic of Serbia, protection and rescue has an increasingly important place and role in the state's national security system. On the basis of the adopted norms in this area in the Republic of Serbia, it is implemented through the established protection and rescue system in the Republic of Serbia. Protection and rescue refers primarily to people, material, cultural and other goods, as well as the preservation of the environment. This mission is carried out by protection and rescue entities, through the protection and rescue forces. In this paper, the system of protection and rescue in the Republic of Serbia is dealt with through normative and legal regulations with special reference to the place and role of the subjects of the system of protection and rescue in the Republic of Serbia. All norms, then regulations and scenarios are only a letter on paper if all of the above is not coordinated uniquely, preferably from one center, controlled, and especially periodically rehearsed after the education of all units involved in the protection and rescue system according to approved scenarios..*

Key words: *protection, rescue, norms, subjects, emergency situation.*

1. INTRODUCTION

Only the necessity of the absence of threats to the national security of a state can lead to potential well-being in society and the state. The positive results of a country in the economic, social, and security aspects and the perception of the national security of the Republic of Serbia should not be seen as a permanent and unchangeable situation, because at no time should the possibility of threats from technical and technological accidents, endangering the environment, natural disasters, endangering the life and health of citizens due to radiological, chemical and biological contamination and other accidents be excluded. We can conclude that these will be constant security risks and threats to the Republic of Serbia. In the case of high-intensity disasters, the actions of these will quickly be transferred to neighboring countries, the region, or perhaps most of the planet, which will require the exchange of information and coordinated action of states in countering disasters (which must be anticipated in the scenarios in the case of these events). Accidents of this and similar types require the need to engage the protection and rescue system of the Republic of Serbia. The manner, quality, simplicity, precision, and completeness of the normative regulation of the existence and engagement of such a system of protection and rescue of a country are of crucial importance for the timeliness of preventing unwanted actions, i.e. mitigating the consequences if an accident has already occurred. The greatest responsibility for preventing and/or taking measures lies with the subjects of the protection and rescue system, and the main focus is

[1] marjanovic.cole.zoran@gmail.com

on their engagement and work on preventive action and the detection and prevention of accidents, which must be a continuous process or action due to a certain disaster or accident that has already occurred.

2. PROTECTION AND RESCUE SYSTEM OF THE REPUBLIC OF SERBIA - ORGANIZATIONAL PART

This part of the research begins with an explanation of several phenomena that, among other things, are the ones that are the reason for which the system for the protection and rescue of a country was formed. To treat a certain threat as a threat of a global catastrophe requires that the damage be serious, and the level global. A catastrophe that would cause millions of victims and tens of billions of dollars in economic loss (for example, A pandemic is certainly considered a global catastrophe, even if some regions of the world avoid it or partially avoid it. For those catastrophes that are much smaller than these ranges, the definition, the conceptual definition is indefinite. Global catastrophes have occurred many times in history (the Anne Shi Uprising (756-763), the Taiping Rebellion (1851-1864) and the famine of the Great Leap Forward in China, the Black Death in Europe, the Spanish Flu pandemic, the two world wars, the Nazi genocides, the famine in British India, Stalin's totalitarianism, the decimation of the Native American population by smallpox and other diseases that accompanied the arrival of European colonizers, probably the Mongol conquests, maybe the Belgian Congo, maybe COVID-19). A subset of the threats of global catastrophe are existential threats, i.e. threats that can cause the extinction of intelligent life originating on planet Earth, or permanently and drastically reduce the quality of its life. Existential threats share several specific characteristics and therefore deserve special consideration. For example, since recovery from existential threats is not possible, we must not allow any existential catastrophe to happen, because in that case, we will not have the opportunity to learn from experience (Bostrom and Ćirković, 2011). If a country is serious and wants security for its citizens, and to try to influence the mitigation of such and similar events, every country must have a well-organized system of protection and rescue. Referring to Erich *Eder*, Kovač and Stojković stated that the geostrategic and social upheaval in 1990 led to the expansion of the concept of "security policy" to the general security of existence, which includes protection from catastrophes caused by civilization. In addition to one's own, especially in Europe, a contribution to international stability is also required (Kovač and Stojković, 2009).

Autor group (*Boin, Hart & Kulpers*In their research, they note that crises usually require intensive cooperation, a network of organizations that may be new to each other. Vertical and horizontal cooperation must be regulated to create a state of coordinated behavior. Very often these situations are urgent, but the network of organizations is often not hierarchically connected. Coordination is not a self-evident feature of a crisis management operation. The question of who is in charge usually arouses great passions. In a crisis, you suddenly "forget" about the sensitivities and conflicts that reigned in everyday life and relations between the authorities and others before the crisis. Disaster researchers see self-organization as a central feature of coordination. In a disaster, communities, local organizations, and individuals, the victims, can be surprisingly creative and adaptable. Their "ad hoc" nodes of cooperation may even be the best response to local needs. The effectiveness of self-organization requires the central authorities to restrain. Effective leaders ask more than they say, they ask for orders, delegation, and decentralization. If network parties clash or local capacities are completely overwhelmed, central officials should take responsibility and intervene (Boin, Hart & Kuipers, 2017).

At the Senadai Conference on Disaster Risk Reduction Frameworks 2015-2030, it was stated that the framework for action, in line with the expected outcome and objective, should focus on action within and across sectors of government at the local, national, regional, and global levels in the following four priority areas. *Priority 1,* Understanding the risk of disaster, *Priority 2*, Strengthening disaster risk management, *priority 3,* Investing in disaster risk reduction for resilience, *priority 4,* Improving disaster preparedness for an effective response and for "building better" in recovery, rehabilitation, and reconstruction. In their approach to disaster risk reduction, states, regional and international organizations, and other relevant stakeholders should take into account the key activities listed for each of these four priorities. *UNISDR*2015) and should be implemented, as appropriate, taking into account appropriate capacities and possibilities, by national laws and regulations. In a context of increasing interdependence, concerted international cooperation, enabling an international environment, and means of application are needed to foster the development of knowledge, capacity, and motivation for disaster risk reduction at all levels, especially for developing countries (UNISDR, 2015).

The European Commission points out that many disasters have significant cross-border impacts. An example of the Danube crossing or forming a border for ten European countries, or in Belgium where in September 2009 an accident at a train junction closed international rail links to France and the UK for several weeks. Risk management in border areas depends on the efficient exchange of information across borders, so data should be easily accessible and usable from those in neighboring cross-border areas. However, the effective exchange of information across borders faces several challenges. They are concerned with how end users use the system and how data providers provide their data (European Commission, 2010).

In addition to states, there are also certain organizations, unions, and alliances that would be involved in protection and rescue in such emergencies. The NATO Crisis Response System provides the Alliance with a comprehensive set of pre-identified political, military, and civilian measures to be implemented by states and NATO in responding to and managing various crisis scenarios. Within this system, crisis management arrangements define the roles and use of civilian professionals during times of crisis (International CEP Handbook 2009 Civil Emergency Planning in the NATO/EAPC Countries, 2009). The Republic of Serbia is officially a neutral state, which means that we should rely primarily on our resources (which is impossible, because misfortune knows no borders) and possibilities, or some interpret that in these cases we can expect cooperation with the East and the West.

To understand the theoretical, conceptual definition of *Protection and Rescue Systems*, it is necessary to determine which terms define this phrase. The first one we note is a *system* word derived from the Greek word *System* which is composed, the composition, the whole, according to a certain point of view, ordered and composed of various things or knowledge a whole, a set of ordered parts (Vujaklija, 1980, Str. 849). Кековић *System* It is defined in the following ways: In terms of organization, a *System* is a collection of different elements, which function as a harmonious whole, to achieve a specific goal. Each organization (military, police...) can behave as a single unit, i.e. a system composed of elements, and in this sense, we speak of organizational systems (Keković, 2017). Stajić and Gaćinović under the concept of social *System* (Unlike mathematical, natural, etc.) They mean an ordered whole composed of various elements or knowledge according to a predefined point of view, to achieve a social goal (Stajić and Gaćinović, 2007). For the sake of the Squirrels and the Squirrels, *System* It includes the following elements: the stated purpose for which the system was established; the strength and means to achieve the goal; the structure of the elements of the system (organization) through which certain activities are carried out to achieve the goal; a set of activities through which this objective can be achieved; and the function of structural elements to achieve the goal (Stajić and Lazić, 2015). In the dictionary of the Serbian language *Protection* has several meanings: when we talk about the protection of life, then we mean "1. *defense, security, assistance to the weaker or younger, support, patronage*; 2. *anti-damage, anti-decay agent*; 3. Legal. *The security provided by the legal norms* (regulations, treaties, laws, etc.): private property, under the protection of the United Nations; 4 . Voj. *Military Defence, Defensive Line*; *заштитница*: to keep as protection, to put under protection, to make one be under someone's guardianship; *Put yourself under protection* ensure, provide support, etc.". Then when we talk about the term "*Заштитити*, protect (trp. protected) then we mean the following, svr. *To shelter from danger, to defend, to provide for someone in the physical sense*; to save from inconveniences, from difficulties, to take into protect: the people from shelling, immovable property; from the bad news. To take care of yourself, to take care of yourself; Protect yourself from the sun, from the grain." (Vujanić et al., 2011, pp. 408, 409). *Salvation* "m. Deliverance from danger, trouble, difficult situations, etc., *Salvation*"There is no salvation for him, it is the only hope for salvation, for the fatherland." (Vujanić et al., 2011, p. 1230). *Save* "(to save), we will save (r. pr. saved, saved; Trt. saved) SVR. (var. save) *извући*, *deliver from some trouble*, *Difficult situations*, to liberate: certain death, someone's life. To get out of some trouble, a difficult situation, to be free." (Vujanić et al., 2011, p. 1230). *Spastican* (Greek. *Spastics* The one who pulls up, the one who pulls. *v. spasmodic.* (Vujaklija, 1980, p. 862). *Protection* With the above synonymous meanings, it is a process that seeks to reduce, mitigate, or neutralize challenges, risks, and threats caused by both natural and artificial sources. *Rescue* With the above synonyms, it includes the undertaking of certain activities by individuals, organizations, and associations that very often involve saving lives or preventing injuries during adverse events or some other risky situation. To conclude, the system *Protection & Rescue* is a form of organization and functioning of a part of society and the state in the implementation of preventive measures to reduce or neutralize challenges, risks, and threats, and save people's lives, material goods, etc. Or to rectify the undesirable actions that have already been suffered by a specific threat.

Ministries, other bodies, and special organizations of the Republic of Serbia, as well as autonomous provinces and local self-government units within their scope of competence organize, plan, and ensure the implementation of measures in the field of protection and rescue. Companies and other legal entities plan and provide funds for organizing, equipping, training, and training civil protection units that they educate, organize, and prepare personal, mutual, and collective protection and implement measures and tasks of civil protection of their employees, material, and other goods. Citizens participate in protection and rescue, fulfill material obligations for protection and rescue by a special law, are trained for personal, mutual, and collective protection, implement prescribed and ordered measures, and perform civil protection tasks.

In 2011, Clifford Oliver *(Clifford Oliver)* In his book "*Catastrophic Disaster Planning and Response“Emphasized* through the example of the largest and most powerful power on the planet, that it does not matter what kind of event causes a disaster, all disasters lead to significant impacts on health, that is, the health of the person, society in general. Disasters cause a significant increase in demand for health services, while at the same time, many of those who provide such services and the facilities in which they provide them are themselves directly affected by the event and are unable to provide adequate service (care) even at the level of normal, regular level of services. This imbalance can be a major challenge for the public, and therefore for public health and emergency managers, and will be infinitely more complicated if emergency managers and public health staff do not understand each other's skills and needs (Clifford, 2011). During the pandemic *COVID 19* Clifford's finding, the analysis proved to be completely correct and very acceptable in practice, i.e. In the real world, where only fragments of very, very selective transmission of information via TV about the health care of US citizens during the pandemic, the total defeat of the health system in such a disaster, emergency, was noted (Marjanović and Mićović, 2022).

The protection and rescue of the population, material, and other goods in the Republic of Serbia is regulated by the following normative framework of the protection and rescue system of the Republic of Serbia:

- Constitution of the Republic of Serbia,
- The Law of Defense,
- The Ministries Act,
- Law on the Serbian Armed Forces,
- Law on Disaster Risk Reduction and Emergency Management,
- National Security Strategy of the Republic of Serbia,
- Defence Strategy of the Republic of Serbia,

Instructions, decisions, decrees, ordinances, and other acts.

The article 97 of the Constitution of the Republic of Serbia defines the competences of the Republic of Serbia, the territorial organization, the system of local self-government, measures in the event of a state of emergency, and the system of environmental protection and improvement. (Službeni glasnik RS, 98/2006.)

The Law on the Defense of the Republic of Serbia regulates civilian protection in Articles 77-80. where it is determined to be organized, prepared and implemented as a system of protection and rescue of people, animals, material and cultural assets, from natural disasters, technical-technological accidents and disasters, the consequences of terrorism, war and other major accidents, and in accordance with current regulations , principles and requirements. (Službeni glasnik RS, broj 116/2007, 88/2009, 88/2009 -dr. zakon, 104/2009 - dr. zakon, 10/2015, 36/2018.)

Based on the Law on Ministries, the Ministry of Internal Affairs performs state administration tasks that, in the field of emergency situations, relate to: protection of life, personal and property security of citizens; providing assistance in case of emergency; shelters; safety, regulation and control of traffic on roads; traffic and transportation weapons, ammunition, explosives and certain other dangerous substances; fire protection; hail protection...("Službeni glasnik RS", br. 128 od 26. oktobra 2020, 116 od 22. oktobra 2022, 92 od 27. oktobra 2023 - dr. zakon)

The Law on Disaster Risk Reduction and Emergency Management regulates disaster risk reduction, prevention and strengthening of resilience and readiness of individuals and communities to respond to the consequences of disasters, protection and rescue of people, material, cultural and other assets, rights and obligations of citizens, associations , legal entities, bodies of local self-government units, autonomous provinces and the Republic of Serbia, management of emergency situations, functioning of civil protection, early warning, notification and warning, international cooperation, inspection supervision and other issues of importance for the organization and functioning of the disaster risk reduction system and management of emergency situations. ("Službeni glasnik RS" br. 87/2018)

The National Security Strategy provides an analysis of the environment of the Republic of Serbia,identifies challenges, risks and security threats, determines national interests, determines the goals, basic principles and elements of the national security policy and defines the structure, principles of functioning and responsibilities within the system security. („Službeni glasnik RS" br. 94/2019)

The Defense Strategy of the Republic of Serbia is a basic strategic document that directs the development of normative, doctrinal and organizational solutions of the defense system, defense planning and financing, and the deployment of defense resources of the Republic of Serbia. („Službeni glasnik RS" br. 94/2019)

3. CONCLUSION

The paper describes the system of protection and rescue from the point of view of scientific consideration of certain theoretical attitudes in the approach to these concepts, where we could state an extremely wide, complex, diverse normative order and, above all, complex (envisaged for a large number of diverse structures in the country). Persons who have been engaged in similar state affairs for years are very sensitive to look at all the obligations and procedures of the subjects of the protection and rescue system that arise from a large (excessive) number of laws and bylaws that regulate this area. This implies the need for quality, basic education of the persons who manage these entities.

Then, the next thing that needs to be looked at is the quality of selection and appointment of persons to managerial positions in local self-governments, up to republic bodies with life and work experience, and security checked, which is often not at the required level and possibly reducing the scope of norms and simplifying obligations to subjects. In some areas, one can conclude that it seems as if it has become a "fashion" to write a new norm, a new strategy, a regulation and thus "complete one's obligations", and what is the effect and whether there will be one at all, with the influence of that new regulation and the obligations that come with it, it often remains immeasurable and unvalued (positive or negative).

The involvement of a large number of diverse entities in the implementation of a certain activity leads to a potential problem, and that is the realization of quality coordination between the subjects of the protection and rescue system, then finances for the implementation of tasks, funds and other support in the implementation of the set obligations.

REFERENCES

[1] Boin, A., ‘t Hart, P. & Kulpers, S. *The Crisis Approach, November 2017*, In book: Handbook of Disaster Research, Project: The Leiden University Crisis Research Center at the Institute of Security and Global Affairs, p. 32. 2017.
[2] Bostrom, N., Ćirković, M. (ured.) *Rizici globalnih katastrofa (GLOBAL CATASTROPHIC RISKS, ориг.)*, Heliks (2008, 2011 by Oxford University Press), стр. 2-4, p. 289, 2011. 2012,
[3] Vujaklija, M. *Leksikon stranih reči i izraza*, Prosveta-Beograd, 1980.
[4] Vujanić, M, Gortan-Premk, D, Dešić, M, Dragićević, R, Nikolić, M, Nogo, Lj, Pavković, V, Ramić, N, Stijović, R, Radović-Tešić, M, Fekete, E. *Rečnik srpskog jezika*, Izmenjeno i popravljeno izdanje, Novi Sad, Republika Srbija, Matica srpska, 2011.
[5] Marjanović, Z., Mićović, M. Uticaj krizne situacije izazvane epidemijom i pandemijom (kovid 19) na korporativnu bezbednost, *Časopis Bezbednost*, 3/2022, LXIV, Beograd, str. 100-119, 2022.
[6] Zakon o odbrani (2007, 2009, 2015, 2018). Službeni glasnik RS, broj 116/2007, 88/2009, 88/2009 -dr. zakon, 104/2009 - dr. zakon, 10/2015, 36/2018.
[7] Zakon o ministarstvima"Službeni glasnik RS", br. 128 od 26. oktobra 2020, 116 od 22. oktobra 2022, 92 od 27. oktobra 2023 - dr. zakon
[8] Zakon o smanjenju rizika od katastrofa i upravljanju vanrednim situacijama ,” Službeni glasnik RS”, broj 87/2018.
[9] *International CEP Handbook 2009 Civil Emergency Planning in the NATO/EAPC Countries-NATO North Atlantic Treaty Organization,* (2009). Published by the Swedish Civil Contingencies Agency (MSB), AB Danagårds Grafiska 2009 Karlstad, Sweden, p. 287-290.
[10] Keković, Z. *Sistemi bezbednosti-sa sistemom bezbednosti Republike Srbije*. Fakultet bezbednosti, Beograd, str. 27, 50-52, 2017.
[11] Kovač, M.. Stojković, D. 2009. *Strategijsko planiranje odbrane*, Vojnoizdavački zavod, Beograd, str. 252 (u: Eder, E. *Definition und Gebrauch des Begriffes „Strategie“,* Osterreichsche Militarische Zeitschrift, Wien, No.2, 1998.
[12] Stajić, Lj., Gaćinović, R. *Uvod u studije bezbednosti*, Draslar partner, Beograd, 2007, str. 90, 2007.
[13] Stajić, Lj., Lazić, R. *Uvod u nacionalnu bezbednost,* ANB, Službeni glasnik, str. 75, 2015
[14] Strategija nacionalne bezbednosti Republike Srbije, „Službeni glasnik RS“, broj 94 od 27. decembra 2019..
[15] Strategija odbrane Republike Srbije, „Službeni glasnik RS“, broj 94 od 27. decembra 2019.
[16] Ustav Republike Srbije, Službeni glasnik RS, 98/2006.
[17] UNISDR, *Sendai framework for disaster risk reduction 2015–2030.* In *3rd United Nations World Conference on DRR*. Sendai, Japan: UNISDR, p. 14, 2015.
[18] UNISDR, *In support of the Sendai Framework for Disaster Risk Reduction 2015–2030, National Disaster Risk Assessment, Cross-border risk assessment-Biological Hazards Risk Assessment,* p. 48, 2017.
[19] Clifford, E. O. *Catastrophic Disaster Planning and Response*, CEM, CBCP, 2011 by Taylor and Francis Group, LLC, p. 183, 2011.

OCCUPATIONAL SAFETY IN THE MODERN BUSSINES CONTEXT

Vesna Nikolić[1]; Srđan Glišović[1], Ivan Mijailović[1],
[1]Faculty of occupational safety, University in Niš, Čarnojevića 10a, 18000 Niš, Serbia
ivan.mijailovic@znrfak.ni.ac.rs

Abstract: *The Fourth Industrial Revolution, with the speed, scope and impact on social, and in particular, economic systems, led to changes and transformations in all segments of modern business. It is characterized by the fusion of technologies, which leads to the erasing of boundaries between the physical, digital and biological spheres, opening up unimagined possibilities for various areas of human work and activity, but also a number of problems for decent and safe work in new conditions. Having in mind the problems and challenges for occupational safety and health in the modern business context, the paper elaborates guidelines for changing the paradigm of safety and health at work in modern conditions.*

Keywords: *occupational safety and health; new technologies; business*

1. BASIC THEORETICAL SETTINGS

The replacement of human labor with machines leads to numerous changes in the labor market. With the development of technology, there is a reduction / disappearance of certain jobs and, on the other hand, the creation of new jobs and productivity growth. ATMs have reduced the number of officers at bank counters; in factories, robots have replaced workers in many jobs that require high precision; shopping over the Internet is increasingly crowding out sellers in stores; self-driving vehicles could endanger professional drivers and taxi drivers, and drones couriers. Even designers, marketers and stock brokers are being replaced by artificial intelligence and powerful computers; robotic surgery achieves unimaginable results in medicine, and interactive, multimedia video courses on the Internet in knowledge transfer, etc. Global trends point to changes in government systems in e-government societies that automate administrative tasks and enable services to be performed online (waste of time, unnecessary documentation and devastation of environmental resources are avoided) [1]. Future jobs will be polarized according to the nature of jobs and whether or not robots can be used in a particular industry [2] Research from the University of Oxford shows that by 2033, 47% of current jobs will be replaced by automation, computers and robots. Robotic border guards and drones are already widely used in the military industry (used during the wars in Iraq, Afghanistan, Syria, etc.). It is difficult to predict all the consequences of the unstoppable development of robotics and artificial intelligence for man and society today.

At the same time, there is a need for new professions and types of jobs, primarily creative, but also those related to new technologies. The authors believe that in the middle of this millennium, the number of employees in the production of material goods will be drastically reduced because they will be replaced by robots. On the other hand, it is estimated that three million jobs will be created as a result of the use of one million robots. [3]

Robotization will certainly contribute to a reduction in employment in local economies and individual industries (e.g. in the automotive and electronics industries), while, in developing countries, it particularly threatens the work engagement of low-skilled people (e.g. in the tire and plastics industry, etc.). Thanks to the globalization accelerated by the Fourth Industrial Revolution, multinational corporations can easily exploit the workforce and environment of developing countries. Nationally, we are witnessing numerous manufacturing facilities and factories of foreign companies that, of course, lead to a decline in unemployment but, at the same time, cause socio-economic problems in many developing countries because they are based on "loose" labor regulations and low wages [4]. In the era of the new industrial revolution, factories in developing countries are no longer attractive because the workforce can be replaced by automated robots. Instead, it is enough to place the production plant near the main market for the rapid production and distribution of products. This is a so-called "re-shoring"[1] trend that, if it continues, will undermine the economic development of these countries [5]. The development of technology is therefore a double-edged sword. In addition to the benefits and benefits it brings, there are various problems that, among other things, relate to the safety and health of workers.

Relentless changes from simple organizations (the Third Industrial Revolution) to innovation based on combinations of technologies (the Fourth Industrial Revolution) force companies to question the way they do business and create conditions for occupational safety and health. In this sense, new technologies can have multiple benefits; as a substitute for workers in performing high-risk jobs; in observing their behavior in order to prevent accidents at work in a timely manner; the record of injuries and accidents; preventing musculoskeletal disorders (e.g., using a wearable robot that supports human strength); training of employees, etc. [6] The greatest benefits for occupational safety and health stem from the wider use of robotics by replacing workers working in unhealthy or hazardous environments, in the space, defense or nuclear industries, in logistics, maintenance or surveillance.[7] Autonomous robots are particularly useful as a replacement for workers who perform dirty, monotonous or unsafe tasks, thus avoiding exposure to dangerous means and conditions and reducing physical, ergonomic and psychosocial risks. Of course, it is necessary to take care of protection and safety when working with robots [3], but also when applying other technologies that characterize the fourth industrial revolution.

2. OCCUPATIONAL SAFETY AND HEALTH FROM THE DISCOURSE OF MODERN BUSINESS PROCESSES

New technologies, their combination and the fourth industrial revolution represent significant support for globalization as a global process that brings, in addition to positive, a number of negative implications for occupational safety and health. Large multinational companies often use cheap labor in developing countries in dangerous workplaces without adequate health and safety measures. Child labor and forced labor, which are banned in most developed countries, are also present in these countries. There are often no provisions on minimum wage and maximum working hours (overtime, night work), while the application of ILO requirements and standards can hardly be talked about in these locations.

Due to globalization and the development of information and communications, time space compression adapts to the time of work, rather than the biological time of the person, which causes a number of health problems: disorders of the circadian rhythm by melatonin change; increase the risk of breast cancer, but also other cancers-cancers of the colon, prostate, etc.; increasing the risk of other diseases - cardiovascular diseases, cerebrovascular diseases, diabetes, depressive disorders, etc.) [8].

Automatization and robotization of simple jobs lead to the development of a sense of fear in workers due to increased concern for their workplace or due to possible difficulties with re-employment. In addition, it is difficult to maintain a work-life balance (leisure time) without negotiating with the employer on a number of elements that define the work itself and working conditions (working time, wages, paid leisure time, improvement of the workplace). Additionally, those problems that arise when the basic elements of social security (payment of pensions, sick leave, annual leave and maternity leave) are not guaranteed, when there are no opportunities for work or advancement, when basic human rights are threatened through discrimination, etc.). [9] Increased instability in employment can increase the number of mental illnesses. Automation of high-risk occupations, leads to the development of anxiety and poor health of workers who are afraid of losing their jobs, reducing wages and social benefits [10]. Also, automation introduced to increase productivity and quality of life paradoxically results in an increase in human working time (e.g. vehicle and driving automation requires more human labor to increase productivity or in the event of a malfunction on the automation machine the worker needs to manually repair it which often leads to injuries at work). The modern business environment is increasingly taking on the characteristics of economy and business "on demand". In an "on-demand"[1] economy, workers are independent contractors who are forced to constantly search for work and their differentia is specific income instability and perpetual stress. In such a context, their legal protection is difficult to achieve. In most countries, independent/self-employed workers are not part of the "working" class defined by labor laws, and employers are not required to provide social assistance, including pensions, insurance, paid leave, maternity leave and sick leave. This is because through the platform, the consumer and the supplier of the workforce communicate and provide work beyond the supervision and instructions of the employer. This type of economy has the advantage of creating new employment opportunities and enabling flexible work, but, on the other hand, it is difficult to ensure legal protection for this category of employees when it comes to occupational safety and health. [11]

To address the challenges of new employment relationships, governments in many countries have expanded the concept of "work" and "workers" in occupational safety and health legislation. The new Law on Safety and Health at Work of the Republic of Serbia [12] for the first time recognizes and defines remote work and work from home and therefore prescribes measures of safety at work for the implementation of which the employer is responsible. Also, this Law covers persons who are self-employed and stipulates that a person who self-employed is responsible for his own safety and the health of others, who are affected by his work and failures in the implementation of safety and health measures at work. A person who is self-employed is also obliged to apply regulations in the field of safety and health at work and to cooperate with other employers and employees in the implementation of safety and health measures at work, when it is related to performing tasks with them.

Certainly, the new concepts of business and work open up numerous questions and challenges for the safety and health of employees. In addition to the problem of inspection supervision, it is difficult for independent workers to form trade unions. They are often registered on multiple platforms, so it is difficult to develop feelings of belonging to the workplace and solidarity with colleagues. Unstable employment usually negatively affects the state of health because it causes psychological and physical health risks, such as mental disorders, dissatisfaction with physical health, anxiety or high blood pressure [13]. It raises the question of responsibility for safety and health at work in the modern business context. The government is responsible for establishing and implementing occupational safety and health policy, research, developing safe technology and enforcing regulations and regulations. The employer is obliged to comply with legal regulations, standards and to ensure a comfortable working environment and working conditions. Workers are obliged to comply with regulations and measures to prevent injuries and accidents in the workplace.

3. CHANGING THE OCCUPATIONAL SAFETY AND HEALTH PARADIGM

The fact that work during the fourth industrial revolution is not permanent and continuous, and that people have more than one job according to their needs, it is difficult to assess the risk of jobs. It is also difficult to determine whether an individual's illness is caused by a particular occupation or certain jobs.

In this situation, the current system of compensation for injuries or occupational diseases cannot protect independent workers. With this in mind, the authors point out that a reorientation is needed from an employer-focused approach to a public health approach under the WHO Convention on Health and Safety [14].

Each country must establish institutional and legislative mechanisms to ensure that international labor standards (ILO) apply equally to its regulations and policies. The Equal Reward Convention seeks to ensure that workers who provide equal value are not discriminated against on the basis of gender, race, color, religion, political opinion, socioeconomic status, social origin or age [15]

In particular, freedom of association, the right to collective bargaining, OSH and the protection of employment and discrimination are particularly needed. The salaries of temporary workers should not be lower than those of other workers who do the same or similar things. In addition, temporary workers should be provided with maternity care, paid sick leave and paid annual leave.

Each country should also prepare for the labor market in line with the development of automation, robotization, digitalization and technologies brought about by the fourth industrial revolution. In this regard, it is important to define at the international level the conditions and standards of work in accordance with modern requirements and determinants of decent and decent work.

Modern technologies and new forms of work imply a series of difficulties in the work of traditional trade unions (especially in multinational corporations). Bearing in mind that different labor relations (such as suppliers, subcontractors, NGOs, etc.) and heterogeneous labor (women, young people, immigrants) are applied, innovations are needed in the organization of trade unions' work. [16] Unions should get to know and understand business in a contemporary business context. The new union would have to overcome the binding to a single position to become a community-based union or a network to replace the traditional union in the fight for the rights of independent workers.

Due to the effects of the Fourth Industrial Revolution, a large number of jobs will be marked by the process of automation and robotization, so concerns about mass unemployment that can lead to instability of the entire society are justified. Also, in a situation of dominance of non-standard employment, the question arises of a larger number of workers who cannot be protected by the applicable labor law. Furthermore, there is a need for social security for the poor because, precisely, the gap between rich and poor represents a significant element of social unrest and instability. There is a need to reform the occupational safety and health system to protect workers' health rights. In this regard, the role of occupational safety experts should be observed, who should be able to respond to the challenges of modern business, which, in turn, is connected with the need for its continuous inspection.

4. CONCLUSION

In recent years, there have been significant advances in computer and communication technologies with a profound impact on all segments of society and human activity. Technology is transforming the way we work, live, communicate, and act. From these technological capabilities, new industries, organizational forms and business models are emerging.

Technological innovation can achieve enormous economic benefits and a number of advantages, as well as numerous problems in the modern business context. To deal with occupational safety and health problems in the era of the fourth industrial revolution, it is necessary to establish new concepts of "decent work", to standardize regulations applicable to businesses in each country, to develop public health as an occupational safety and health service, innovative trade union organizations and constantly promote the development of experts of appropriate knowledge, skills and competencies responsible for new issues of safety and health at work.

Knowing that the present time is not only a time of technological progress, but also of social and cultural changes in which the way of human thinking, work and learning is changing, it is necessary to invest in both personal and professional development in order to develop the competencies and skills required by the modern business context. Certainly, it takes a lot of time to accept the changes, but the speed, coverage and impact of change require faster responses and timely preparation and training of young / student population in order to successfully solve occupational safety and health issues in the future.

5. ACKNOWLEDGEMENT

This work was supported by Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Project number 451-03-47/2023-01/200148.

6. REFERENCES

[1] Yildiz M. E-government research: reviewing the literature, limitations, and ways forward. Gov Inf Q 2007;24(3):646—65

[2] Carbonero F, Ernst E, Weber E. *Robots worldwide: the impact of automation on employment and trade*. ILO Res Dep Work Pap 2018;36.

[3] Nikolić, G.: Roboti i sigurnost na radu, Stručni skup – Zaštita zdravlja i sigurnost na radu, Zagreb, 18.05.2017, Zbornik radova, 3-10. Hrvatska udruga za zdravo radno mjesto, 2017

[4] Mun-sub Y, Hyun-Dae C. *A study on the reduction of manufacturing jobs and countermeasures by the entry of advanced countries*. STEPI Insight 2014; 134(0): 1-16

[5] Simchi-Levi D. *US re-shoring: a turning point,* Annual Re-shoring Report; 2012**.**

[6] Ciullo A, Catalano M G, Bicchi A, Ajoudani A. *A supernumerary soft robotic hand-arm system for improving worker ergonomics*. Int Symp Wearable Robotics 2018:520—4.

[7] EU-OSHA, https://osha.europa.eu/hr/tools-and-publications/publications/futurework-robotics/view,

[8] Schwab Klaus. *Globalization 4.0: a new architecture for the fourth industrial revolution*. Foreign Affairs. 2019.

[9] Patel PC, Devaraj S, Hicks MJ, Wornell EJ. *County-level job automation risk and health: evidence from the United States.* Soc Sci Med 2018;202:54-60.

[10] Rojas-Rueda D. *Autonomous vehicles and mental health*. J Urban Des Ment Heal 2017;3(2).

[11] Hyun-Sung L *A research on labor of on-demand economy*, 2017.

[12] International Labor Office. Rules of the game: a brief introduction to International Labor Standards. Int Labor Off 2014:1—130.

[13] Kim SH. The 21st century proletarian "platform labor. Minplus. 2018

[14] International Labor Office. ILO declaration on social justice for a fair globalization; 2008.

[15] WHO global plan of action on workers' health baseline for implementation. WHO Doc Prod Serv; 2017.

[16] Uma Rani A, Anita A, Urvashi A, Bjorn Serritzlev B, Janine Marie B. A reflection on the future of work and society. Geneva: International Labor Office. 2017.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

CAN PORTUGUESE TEENAGERS SUE CROATIA OVER CLIMATE INACTION? - RECENT CLIMATE CHANGE LITIGATION IN EUROPE

Ana Rački Marinković[1]

[1] University of Applied Sciences in Security and Safety, Veslačka 2A, Zagreb, CROATIA, ana.racki.marinkovic@vss.hr

Abstract: *Climate inaction is increasingly being challenged before European courts. This paper examines the recent landmark human rights cases at the ECtHR dealing with climate change. Those climate change cases focus on the argument that inadequate climate action violates human rights, in particular, the right to life and the right to privacy guaranteed under Articles 2 and 8 of the European Convention on Human Rights. The paper analyses the legal arguments employed, the potential impact on national climate policies, and the significance of these cases. The specific focus will be on the historic climate case Duarte Agostinho and Others v. Portugal and Others (no. 39371/20). Since applicants filed a complaint against Portugal and 32 other European countries, including all European Union member states, the paper will further investigate the influence this may have in global climate policy by challenging the notion that responsibility lies solely within national borders. Therefore, a potential outcome of this case could directly influence Croatia's approach to climate policy and its efforts to mitigate climate change.*

Keywords: *climate change litigation, human rights, climate policy responsibility*

1. INTRODUCTION

The fact that climate change poses a threat to humanity and the need for decisive policies to tackle it is something the scientific community is united about [1]. As highlighted in the preamble of the European Climate Law, i.e. the Regulation (EU) 2021/1119, establishing the framework for achieving climate neutrality "the existential threat posed by climate change requires enhanced ambition and increased climate action" [2]. Yet, the world is still not on track to meet sustainable development goals. Governments play a critical role in the fight against climate change, and since climate change is a global problem that requires a global response, coordinating the combat against climate change on a global scale through international agreements seems crucial. However, one must remember that legal norms and principles in international treaties govern interactions between sovereign states. Adherence to these norms, since there isn't any supranational enforcement authority, is primarily cooperative and the efficacy of international law depends on the voluntary acceptance of its rules by sovereign states. Environmental law seems to be a particularly vivid field of international law, with more than a dozen treaties concluded since 1973 (when the Declaration of the United Nations Conference on the Human Environment was drafted). Over the past three decades, countries have also tried to coordinate their response to climate change since greenhouse gases, once emitted, evenly disperse themselves through the atmosphere, and "a greenhouse gas emission anywhere is a threat to climate everywhere" [3]. Countries have come together to tackle this issue, starting from international agreements like the Kyoto Protocol [4] to the current and most significant climate agreement so far, the Paris Agreement [5], which is based on participating countries voluntary pledges. It is nearly universally accepted, with 195 countries making such pledges, and many countries even pledge to go to net zero emissions by the middle of the century. Even so, it seems that currently, these pledges, even if fulfilled, will only limit the global average temperature to between 2.4°C and 2.8°C [6]. They therefore lack the necessary ambition to limit the global warming to 1.5°C, which is the target outlined in the agreement. Existing international treaties addressing climate change have, therefore, failed to produce evident success so far.

This has resulted in the rise of climate inaction litigation as a tactic to force governments to fight climate change effectively. The main driving force behind this "climate litigation boom" lies in the well-known failure on the part of national governments to live up to the obligations enshrined in the Paris Agreement as well as the lack of ambition and commitment, which has been shown as the inherent weaknesses of the Paris Agreement [7]. The trend of addressing the national court when governments and politics have failed to do what it takes is usually based on claims that government climate inaction has deprived the plaintiffs of their human rights, such as the right to life, privacy, and property. Therefore, it comes as no surprise that climate change cases have also been brought before the European Court of Human Rights (hereinafter: the Court or the ECtHR).

The paper will analyse the legal arguments employed in three climate change cases recently judged by the Court and how the outcome can influence Croatia's approach to climate policy and its efforts to mitigate climate change. In the case *Duarte Agostinho and Others v. Portugal and Others* (no. 39371/20), applicants filed a complaint against Portugal but also other 32 European countries, including all European Union member states, thereby challenging the notion that responsibility lies solely within national borders. Although this case was declared inadmissible by the Court, thereby failing to have direct impact on national climate policies, the judgement in the case *Verein Klimaseniorinnen Schweiz and Others v. Switzerland* (no. 53600/20) where the Court has established that "climate change is one of the most pressing issues of our times" [8, para 410] and "poses a serious current and future threat to human rights" [8, para 436] will have influence on national climate policies of all countries of the Council of Europe, including Croatia. This is because "states should take into account not only judgments of the Court against the state itself but also the Court's developing case law in judgments finding a violation of the Convention by other states" [9]. The Court's judgments and decisions serve not only to decide those cases brought before it but, more generally, to elucidate, safeguard and develop the rules instituted by the European Convention on Human Rights (hereafter "the Convention"), thereby contributing to the observance by the states of the engagements undertaken by them as contracting parties [10]. It follows that Croatia should consider the conclusions to be drawn from the judgment against Switzerland regarding climate inaction if the same problem of principle exists within Croatia's own legal system. Moreover, if climate inaction cases are brought before the national courts of Croatia, plaintiffs may rely on the Court's case law and refer to this precedent decision of the Court regarding violations of the Convention due to climate inaction.

The method of qualitative empirical legal research was used which involved extracting information from the text of court judgements in three relevant cases before the ECtHR which was then interpreted and organized to predict the influence these may have on Croatia's climate policy and its efforts to mitigate climate change.

2. RECENT CLIMATE CHANGE CASES BEFORE THE ECtHR

In recent years, there has been a growing trend in people and organisations using Europe's system for protecting human rights to help tackle environmental problems [11]. The ECtHR is established by the Convention to safeguard the human rights set forth in the Convention, allowing any person who feels their rights have been violated under the Convention by a contracting state to take a case to the Court. For this, the system is considered by many to be the most effective system of human rights protection [12], and even more so when compared with other international treaties that either have no enforcement mechanisms foreseen or such mechanisms are not open to individual complaints. Such collective enforcement materialised in the existence of a permanent judicial body accessible by almost anyone, empowered to find violations of the Convention in judgments is further strengthened by the fact that contracting parties have undertaken to abide to these judgements and a mechanism for supervising the execution of judgments further assures its effectiveness [13].

The Convention does not recognise a right to a healthy environment as such. Put into the context of the time it was drafted, after the Second World War, it comes as no surprise that the Convention deals with fundamental human rights, such as the right to life, freedom from torture, the right to a fair trial, etc. However, the Court regards the Convention as a living instrument interpreted considering present-day conditions. So far, the ECtHR has thus ruled on some 300 environment-related cases, applying concepts such as the right to life, free speech and family life to a wide range of issues, including pollution, man-made or natural disasters and access to environmental information [11]. This is sometimes also referred to as the concept of "greening" of traditional human rights [14]. Still, until the three cases that will be presented below, it has not had an opportunity to decide on the issue of the contracting party's responsibility due to climate inaction, which deprived individuals of their human rights.

As previously stated, climate inaction litigation has been on the rise throughout the world for some time now. From 1986 until May 2020, plaintiffs globally have brought more than 1,500 climate-related lawsuits, with the rate of claims increasing [15]. However, for many years, such litigation had a low success rate [3], partially also because they had failed to show strong evidence of causation that greenhouse gas emissions have caused the impacts suffered by plaintiffs [16]. More recently, in the Juliana v. United States lawsuit, the plaintiffs claimed the government had known for decades that fossil fuels cause global warming yet continued policies promoting them, thereby violating plaintiffs' constitutional rights to life, liberty, and property. However, the plaintiffs lost the case due to a lack of standing to bring their claims since, according to the US court's reasoning, injuries they had incurred by climate change were not likely redressable by a favourable judicial decision, as it would not suffice to stop catastrophic climate change [3]. A famous climate case known as The People's Climate Case brought before the European Court of Justice (ECJ) by Armando Ferrão Carvalho et al. against the European Parliament and the Council was also unsuccessful on the basis of legal standing. Ten families from various European and non-European Union countries which sued the European Union, arguing its 2030 climate targets were insufficient to protect their livelihoods and human rights from climate change, failed to demonstrate, according to the EU General Court and the ECJ, the EU's climate policy individually and directly impacted them. The harm they claimed was not specific or unique enough to their situations compared to the broader population.

As regards national climate inaction litigation in Europe, approaches taken by national courts vary significantly. For example, the Spanish Supreme court in the Greenpeace v. Spain II decision ruled that since Spain must adhere to the provisions of the Paris Agreement through the EU's mechanisms and regulations, if it found Spain in non-compliance with the Paris Agreement, it would, in essence, indirectly suggest a lack of compliance on the part of the EU, which is outside of its jurisdiction [17]. On the other hand, in the case Urgenda Foundation v. the Netherlands and some other national courts in Europe [14; 7], the Dutch Supreme Court found their national states liable for not protecting human rights and freedoms due to their climate inaction.

With this limited success and much broader unsuccess rate of climate inaction litigation in Europe, all eyes were set on the ECtHR to give guidance in this matter by deciding the cases brought before it. It has to be outlined that according to the ECtHR, there were climate change applications brought before it other than the three cases; however, those were granted priority, and while they were not joined, they were all ruled on by the same composition of the Grand Chamber. The ECtHR decided to adjourn its examination of those other cases until the Grand Chamber ruled on these three climate change cases [18].

2.1. Case Duarte Agostinho and Others v. Portugal and Others (no. 39371/20)

The case was initiated by six Portuguese nationals aged between 11 and 24 who claimed that the forest fires that have occurred in Portugal as a direct result of global warming had threatened their right to life and the right to respect for private and family life and that as young people, they stand to experience the worst effects of climate change. This case received much attention because the claim was initiated not only against Portugal but also against 32 other countries. This included all EU member states, as well as Norway, Russia, Switzerland, Turkey, Ukraine and the United Kingdom. Hence, the applicants have challenged whether all 33 States concerned are failing to comply with their positive obligations under Articles 2 (right to life) and 8 (right to respect for private and family life) of the Convention, read in the light of their undertakings under the Paris Agreement. The ratio behind such a claim was that greenhouse gas emissions causing climate change are transboundary, so the countries' obligation to secure human rights should also not be limited by borders and only subsist in relation to nationals of such countries. This would then imply countries' extraterritorial jurisdiction and, on such basis, the capability of being sued before the ECtHR.

However, the Court decided that since the applicants live in Portugal, other countries accept that Portugal lacks effective control over the victims, even though they control the root cause of the risk or harm. The Court stated that "the ability of a state's decision to impact the situation of individuals abroad is not sufficient in itself to establish jurisdiction for the purposes of Article 1 of the ECHR" [19, para. 184]. Therefore, the

ECtHR found that other defendant countries did not have extraterritorial jurisdiction in this case and dismissed it with respect to all defendants except Portugal. By doing so, the Court failed to challenge the notion that responsibility for climate change lies solely within national borders, despite the specificity of climate change-related harms or the collective nature of the mitigation effort. The Court suggested that otherwise an unlimited expansion of States' extraterritorial jurisdiction and responsibilities under the Convention towards people practically anywhere in the world be entailed, which would turn the Convention into a global climate-change treaty (19, para. 208). However, while rejecting the possibility of hearing the case, the Court did not question a primary obligation under the Convention to avoid the production of extraterritorial environmental harm, nor did it rule out the possibility of the use of domestic courts by affected foreign individuals to enforce it [20]. Since the applicants had not used the legal avenues available in Portugal prior to making their complaint before the ECtHR, it was found inadmissible in respect of Portugal for non-exhaustion of domestic remedies, which is a precondition for being able to be heard before the ECtHR.

2.2. Case Carême v. France (no. 7189/21)

In the case, Carême v. France, the ECtHR reaffirmed that an applicant must have a victim status before filing a claim. Under the Convention, *actio popularis* protection is prohibited since the Court protects individual rights of applicants and not the general interest. Individual protection from harm on the enjoyment of one's human rights following the effects of climate change exists only in situations when one can claim to have victim status, which, in the circumstances of that case, the applicant did not have [21, para. 83]. Rather, the applicant sought the Court to review France's efforts to mitigate climate change, which he submitted as a former inhabitant and mayor of the municipality of Grande-Synthe, the municipality expected to be exposed to the risk of climate change-induced flooding.

2.3. Case Verein Klimaseniorinnen Schweiz and Others v. Switzerland (no. 53600/20)

This case was filed by a Swiss association, a group of senior women advocating for climate action due to its impact on their living conditions and health, and four of its members, all claiming that the Swiss authorities are not taking enough action to mitigate climate change.

The Court emphasised that the threshold for establishing victim status in climate change cases is especially high. The Court found that the four individual applicants did not fulfil the victim-status criteria; however, regarding the association itself, the Court held that in the context of climate change as a common concern of humankind and the need to promote intergenerational burden-sharing, it may be granted legal standing. Moreover, the Court set certain principles for an association to have the right to act.

Unlike the *Duarte case*, the applicants have exhausted domestic remedies. Still, the system failed to "take into consideration the compelling scientific evidence concerning climate change" [8, para 509] or engage in it "seriously" [8, para 636].

According to the ECtHR ruling, inadequate State action to combat climate change exacerbates the risks of harmful consequences and subsequent threats to the enjoyment of human rights – threats already recognised by governments worldwide and confirmed by scientific knowledge. Regarding the causal relationship between State actions and/or omissions relating to climate change and the harm, or risk of harm, affecting individuals, the Court found that Article 8 must be seen as encompassing a right for individuals to effective protection by the State authorities from serious adverse effects of climate change on their life, health, well-being and quality of life. Further, it found Switzerland had failed to comply with its duties ("positive obligations") under the Convention concerning climate change since it had not acted in time and in an appropriate way to devise, develop and implement relevant legislation and measures to mitigate the effects of climate change in this case [18].

3. CONCLUSION

The ECtHR used the three described cases to develop its case law on climate change disputes. Such case law is binding on all countries that are members of the Convention, including Croatia. Therefore, Croatia and other countries should not wait until held liable for the declared violation but rather take preventive measures to avoid such a decision by adjusting legislation and its application according to the case law of the ECtHR. The established case law should also guide climate change disputes before domestic courts. The Court did not find climate change to represent a valid reason for departing from the already established practices regarding the scope of extraterritorial jurisdiction and the requirement to exhaust legal remedies. Thereby, the Court has adopted a more reserved approach and chose to emphasise the margin of appreciation of the member states under the principle of subsidiarity. In that way, even though the *Duarte case* was found inadmissible, it may well influence the burst of national litigation for climate inaction since the Court has urged applicants to exhaust domestic remedies. Since global climate change harm can be found in the territory of many contracting states of the Convention, national courts may be called upon to rule on climate inaction in dozens of countries in Europe along similar lines. The interpretation of the Court that the Convention encompasses a right to effective protection by the State authorities from the serious adverse effects of climate change on lives and health must be obeyed by national courts should such cases be initiated. In doing so, the principles regarding the high threshold for establishing victim status in climate change cases, as well as conditions under which associations can bring legal action in climate cases set by the ECtHR in the *Verein Klimaseniorinnen Schweiz case,* must also be duly considered. Recent ECtHR rulings on climate change cases will therefore have a significant impact on national human rights-based climate litigation and should be a warning for the European countries, including Croatia, if they fail to meet their climate targets.

REFERENCES

[1] UN Environment Programme, Global resources Outlook 2024: Bend the Trend – Pathways to a liveable plat as resources use spikes, International Resource Panel, ISBN 978-92-807-4128-5, Nairobi, (2024)

[2] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'). Official Journal of the of the European Union, 9 July 2021, OJ L 243, 9.7.2021, p. 1–17

[3] Kempf, C.N.: Why Did So Many Do So Little? Movement Building and Climate Change Litigation in the Time of Juliana v. United States, *Texas Law Review,* Vol.99 (2021) No.5, pp. 1005-1040, ISSN 0040-4411

[4] Kyoto Protocol to the United Nations Framework Convention on Climate Change, 11, December 1997, 2303 U.N.T.S. 162; U.N. Doc FCCC/CP/1997/7/Add.1

[5] Paris Agreement to the United Nations Framework Convention on Climate Change, 12 December 2015, U.N. Doc. FCCC/CP/2015/L.9/Rev/1

[6] Maslin, M. A.; Lang, J.; Harvey, F.: A short history of the successes and failures of the international climate change negotiations, *UCL Open: Environment*. Vol. 5 (2023) No.8, pp. 1-16, ISSN 2632-0886.

[7] Pouikli K.: Editorial: a short history of the climate change litigation boom across Europe. *ERA Forum*. Vol. 22 (2021) No.4, pp. 569–586. ISSN 1863-9038

[8] Verein Klimaseniorinnen Schweiz and others v. Switzerland (dec.) [ECtHR Grand Chamber], no. 53600/20, 9 April 2024

[9] High Level Conference on the Future of the European Court of Human Rights Interlaken Declaration and Action Plan, 19 February 2010. *Available from* https://www.echr.coe.int/documents/d/echr/2010_interlaken_finaldeclaration_eng *Accessed: 2024-05-02.*

[10] Council of Europe/European Court of Human Rights, Guide to the case-law of the European Court of Human Rights – Environment 2022, *Available from* https://www.echr.coe.int/documents/d/echr/Guide_Environment_ENG *Accessed: 2024-05-02*.

[11] Council of Europe, Human rights and the environment, *Available from* https://www.coe.int/en/web/portal/human-rights-environment *Accessed: 2024-05-02*.

[12] Goldhaber, M.: *A People's History of the European Court of Human Rights,* Rutgers University Press, ISBN 978-0-8135-4461-8, New Jersey, (2008)

[13] Ľalík, T.: Understanding the Binding Effect of the Case-Law of the ECtHR in Domestic Legal Order, *International Conference: Effectiveness of the European System of Protection of Human Rights*, Warszawa, Sejm, 18-19 April, 2011 *Available from* https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1951830 *Accessed: 2024-05-02.*

[14] Izyumenko, E.: Intellectual Property in the Age of the Environmental Crisis: How Trademarks and Copyright Challenge the Human Right to a Healthy Environment, *Available from* https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4735761 *Accessed: 2024-05-02*

[15] Toolan, N.; Marcus, H.; Hanna E.G.; Wannous C., Legal implications of the climate-health crisis: A case study analysis of the role of public health in climate litigation. *PLOS ONE* Vol. 17 (2022) No. 6, pp. 1-31, eISSN 1932-6203.

[16] Stuart-Smith, R.F.; Otto, F.E.L.; Saad, A.I. et al.: Filling the evidentiary gap in climate litigation. *Nature Climate Change,* Vol. 11 (2021), pp. 651–655 eISSN 1758-6798

[17] Merinero, S.G.; Tigre, M.A.: Understanding Unsuccessful Climate Litigation: The Spanish Greenpeace Case *Available from* https://blogs.law.columbia.edu/climatechange/2023/09/11/understanding-unsuccessful-climate-litigation-the-spanish-greenpeace-case/ *Accessed: 2024-05-02*

[18] European Court of Human Rights: Climate change factsheet, *Available from* https://www.echr.coe.int/documents/d/echr/fs_climate_change_eng *Accessed: 2024-05-02*

[19] Duarte Agostinho and others v Portugal and 32 others (dec.) [ECtHR Grand Chamber], no. 39371/20, 9 April 2024

[20] Rocha A.: States' extraterritorial jurisdiction for climate-related impacts, *Available from* https://blogs.law.columbia.edu/climatechange/2024/04/12/states-extraterritorial-jurisdiction-for-climate-related-impacts/ *Accessed: 2024-05-02*

[21] Carême v France (dec.) [ECtHR Grand Chamber], no. 7189/21, 9 April 2024

ASPECTS OF CORPORATE SOCIAL RESPONSIBILITY IN THE BANKING SECTOR OF THE REPUBLIC OF CROATIA

Anamarija Šinkovac, studentica[1]; Ivana Varičak[2]

[1] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA
[2] Karlovac University of Applied Sciences,Trg J.J. Strossmayera 9, Karlovac, CROATIA

Abstract: *This paper deals with the key aspects of social responsibility in the banking sector of the Republic of Croatia. The main focus is on the comprehensive picture of CSR in that sector. CSR is an indispensable part of modern business, emphasizing the responsibility of companies towards society, the environment and the economy. CSR practices are the response of business sector to the challenges of sustainable development. It is clear that the banking sector has a significant impact on society and the economy, thus acquiring a special responsibility in promoting social responsibility. Through an analysis of the integrity, value and mission of banks, the paper draws a conclusion about their contribution to social and environmental prosperity. It also examines how banks implement initiatives and activities that support CSR, including environmental sustainability, financing socially responsible projects, ethical banking, customer education and cooperation with social partners. Examples of three leading banks in Croatia are presented: Zagrebačka Bank, Privredna Bank Zagreb. and Erste&Steiermärkische Bank. Through the analysis of their practices and transparency in relation to CSR, the paper highlights the differences and similarities in their approaches.*

Keywords: *Sustainable development, corporate social responsibility, banking sector, ethics*

1. INTRODUCTION

During the last twenty years, many companies have shown an increasing interest in implementing social responsibility in their operations through the following areas: [1]

- environment - responsibility towards the environment is a priority of the economy, considering the problems that arise due to excessive exploitation of natural resources and destruction of nature, so numerous norms, rules and guidelines on environmental protection have been formed with the aim of protection;
- norms of management and business - issues in the sphere of business management are current, given that an increasing number of affairs related to bad management that directly affect investments in the economy are coming to the public;

- human rights - the link between the economy and human rights is inextricable, because human rights in business are present mostly when it comes to child labor, but also the labor rights of all employees.

In accordance with the above, it is clear how companies implement social responsibility in their business in order to meet the needs of the market, that is, how the development of society and technology dictates to them, which is also visible through a historical review with the aim of sustainability on the market and achieving a competitive advantage.

The subject of this work is corporate social responsibility in the banking sector of the Republic of Croatia. The aim of the work is to explore the concept of corporate social responsibility (CSR) in the context of the banking sector of the Republic of Croatia, to analyse the role and activities of banks in promoting social responsibility. The method of analysis and description was used to explain the concept of corporate social responsibility. Comparative method was used to compare the socially responsible activities of selected commercial banks. Synthesis was used for conclusion purposes.

2. THE CONCEPT OF CORPORATE SOCIAL RESPONSIBILITY

CSR is becoming an increasingly important aspect of the modern business world. The European Commission in its Guidelines for Corporate Social Responsibility Policy defines corporate social responsibility as "a concept according to which a company, on a voluntary basis, integrates concern for social issues and environmental protection into its business activities and relationships with stakeholders (owners, shareholders, employees, consumers, suppliers, government, media and general public). [5]

This business paradigm recognizes that companies have a responsibility to society and the environment in which they operate, not only to their shareholders and profits. [2]

CSR can be divided into:

- economic responsibility: the basic purpose of this aspect of CSR is to create economic value for the company and its shareholders. This includes complying with the law and achieving financial sustainability
- social responsibility: the focus is on the company's impact on the society in which it operates, including care for workers, the community and social issues.
- environmental responsibility: this aspect of CSR includes caring for the environment and reducing the negative environmental impacts of business.
- philanthropy and voluntarism: includes donations, sponsorships, volunteering and contributions to charities and the community.
- ethics and transparency: companies commit to ethical behavior and transparency in their business practices.

CSR can be divided into economic, social, environmental, philanthropic, ethical and transparent responsibility which provides a comprehensive framework for understanding the various aspects that companies can contribute to sustainable development and social responsibility. This diversity allows companies to adapt their strategies and activities to the specific needs and challenges of their industries and communities.

3. CORPORATE SOCIAL RESPONSIBILITY IN THE BANKING SECTOR

In the banking sector, CSR is not only an ethical obligation, but also a key strategy that promotes sustainable development, customer trust and positive social impact. [6] The banking sector has a key role in supporting socially responsible practices and promoting sustainable development. Banks around the world recognize the importance of their role in society and implement various activities to become socially responsible. "Taking into account the specifics of banking, as a service-type activity, the question arises as to what can be considered socially responsible behavior of banks. There is no official consensus regarding the list of such activities, considering their self-regulation.[7]

The role of the banking sector in promoting social responsibility can be significant for several reasons: [6]

- financing socially responsible projects: banks play a key role in financing projects that promote social responsibility, such as environmental protection, education, health care and poverty projects; through loans and financing, banks support initiatives that have a positive social impact.
- sustainable banking: banking institutions are increasingly adopting sustainable practices in their own operations; this includes reducing one's own environmental footprint, applying ethical and transparent business standards, and promoting sustainable investing.
- socially responsible investment: banks offer products and services that enable clients to invest in socially responsible projects and companies; this includes sustainability funds, ethical investments and similar products that promote CSR.
- client education: banks often implement education and information programs to make their clients more aware of social and environmental issues; this may include seminars, educational materials and information on socially responsible financial decisions.

Although the specific role of banks in promoting social responsibility may differ by bank and region, the banking sector has the potential to be a key player in achieving social and environmental goals. Promoting CSR is often aligned with the long-term interests of banks and contributes to their reputation and sustainable growth. One of the key aspects of CSR in the banking sector is environmental care. Banks have become increasingly aware of the impact of their operations on the environment and recognize the importance of protecting nature and preserving the ecological balance. Banks implement environmentally conscious initiatives, including reducing their own ecological footprint, financing renewable energy projects and supporting clients in achieving sustainable goals.[8]

Banks play a key role in financing projects that promote social responsibility and contribute to the common good of the community, such as poverty alleviation projects, education, healthcare and other socially beneficial initiatives. This role is not only financial, but has deeper social and economic implications that make the banking sector a vital player in achieving social goals.[9] Ethical banks and institutions focused on socially responsible business are becoming more and more popular. These banks are committed to transparency and ethical business practices, often avoiding investments in controversial or harmful sectors.

Ethical banks and institutions focused on socially responsible business are becoming more and more popular. These banks are committed to transparency and ethical business practices, often avoiding investments in controversial or harmful sectors. [6] Ethical banking represents, therefore, a significant paradigm in the banking sector that is expanding more and more and attracts the attention of clients who want their financial resources to support values and goals that go beyond mere profit maximization. This segment of the banking sector is characterized by its unique approach and business models Educating and informing clients are key aspects of banks' CSR. This approach includes activities aimed at raising awareness and understanding of clients about social and environmental issues and encouraging responsible financial behavior. In other words, banks implement education and information programs to make their customers more aware of social and environmental issues and to encourage them to make responsible financial decisions.[7] Banks often collaborate with non-governmental organizations, government agencies and other social partners to work together to solve social problems and improve communities.

4. CORPORATE SOCIAL RESPONSIBILITY IN SELECTED BANKS IN CROATIA

For the purpose of this paper CSR activities of three banks in Croatia were compared (Zagrebačka Bank, Privredna Bank and Erste&Steiermärkische bank). All three banks in Croatia clearly emphasize their values and mission within the framework of socially responsible business. They promote integrity through respect for the law and high ethical standards and support the local community and sustainability through various initiatives and projects. Each of them has its own specific programs and initiatives directed towards its values and mission, but their common goal is to contribute to a better society and the community in which they operate.

Table 1. Comparison and analysis of data, activities and initiatives implemented by banks

Zagrebačka Bank	**Privredna Bank Zagreb**	**Erste&Steiermärkische Bank**
Financial education programs	Ethical business	Social responsibility of employees
Sustainability and environmental projects	Sustainability in banking	Initiatives for the local community
Social responsibility	Training and mentoring programs	Environmental initiatives
Ethical business	Cultural and sports sponsorships	Financial literacy
Sustainability in banking	Social responsibility of employees	Corporate transparency
Annual sustainability reports	Support for education	Transparency about financial practices
Participation in global initiatives	Transparency about business goals	Social and environmental reports
Transparency	Annual sustainability reports	Responsibility in investments
	Participation in local initiatives	Transparency about sustainability goals
	Transparency about financial practices	

All three banks in Croatia actively strive to provide detailed reports and transparency regarding their corporate social responsibility practices. This is key to building stakeholder trust and enabling their clients and communities to better understand their social and environmental impact. They also implement various initiatives and activities to support socially responsible business, although the focus and approach may differ.

Their goal is to contribute to the sustainable economic development and social well-being of Croatia through their activities and engagement in the community.

5. CONCLUSION

In conclusion, it can be said that the subject of CSR in the banking sector is an important area that has a significant impact on the economy, society and the environment. CSR is a comprehensive concept consisting of a series of activities and practices that aim to promote economic, social and environmental values within an organization. This concept has its roots in the history of corporate responsibility and has evolved to include a wider range of aspects, including ethics, transparency, environmental protection and social welfare. In the banking sector, CSR plays a key role in promoting financial stability, supporting economic growth and meeting community needs. The banking sector in Croatia recognizes the importance of CSR and is increasingly oriented towards integrity, transparency and responsible business. Banks in Croatia implement a number of initiatives and activities aimed at society and the environment, including financing sustainable projects, supporting local communities and developing sustainable financial products. In addition, the banking sector plays a key role in promoting the financial literacy of citizens.

REFERENCES

[1] Bagić, A, Škrabalo, M, Narančić, L. (2006): Pregled društvene odgovornosti poduzeća u Hrvatskoj. Zagreb: AED
[2] Kotler, P., Lee, N. (2004): Corporate Social Responsibility: Doing the Most Good for Your Company and Your Cause. Wiley; Morsing, M., Schultz, M. (2006): Corporate Social Responsibility Communication: Stakeholder Information, Response and Involvement Strategies. Business Ethics: A European Review; 15(4): 323-338.
[3] Weber, O., Feltmate, B. (2016): Sustainable Banking: Managing the Social and Environmental Impact of Financial Institutions, University of Toronto Press
[4] Kundid, A. (2012): Društveno odgovorno poslovanje banaka u Republici Hrvatskoj. Ekonomska misao i praksa; 21(2): 497-528., str.502.
[5] European Commission: EC White Paper on Corporate Social Responsibility (2003) https://www.europarl.europa.eu/doceo/document/TA-5-2003-0200_EN.html
[6] Focas, C., Soares, N. (2019): Ethical Banking in Europe: The Role of Ethical Investment in the Face of Financialization. Review of International Political Economy: 26(5): 831-854.
[7] Radu, S. (2016): The Role of Banking Institutions in CSR Communication and Consumer Trust Building. Procedia Economics and Finance; 39: 822-828.
[8] Scholtens, B., Kang, F. (2013): Corporate Social Responsibility and Bank Risk. Journal of Banking & Finance; 37(9): 3529-3547.
[9] Oikonomou, I., Brooks, C. (2018): The Impact of Corporate Social Responsibility on Bank Lending. European Financial Management: 24(2): 220-252.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

THE COMPLEXITY AND SPECIFICITY OF THE WORK OF PORT WORKERS IN SEAPORTS REQUIRES SPECIAL REGULATIONS FOR THEIR SAFETY AND HEALTH PROTECTION AT WORK

prof. Ph.D. Marinko Đ. Učur, B.Sc. lawyer
[1] scientific advisor in a permanent position
Rijeka (retired)

Abstract *The labor relations of port workers in seaports in general and in the state of the Republic of Croatia are extremely complex, specific, and concrete with working conditions that determine the rights, obligations, and responsibilities of the subjects of those relations, both port workers and seaports, as employers. This complexity, specificity, and concreteness are particularly present and relate to occupational safety and occupational health protection in the performance of port work. Regulating these issues and relationships (heteronomous and autonomous norms) requires nontechnical and other knowledge (multidisciplinary and interdisciplinary) about the name of the regulation, the procedure of adoption, especially about the content, and their spatial and temporal validity. The subject of this paper points to the lack of specific regulations (of a universal, regional, and national character) on the safety and health protection at work of port workers working in seaports in the Republic of Croatia. (*

Keywords: *port workers, seaports, specificity of safety and health protection, lack of regulations*

1. INTRODUCTION

The complexity and uniqueness (specificity, characteristic) of the work and labor relations of port transport workers (hereinafter: LTR) are emphasized, especially in terms of working conditions, safety, and health protection at work. This complexity and uniqueness is expressed in the sources of law of a universal, regional, and national character, which constitute "a system of rules, principles, measures, procedures, and activities, the organized application of which achieves and improves safety and health protection at work to prevent risks at work, injuries at work, occupational diseases, work-related illnesses and other material and non-material damages at work and in connection with work".[1] The practice of work and labor relations in seaports in the Republic of Croatia testifies to the complexity, particularity, and demandingness of relations in safety and health protection at work LTR and its advantage and everyday demandingness about legal norms which are mostly general and less special (lex specialis). The process of creating at least an approximate balance between regulations and practice will take a long time, with constant harmonization, which refers to the protection of LTR, ways, and procedures of training and informing workers and employers, and concrete measures to prevent risks at work, not neglecting the design and production of work equipment, rules on the use, maintenance, inspection and testing of work equipment in the port, "to eliminate risk factors and their harmful consequences".

[1] Occupational Safety Act "N.N." 71/14, 118/14, 92/18, 96/18.

This applies to all occupational safety rules: basic, special, and recognized, which constitute "systematically organized action in... the organization of work and the implementation of work procedures", that is, production in a broader sense.

2. REFERENCE TO UNIVERSAL AND REGIONAL SOURCES OF RIGHTS

Regulations on safety and health protection at work of a universal and regional character do not pay due attention to the specific relations of subjects in matters of safety and health protection at work LTR. This situation is somewhat "remedied" by heteronomous and especially autonomous regulations in the Republic of Croatia.

2.1. ILO Convention on Safety and Health at Work (Port Work) 1979 and other ILO conventions

The ILO Convention on Safety and Health at Work (Port Work) 1979 "covers any and every part of the work, loading or unloading of any ship, as well as any work-related thereto...", and every worker (person) engaged in that work[2]. The Republic of Croatia has not ratified this Convention. The Convention provides a definition of port operations, free equipment, and ship, and prescribes the obligation of the state ("which ratifies this Convention") to take occupational safety measures (taxatively determined) and special measures for facilities and means of work. The obligations of employers, port workers, and other subjects in port work have been determined.

2.2 Directives of the European Union (EU)

The directives are part of secondary sources of law on safety and health protection at work and are numerous. They are adopted by regulations in the Republic of Croatia and are part of the legal system of the country. Port work and LTR are indirectly applied, for the most part, but also directly because they relate to the activity, port operations, working environment, place of work, means of work, and more. These are:

1) Council Directive 1989/391/EEC – ("framework directive") on safety and health protection at work ("fundamental Law");

2) Directive 1989/654/EEC on minimum safety and health requirements for the workplace;

3) Directive 2009/104/EC on minimum and health standards for the safety and health of workers when using work equipment at work;

---

[2] Convention no. 152 (1979), International Labor Organization (June 25, 1979) port work; Recommendation of the ILO, along with the Convention (1979) on occupational safety and health in port operations, 1979 (No. 160); Revised: Convention on Marking the Weight (Package) of Packages Transparent by Ships (1929); Convention on protection against accidents (port workers) no. 32 (1932); ILO Convention on the Protection of Machinery (1963); Convention on working environment (environment), air pollution, ports, vibrations (1977); Convention no. 137 (1973) on the social repercussions of new work methods in ports (not ratified).

UČUR, Marinko, LALETA, Sandra, Conventions of the International Labor Organization (with comments), TIM PRESS, Zagreb, Faculty of Law, Rijeka, 2007.

4) Directive 1989/656/EEC on minimum health and safety requirements for the use of personal protective equipment by workers in the workplace;

5) Directive 1990/269/EEC on the minimum safety and health conditions for manual handling of loads in cases where there is a risk, especially of injury to the worker's back;

6) Directive 1992/58/EEC on the minimum requirements for placing safety signs and/or signs for health protection at work

7) Directive 2002/64/EC on risks caused by physical factors (vibrations, etc.)

8) Directive 2003/10/EC on risks arising from physical factors (noise);

9) Directives related to the workplace, work equipment, safety signs, personal protective equipment;

10) Directives on exposure to chemical hazards; physical harm, about the protection of young people, exposure to biological harm, etc.[3]

2.3. Indirect universal and regional hot rights of LTR to safety and health protection at work

It is indisputable that other regulations of a universal and regional character, as sources of natural (human rights, human rights), are also indirect sources of LTR rights to safety and protection at work, namely: Universal (general) Declaration of human rights, 1948; International Covenant on Economic, Social and Cultural Rights (OUN, 1966); Constitution of the ILO (1919, 1944); Constitution of the World Health Organization (WHO), 1948; European Social Charter (Torino, 1961); European Convention on the Protection of Human Rights and Fundamental Freedoms (1950) and others[4].

3. STATE CONSTITUTION AND NATIONAL REGULATIONS OF THE REPUBLIC OF CROATIA

The principles and fundamental rights and freedoms of safety and health protection at work are regulated by the "law above laws" in the Constitution of the Republic of Croatia, and by the principle of constitutionality and legality (the Labor Act, the Occupational Safety Act, and numerous other laws on labor law and social law relations) and with the principle of legality numerous sub-legal (implemented) acts of a heteronomous character and even more numerous autonomous general normative acts (collective agreements, regulations on occupational safety, risk assessment, decisions and other acts with general norms). One cannot object to the norms of the Constitution and general laws on work and occupational health when it comes to safety and health protection at work, but there is a lack of by-laws on LTR, their safety and health

[3] All the above and other directives are published in the book: UČUR, KOVAČ, ŠIJAKOVIĆ, KRIŠTO, Fundamentals of Law and Legislation for the Protection of Health and Safety at Work, ZIRS, Zagreb, 2023, p. 121 -132. and others.

[4] UČUR, Marinko, Source of international law on safety and health protection at work, Libertine publishing house, Rijeka, 2024.

protection at work. This "burden" and obligation is assumed by the creators of norms in autonomous general normative acts[5].

3. CONCLUSION

In all scientific disciplines, the special nature of the economic activities of seaports, as one of the areas of marine technology, is emphasized. This particularity (specificity) is emphasized in labor law and social law relations, and especially in the safety and health protection at work of port transport workers (LTR). There is a lack of regulations at all levels (of different spatial and temporal validity) whose content would regulate the above-mentioned particularities, so the general system of rules (basic, special, recognized) is mainly applied. For this reason, it is required that this "burden" be taken over by entities that appear as addressees of by-laws, and in social dialogue, employers and workers, their associations and bodies in the creation, realization, and protection of norms and relations in autonomous general normative acts.

REFERENCES

Note on literature: Basic literature and regulations are listed in the invitation notes and the content of the paper.

[5] Constitution of the Republic of Croatia "NN" 56/90,...76/10, 5/14; Labor Law "N.N." 93/14; 127/17, 98/19, 151/22, 64/23; Occupational Safety Act "N.N." 71/14, 118/14, 94/18, 96/18; Ordinance on safety at work during loading and unloading of cargo "N.N." 49/86; Rulebook on the protection at work of workers exposed to stat dynamic psychophysiological and other efforts at work "N.N." 73/21; Rulebook on the protection of workers from exposure to noise at work "N.N." 148/23; Ordinance on the protection of workers from exposure to vibrations at work "N.N." 148/23.

SECURITY MANAGEMENT SYSTEMS DURING AN EARTHQUAKE

Zoran Vučinić[1]; Manuela Žakula[2]
[1]Zavod za hitnu medicinu karlovačke županije, dr.Vladka Mačeka 48, 47000 Karlovac,
[2]Karlovac University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac
zoranvucinic5@g,mail.com
manuela.zakula@vuka.hr

Abstract: *The causes of earthquakes are tectonic movements that occur in the regional area. As a result of the pushing and pulling of individual tectonic units the lithosphere cracks one under the other and cracks (faults) become seismic sources of earthquakes Earthquake safety systems are key to this Education on safety management systems should be raised to an even higher and more professional level with greater use of experiential workshops that can cover all doubts related to the safety management system during an earthquake The scientific paper offers practical solutions for effective management of emergencies Also, empirical research was conducted by the target group, members of fire brigades. The results of the empirical research showed that the good side of the system is that people are ready to help ready and use operational forces. The results of the research showed that members of the fire department were poorly educated about the safety management system.*

Keywords: *earthquake, safety management, education, recommendations.*

1. INTRODUCTION

As a rule, the assessment of seismic risk is based on the expected damage to the existing stock of buildings, on which the possible dangers to human health and life, and the corresponding financial losses due to the resulting damage, are calculated. The assessment of possible losses due to earthquakes in seismically active areas is extremely important for implementing the risk mitigation strategy and planning emergency interventions in the event of an earthquake. It is of particular interest to state authorities, engineers in practice and the social community. Critical infrastructure is defined according to the Act on Critical Infrastructures of the Republic of Croatia (Official Gazette No. 56/13). The Advanced Seismic Assessment Module is a technical post-earthquake intervention service that EUCENTRE has developed over the years through a series of national and European pilot projects, field exercises and direct experiences after the last major earthquake events. Education about safety management systems should be raised to an even higher and more professional level with greater use of experiential workshops that can address all doubts related to the safety management system during an earthquake. The analysis of the drawbacks of the security management system showed where it is necessary to improve the effectiveness of the coordination mechanisms in response to extraordinary events while the analysis of the strengths of the system indicates the good work of the operational forces.

2. SECURITY MANAGEMENT SYSTEMS DURING AN EARTHQUAKE

People will never be completely protected from natural disasters because it is very difficult to predict where and when the next one will happen. However, what can be done is to learn from past events and consequently plan and prepare appropriate responses. Researchers in the scientific field of natural disaster management advocate different theoretical bases and frameworks. This is precisely why the very definition of management is unclear and there is no agreement about it. [1] All disasters have four specific stages in their development. These are emergence, initiation, culmination and deposition. In the emergence phase, the preconditions for a future disaster are created: unfavorable natural processes are activated, technological failures and construction-production defects accumulate, there is an overload of equipment and employees, extreme physical conditions of the production process, and negative anthropogenic impacts on the environment. [2]. There are several definitions of natural disaster management: "the discipline and profession that applies science, technology, planning, and management to control extreme events that can injure or kill large numbers of people, cause extensive property damage, and disrupt life in society" (ICMA), [3], "risk management so that societies can live with natural and technical hazards and control the disasters they cause, [4],a discipline dealing with risk and risk avoidance, [5],a state of responsibility and ability to manage all types of disasters through the coordination of the actions of a large number of entities and protection and rescue forces. [6] Integrated management of natural disasters represents an important strategy and model in modern disaster management. [7] Practical solutions for effective management during an earthquake are the following. [8]

The legal regulations must provide a normative framework for implementing tasks from the planning and preparedness phase to the end of emergencies.

2. A political framework for the activation and unified action of all factors of the complex system at all levels.

3. A system for planning the sustainable development of society at all levels which must also include planning for an effective response to existing and possible new risks of crises and disasters.

4. The establishment of a unique national organization that must be the hub of activities that includes all factors in monitoring the situation, assessing threats and vulnerabilities, assessing risks (long-term and short-term), and making and implementing decisions to overcome emergencies.

5. A system of financing a complex response system to crises and disasters that includes all levels, from individuals and legal entities, local and regional self-government to the state level.

Regarding the system of managing systems during an earthquake, organizational changes are needed. Organizational changes mean changes in the organizational structure of the organization and do not include technological changes, changes in the development strategy, or financial policies of the organization. [9] Organizational changes are introduced when certain problems and difficulties arise in the organization caused by the influence of external or internal factors which the organization cannot solve with the existing organizational and management structure. The only solution in these conditions is the introduction of organizational changes that create conditions for overcoming the problems that have arisen. These organizational changes are aimed at improving the functioning and development of the organization as a whole or its specific parts. These changes refer to the organizational or management structure of the organization which includes changes in organizational and management techniques and methods [10].

Changes in the organizational structure are not possible (more precisely, they cannot be successful) without changes in the people who make up the organization and changes in the relationship of the organization to the environment and with a changed organizational structure.[11]

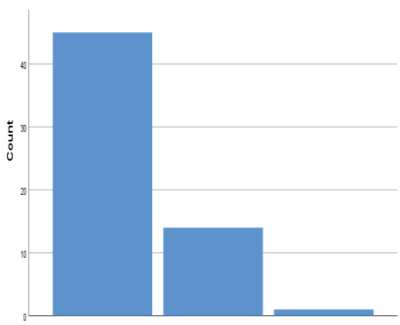
3. EMPIRICAL RESEARCH

The empirical research is shown as follows:

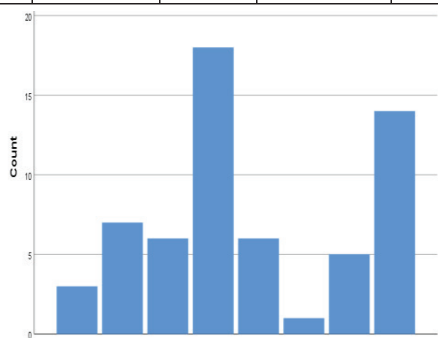
Table 1. The results of descriptive statistics.

The highest result is related to the age of the respondent (M=4.83, SD=2.249), the work experience of the respondent (M=3.55, SD=1.751), has the highest arithmetic mean, while the lowest value has the category knowledge of the work of EUCENTRE from Italy (M=1.38, SD=0.962).

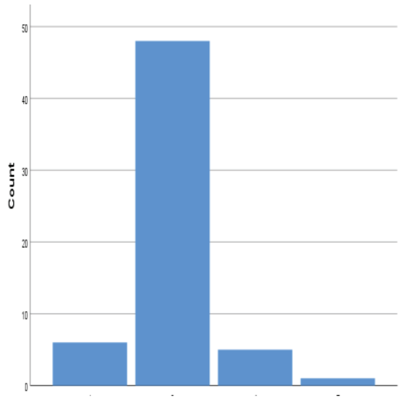
Descriptive Statistics						
CATEGORY	N	Range	Min	Max	Mean	Std. Dev.
Age	60	7	1	8	4,83	2,249
Work position	60	4	1	5	2,12	0,761
Work length	60	7	1	8	3,55	1,751
Work position	60	5	1	6	2,47	1,467
Education	60	3	1	4	1,42	0,619
Assessment of the state of the earthquake safety management system	60	4	1	5	2,30	0,962
Know about EUCENTRE	60	2	1	3	1,38	0,715
Agree that Croatia should have a similar organization	60	2	1	3	2,22	0,524
Which factor is the best developed?	60	4	1	5	2,28	1,485



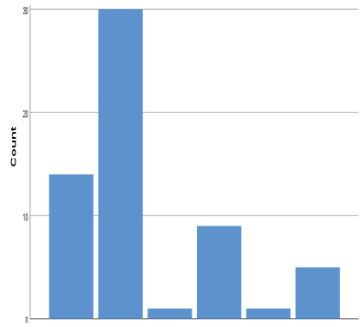
Graph 1. Sex structure.



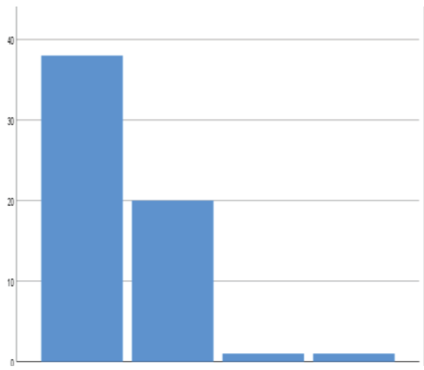
Graph 2. Age structure.



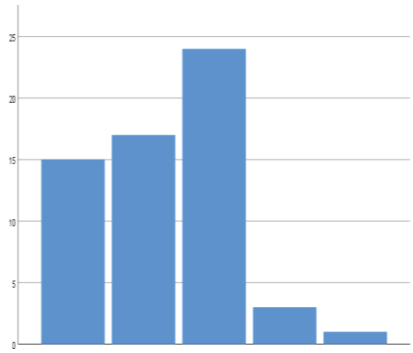
Graph 3. Work structure.



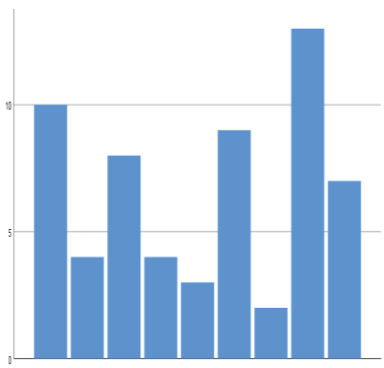
Graph 4. Working position structure.



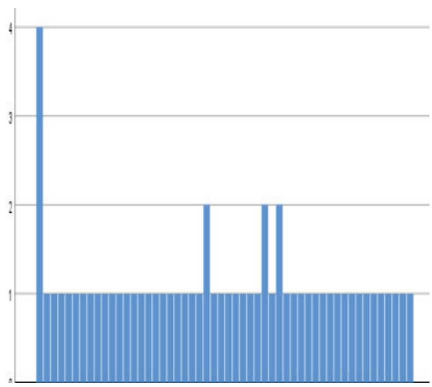
Graph 5. Education on earthquake management systems.



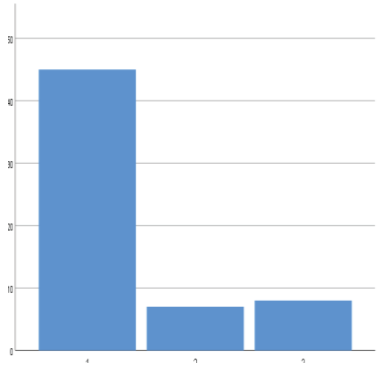
Graph 6. General assessment.



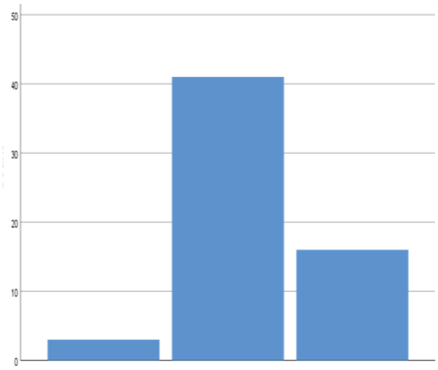
Graph 7: Safety Management System: Drawbacks.



Graph 8: Safety Management System: Good Sides.



Graph 9. EUCENTRE (known or not).



Graph 10. Attitude about EDUCENTRE.

According to Chart 1 on the gender structure of the respondents, it was determined that 75% of the respondents were male compared to the proportion of female respondents (23.3%). 1.7% of the respondents did not specify their gender. The largest share of the age structure is from 33 to 37 years old (30%) and the lowest share is from the age structure of 43 to 49 years. A significant proportion of respondents aged 45 and over (23.3%) was observed (Graph 2). According to the research results shown in Graph 3., the largest share of work status comprises respondents who are employed indefinitely, full-time (80%), in contrast to the 8.3% of respondents considering changing their work status. The category "Member of the fire brigade" has a share of 50% while the category "Member of civil protection" has a share of 15%, and the category "Member of the Ministry of the Interior of the Republic of Croatia" has a share of 1.7%.The category members of a healthcare institution recorded a share of 15% of respondents while the category experts from the field of safety engineering recorded a share of 23.3% of respondents (Graph 4). A worrisome trend of a decrease in the share of respondents regarding training on earthquake safety management systems. Out of a total of 100% of respondents, 63.3% had never received training, while 33.3% of respondents received training once or twice a year. These indicators point to the need for changes in the system of training experts in the field of security as well as members of the Fire Department (Graph 5.). Based on the results of the research on the general assessment of the state of security management, an average score of 33.3 was obtained (Graph 6.). Graph 7. indicates that content (67%) is critical when it comes to planning activities. Graph 8. shows that the good side is that people are ready to help, ready to rescue people from the ruins and buried buildings (58.6%) and another good side is the use of operational forces (46.6%). Knowledge of EUCENTRE's work is a category that is presented in Graph 9., showing that 75% of respondents are not familiar with EUCENTRE's work. Graph 9. is followed by the results of the survey on the attitude of respondents to introduce EUCENTRE in the Republic of Croatia. 68.3% agree with the introduction of EUCENTRE while 26.7% are not sure of the answer which shows that it is necessary to clarify what it is about and how EUCENTRE works.

3. CONCLUSION

Like everything here, a lot depends on the enthusiasm and will of the people in the system while the system itself is sluggish and not prone to change. In an earthquake situation, people quickly organize to help the victims, as we had the opportunity to see in Zagreb and Sisak but then the system fails to organize things or put them in order according to certain rules and frameworks. There is no classification and uniform form of equipping the units; everything is organized badly at the local level and there is no team training at the regional level. The command staff is not familiar with and trained in ICS. There are no reconnaissance teams, there is no solution for taking care of rescuers in the field. Poor preparation for self-sustainability. Poor preparation for the health care of rescuers. We do not have a developed system of command in these situations (The command is given by people who do not have the knowledge and skills for these specific interventions). The system of cartography and communications is not developed for crises. There are no support teams, there are no regional warehouses for such situations. There are no elaborate SOPs, and there is no management and responsibility system in the field. The indicators of the research results are attached to this.

0

[1]. P. Blaikie, T. Cannon, I. Davis, B. Wisner, At risk: natural hazards, people's vulnerability, and disasters. Routledge, London, 2004, pp.53

[2] S. Asghar, D. Alahakoon, L. Churilov, A comprehensive conceptual model for disaster management. Journal of Humanitarian Assistance, 1-15, 2006. pp. 31

[3] B. Phillips, P. Jenkins, he roles of faith-based organizations after Hurricane Katrina. Geographical Review, 366-385, 2010, pp. 26.

[4] D. Waugh, Geography: an integrated approach, Nelson Hornes, New York, 2001, pp. 98

[5] G. Haddow, J. Bullock, P. Coppola, Introduction to emergency management, Butterworth-Heinemann, New York, 2007, pp. 76

[6] C. Flint, M. Brennan, Community emergency response teams: From disaster responders to community builders. Rural realities, 1(3), 1-9, 2006

[7] Integrisano upravljanje u prirodnim katastrofama, https://www.academia.edu/19247583/Integrisano_upravljanje_u_prirodnim_katastrofama

[8] Kešetović, Ž., Toth, I. : Problemi kriznog menadžmenta, Veleučilište Velika Gorica, 2012.

[9]. D. Bogdanović. Upravljanje promjenama. Univerzitet u Beogradu. Tehnički fakultet u Boru. 2016.

[10] Jacobs D., Homburger A.: Making Business Competitive, Kogan Page, London, 1990

[11] Cvijanović M. J.: Organizacione promene, Monografija, EkonomskiInstitut, Beograd, 2005

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

ASSISTANCE TO PERSONS WITH DISABILITIES IN CRISIS SITUATIONS

[1]Branko Zlomislić, [2]Zvonimir Matusinović, [3]Zoran Vučinić, [4]Lidija Jakšić, [5]Igor Peternel

[1]University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia

[2]University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, zvonimir.matusinovic@vuka.hr

[3]Zavod za hitnu medicinu karlovačke županije, Vladka Mačeka 48, 47000 Karlovac, Croatia, zoranvucinic5@gmaill.com

[4]University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, lidija.jaksic@vuka.hr

[5]University of Applied Sciences, Trg J.J. Strossmayera 9, 47000 Karlovac, Croatia, igor.peternel@vuka.hr

Abstract: *The aim of this paper is to investigate and show the readiness and competence of the population and institutions to help people with disabilities in crisis situations. The objectives of this paper are to explain the types of disabilities and crisis situations, to explain the treatment and assistance to persons with disabilities in crisis situations, to investigate the current situation in Croatia regarding crisis situations, to investigate whether they have organizations that help people with disabilities in crisis situations, to find out whether there are legal minimums regarding protection at work, and to conduct research on the knowledge of the population on how to help people with disabilities, and research on the satisfaction of people with disabilities with the help provided.*

Keywords: *people with disabilities, crisis situations, helping people with disabilities during crisis situations*

1. INTRODUCTION

People with disabilities are considered to be people who have different types and degrees of health impairment, different difficulties or obstacles, i.e. irregularities in mental, physical, psychophysical and social development.

Disabilities fall into many categories, the main examples of which are: personal mobility difficulties, visual impairment, deafness, communication and word articulation problems, cognitive disorders, various medical problems including those requiring the use of life support systems, psychiatric disorders and age-related infirmities.[1]

The causes of disability are numerous, and they are divided into: hereditary and acquired, endogenous and exogenous, organic and functional, as well as trauma and diseases, etc.[2] More than 1 billion people in the world live with disabilities.[3]

A crisis situation is a situation that threatens the safety of human life and causes damage to the environment. In crisis situations, human lives are lost, they damage the physical and psychological health of people, especially those who were not prepared for it.

The stages of human feelings in crisis situations are: panic, shock and disbelief, not accepting the seriousness of the situation, looking for various excuses and culprits, anger and rage, confusion, apathy, feeling sad and accepting the situation and readiness to adapt.

Crisis situations include hurricanes, tsunamis, earthquakes, storms, and other events such as floods, fires, landslides, threats of terrorism, and other human-driven attempts to create mass panic in society can be added to these disasters.[4]

Crisis situations are characterized by 4 time-sensitive phases: mitigation, preparedness, response and recovery. Emergency preparedness refers to all actions taken prior to a disaster by responders and those directly affected that enable the proactive engagement of societal units when a disaster occurs.[4]

First of all, it is necessary to know which crisis situations and threats are possible in a certain region, how to find out important information about a crisis situation, who to turn to for help and where to go in case of a crisis situation. Furthermore, it is desirable to have a backpack with all the necessities for crisis situations, and to know basic first aid. Various educations and dissemination of useful information on how to better prepare for crisis situations are extremely important. The best preparation for a crisis situation is to plan and do everything possible in advance to be ready.

Every crisis situation is different. However, there are certain things that should always be done in case of a crisis situation, such as entering the house at the sound of the siren and closing all windows and doors, informing and warning people in your region. In case of injury or danger, call the emergency services. If the person is not injured, help others if possible. 10 important tips in the event of a disaster from the Red Cross: in the event of a disaster, call the emergency services and follow their instructions, stay together with your loved ones in a safe place, provide first aid and call for help, if it is not safe to leave the building and stay outside, if it is safe with yourself bring a kit for disasters and pets, if it is safe to turn off the gas, electricity, water supply and lock the facility, if it is safe to enter the facility and stay in it, listen to the local radio station and follow safety instructions, check if you can help neighbors and follow your personal disaster plan.[5]

In crisis situations, regardless of the consequences, the most important thing is to be calm and think positively. One should not give in to negative influences because what has already happened cannot be changed, but with a positive attitude and calmness it is easier to find solutions to get out of that situation.

Civil protection is responsible for the protection and rescue of citizens, material goods and the environment in crisis situations in the Republic of Croatia. In the system of civil protection in the Republic of Croatia, the following are active: fire department, Croatian Red Cross, Croatian Mountain Rescue Service, various associations, various units and commissioners of civil protection and legal entities in the system of civil protection.

Today, people with disabilities (15% of the world's population) are disproportionately affected by disasters, conflicts and other crises. They are more likely to be victims when a crisis strikes, are often less able to evacuate or escape the disaster, and are more likely to have their lives threatened. And yet, they are still not prioritized when it comes to crisis planning and response. People with disabilities may encounter physical barriers or have particular communication difficulties that prevent them from responding effectively to crisis situations and prevent them from using facilities and assistance available to people without disabilities.

2. RESEARCH AND DISCUSSION

As part of this work, several surveys were conducted. The first one, entitled "Help for people with disabilities in crisis situations" for 140 respondents. And the second one for people with disabilities entitled "Satisfaction of people with disabilities with help in crisis situations" on 185 respondents. Based on the number of respondents, we can conclude that people with disabilities were more interested in this topic since a larger number of respondents responded.

2.1. Survey "Help for people with disabilities in crisis situations"

The survey was conducted in the period from March 18, 2024. until 24.03.2024. to 140 respondents with the help of a Google form and was distributed via the social networks Facebook and Whatsapp.

The majority of respondents, 101, or 72%, were women, while 39, or 28%, were men. The majority of respondents were in the age group between 36-45 years, 58 and 42% respectively. Then those between 46-55 years of age, 40 of them, or 29%. There were 21 respondents between the ages of 26-35 (14%), and 9 respondents between the ages of 18-25 (6%). 12 respondents were aged 56+ (9%). Most respondents completed secondary school, 69% (97 respondents). Then, 26% of respondents had a higher education (37 respondents), while 5%, or 6 respondents, only completed elementary school. The majority of respondents (66%) are from the City of Zagreb. 16% are from Adriatic Croatia, and 14% are from Pannonian Croatia. The smallest number of respondents (4%) is from Northern Croatia. 96 respondents (69%) say that they have a disabled person in their family or neighborhood, while 44 respondents (31%) do not.

To the question "Would you remember a disabled person in the neighborhood in a crisis situation (earthquake, fire, flood, etc.)?", 74% of respondents (105 of them) said that they would remember a disabled person in a crisis situation, 2% of respondents (2) says that they would not remember, while 33, 24% of respondents do not know.

Only 33% of the respondents (45 of them) answered yes to the question "Have you had the opportunity to help a person with a disability in a crisis situation?", while most of them, 67% (95 respondents) answered that they did not have the opportunity to help a person with a disability in crisis situation. As many as 53% of respondents (75 of them) believe that they are not sufficiently informed about how to help people with disabilities in a crisis situation. 23% of the respondents (32) think that they are sufficiently knowledgeable, while 24% of the respondents (33) do not know.

For the question "How likely is it that you would go to training on helping people with disabilities in crisis situations?", respondents could choose from 1 to 5. 1 indicated not at all likely, while 5 indicated very likely. Most of the respondents, 50 of them, would very likely go to education. 34 respondents would probably go, while 38 respondents gave a score of 3, which means that they were not sure if they went to education or not. Only 4 respondents answered that it was unlikely that they would go to education, as did 14 respondents who answered that they probably would not go to education.

The next question with a short answer was, "Have you ever come across instructions on how to help people with disabilities in crisis situations?" If yes, state where." The majority of respondents (113) did not encounter instructions on how to help people with disabilities in crisis situations, while only 27 respondents encountered instructions on how to help people with disabilities. Of these 27 respondents, 1 respondent met with instructions in a hospital, 2 respondents at school, 6 at the Karlovac Polytechnic, 2 respondents at the workplace, 2 in civil protection, 1 respondent in military training, 1 in the fire department and 1 respondent in workshops for the inclusion of people with disabilities as part of the tourism development project.

To the question "Do you think about what obstacles people with disabilities have in crisis situations?" If yes, name some", the respondents gave different answers. 23 respondents said they don't think about it, 21 respondents say they do, 5 respondents say they don't know, and 7 respondents say they sometimes think about it. 11 respondents answered that they were thinking about it and cited the impossibility of quick reaction as an obstacle. Exiting the facility was mentioned by 10 respondents as an obstacle. Most of the respondents, 27, stated the impossibility of using the elevator. 13 respondents answered that they cannot be independent, and 9 respondents indicated poor access for the disabled. As an obstacle, 10 respondents cited dependence on others, and 4 respondents cited panic attacks as an obstacle.

The last question in the survey was a short-answer question, "In the event of an earthquake, how would you help a person in a wheelchair living in a building on the 5th floor?" Most respondents (38) said that in the event of an earthquake, they would take a person in a wheelchair outside to back. 29 respondents would call for help, and 22 respondents did not know what to do. 17 respondents would take the person down the stairs, 13 respondents would check how the person is doing, 11 respondents would wait for the professional services together with the person, and 10 respondents would give the person a place in the elevator.

At the end of the survey, it can be concluded that the majority of respondents have not had the opportunity to help a person with a disability in a crisis situation, but most think that they would remember a person with a disability they know in a crisis situation. More than half of the respondents believe that they are not sufficiently informed about how to help a person with disabilities in a crisis situation, but they are willing to go to education. As many as 80% of respondents have never come across instructions on how to help people with disabilities in crisis situations. Respondents mentioned various obstacles for people with disabilities in a crisis situation, and they mostly emphasized the impossibility of using the elevator and the lack of access roads for people with disabilities.

2.2. Survey "Satisfaction of persons with disabilities with available help in crisis situations"

This survey was also conducted in the period from March 18, 2024. until 24.03.2024. to 185 respondents with the help of a Google form. The survey was intended only for people with disabilities, and was divided into the group Inclusive Supplement of the Republic of Croatia, the Association of Associations of Persons with Disabilities in Karlovac County, and the Croatian Association of the Blind.

In this survey, the majority of respondents, 124, or 67%, were men, while 61, or 33%, were women. 53 respondents (27%) are between the ages of 46-55, and 49 respondents (26%) are between the ages of 36-45. 37 respondents (20%) are in the age group between 26-35 years old, 26 respondents (14%) are in the 56+ group and 20 respondents (13%) are between 18-25 years old. The majority of respondents, 97 of them (53%) live in the City of Zagreb. Then, 34 respondents (18%) live in Adriatic Croatia, 32 respondents (17%) in Northern Croatia, while 22 respondents (12%) live in Pannonian Croatia. 155 respondents (84%) completed high school, 18 of them (10%) completed college, while 12 respondents (6%) completed elementary school.

The largest number of respondents, 130 (73%) have physical disabilities, 14 respondents (12%) have intellectual disabilities, 17 respondents (10%) have hearing impairment, and 10 respondents (5%) have visual impairment. 66 respondents (34%) have 100% disability, while 29 respondents (16%) do not know. Then, 24 respondents (12%) have 80% disability, and 16 respondents (8%) have 70% disability. 10 respondents each (6%) have 90%, 60%, 50%, 40% and 30% disability. The majority of respondents 152, 82% were helped by family, while 12%, 22 respondents were helped by neighbors, and 6%, 9 respondents were helped by civil protection.

For the question "How satisfied are you with the help provided?" respondents could choose from 1 to 5. 1 indicated that they were not at all satisfied, and 5 indicated that they were very satisfied with the help provided. Most respondents, 80 of them, are very satisfied with the assistance provided in crisis situations. 41 respondents are satisfied with the help provided, while 39 respondents answered that they are not sure if they are satisfied with the help provided in crisis situations. 12 respondents are not at all satisfied with the help provided, as are 13 respondents who are also not satisfied.

As many as 173 respondents (94%) answered that they think that the access roads for people with disabilities in the Republic of Croatia are not sufficiently adapted, and only 12 respondents (6%) think that they are. Furthermore, the majority of respondents, 86 of them (46%) believe that emergency services are not sufficiently educated on how to help people with disabilities in crisis situations. 61 respondents (33%) do not know, and only 37 respondents (21%) believe that the emergency services are sufficiently educated to help people with disabilities in crisis situations.

The last question in the survey was "Do you have a personal plan in case of a crisis?". 110 respondents (60%) do not have a personal plan in case of a crisis situation, while 75 respondents (40%) do.

At the end of the survey, we can conclude that the majority of respondents were in a crisis situation and most of them were helped by their family. Most respondents are satisfied with the assistance provided in a crisis situation. As many as 94% of respondents are not satisfied with the adaptation of access roads in the Republic of Croatia for people with disabilities. The majority of respondents believe that the emergency services are not sufficiently trained to help people with disabilities in crisis situations, and more than half of the respondents do not have a personal plan in case of a crisis.

The results of this research were compared with the results of a survey conducted in Croatia by the Directorate of Civil Protection of the Ministry of the Interior of the Republic of Croatia with the help of the European Commission in the "See me" project. The results of the research mostly coincided, and similar conclusions were reached, such as: Croatian emergency services do not have elaborate guidelines for dealing with people with disabilities in crisis situations, people with disabilities encounter problems in communication and transfer, people with disabilities encounter numerous obstacles such as constructive barriers (stairs, heavy doors, road blocks, ramps) and the unprofessionalism of emergency services and misunderstanding.

In order to improve the situation in both studies, it was concluded that education and training of rescuers in rescue is needed in Croatia. It is important to include people with disabilities in these trainings because they know best how to best help them and how to deal with them in such situations, because sometimes it is very difficult for rescuers to establish communication with people with disabilities because they know how to panic and it is difficult to calm them down and convince them to cooperation.

3. CONCLUSION

Based on the conducted research, it can be concluded that in the Republic of Croatia, as far as helping people with disabilities in crisis situations is concerned, a lot of work still needs to be done in terms of educating the population and emergency services.

When alerting, informing, evacuating and helping people with disabilities, it is necessary to consider the types of disabilities, because they all react differently in certain situations. Also, it is necessary to anticipate and procure material resources, appropriate aids and medicines needed in such situations.

One of the most important things would be the inclusion of people with disabilities in the preparation and planning of the crisis management program. They should be instructed in the types of crisis situations, familiarized with the methods of raising the alarm, educated on who to call in such situations and the ways in which the emergency services act to remain as calm as possible, all this in order to reduce the stress and shock experienced by people with disabilities in such situations.

Also, it is necessary to train emergency service workers how to deal with people with disabilities in crisis situations, placing emphasis on dealing with individual people with physical impairments as well as with cognitive difficulties. Some of these people do not use verbal communication, so they can have specific reactions, therefore their acceptance of the situation can be unpredictable. In addition to the education of emergency services and people with disabilities, it is very important to acquire the necessary assistance and rescue equipment in accordance with the latest technological achievements.

In addition to all of the above, it is extremely important to make the entire social community aware of the existence and need to help people with disabilities by conducting various campaigns, forums, filming films, making leaflets, and even introducing the mentioned topic into the education system.

REFERENCES

[1] Alexander D.: „Disability and Disaster“, Centre for the Study of civil protection and risk conditions, University of Florence, Italy, 2012.

[2] Zovko G.: „Invalidi i društvo“, Pravni Fakultet, Zagreb, 1999.

[3] United Nation Development Programme, https://www.undp.org/blog/our-crisis-response-must-include-people-disabilities *Accessed:* 2024-01-29.

[4] Fox M.; White G.; Rooney C. and Rowland J.: “Disaster Preparedness and Response for Persons with Mobility Impairments”, *Journal od Disability Policy Studies*, **Vol. 17, Issue 4,** 196-205, 2007.

[5] Crveni Križ, https://www.crveni-kriz-ivanec.hr/aktivnosti/priprema-i-odgovor-na-katastrofe/ *Accessed:* 2024-02-02.

THE IMPORTANCE OF INTERPERSONAL RELATIONSHIPS IN FIREFIGHTING

Manuela Žakula[1]; Andreja Primužak[1];Nikola Turina[1](student); Mirjana Cibulka[1]
[1,2,3,4] Karlovac University of Applied Sciences, Trg J. J. Strossmayera 9, HR-47000 Karlovac, manuela.zakula@vuka.hr, andreja.primuzak@vuka.hr, mirjana.cibulka@vuka.hr

Abstract: *The work efficiency of the members of fire brigades is constantly being investigated. One of the elements that improve this efficiency is quality interpersonal relations among the members of fire departments. One of the ways to improve communication within a fire department is through workshops (in the form of psychotherapy), and they could be conducted in Volunteer Fire Fighters Association, Public Firefighting Brigades, in general in all types of fire departments. In this way, the relationship between the members of fire brigades, the relationship between professional and volunteer firefighters, and the relationship between firefighters and local communities is improved, all with the aim of maintaining safety and protecting people and property. The work aimed to examine the existing and future ways of improving relations between members of fire departments at the state level through an online survey. The research showed that significant modifications and constant training are needed to improve interpersonal relations among members of fire departments.*

Keywords: interpersonal relations, firefighters, survey, training

1. INTRODUCTION

The profession of firefighting is one of the most complex and stressful professions since it protects the lives and property of people. Due to the complexity of the scope of work, the demands placed on firefighters when they are accepted into the service and during their work in the service are also extremely high. The requirements for admission to the service of fire departments are reflected in the Law on Fire Department [2].
In firefighting, as well as in other areas of human activities where a person performs various complex activities, the person - the firefighter - is the most important factor for the success of a fire intervention. Important aspects that influence the effectiveness of firefighters in firefighting are certainly firefighting equipment, technique, and tactics. However, if the firefighter is not sufficiently psychophysically prepared, motivated, and trained, the outcome of the firefighting intervention is very uncertain.
To establish correct interpersonal relations, first of all, one must know how to communicate. The level of the quality of work, professional training, teamwork, the possibility of continuing training, and the working atmosphere depend to a large extent on internal communication.

2. KEY SEGMENTS FOR IMPROVING THE QUALITY OF RELATIONSHIPS WITHIN THE FIREFIGHTING PROFESSION

2.1. Individual psychological support system

The work of firefighters at the scene of intervention is always extremely urgent, and sometimes the lack of time has devastating consequences for the victims who were not saved. Due to such and similar circumstances, the job of a firefighter can be considered one of the most stressful jobs today. There is little interest on the part of the authorities in the mental health of firefighters and a lack of research on the subject [4]. It is common knowledge for firefighters and people that their work is highly stressful [5]. Psychological support is an indispensable, equally valuable, and significant segment of care for the members of fire departments. It consists of understanding, listening, and presence. The goal of systematic individual psychological support is emotional well-being, self-esteem, acceptance of workplace outcomes, and maintaining good relationships with superiors and other team members. Through systematic individual support, The firefighters want to get to know the problems faced by fire brigade members during work, help them feel safe and protected with all their rights, and have their lives under control.

2.2. Relationship with superiors/colleagues

Leadership is often equated with the term of management. A manager is an individual who performs traditional administrative tasks, such as planning, organizing and controlling, and a leader is a person who, in addition to fulfilling an administrative function, can motivate and inspire subordinates at the same time in order to help the organization fulfill its full potential. When it comes to the members of the fire department and their relationships with their superiors, management is specific since it is a question of work tasks concerning the safety and protection of people, and a high level of mutual respect, trust, encouragement, and acceptance is extremely necessary. All three parties (superiors, members of the fire brigade, and colleagues) must be able to find ways to communicate properly, but they must also and without hesitation ask for any form of psychological help. In view of the very frequent interventions, earthquakes, and floods that occur in Croatia, deliberations and initiatives are being initiated regarding the introduction of workshops in the form of psychotherapy for firefighters. It is important that the information is understood in the process of communication. Successful communication implies that the information is accurately received in terms of content and the meaning determined by the sender. The concept of successful communication focuses on the difference between data and information [3]. Timeliness means that information should arrive when it is needed.
The key segments of improving the quality of relations within the firefighting profession can be different: mutual agreements, joint division of work during the intervention, mutual assistance outside working hours, training, work meetings, and greater psychological support.

Table 1. Caring/deadly habits

Seven Caring Habits	**Seven Deadly Habits**
Support	Criticizing
Encouragement	Blaming
Listening	Complaining
Acceptance	Complaining
Trust	Threatening
Respect	Punishing
Alignment	Bribing or Rewarding for Control

2.3. Caring habits

The meaning and effectiveness of the caring habits, how to use them and interpret them correctly, as well as the ineffectiveness of the deadly habits, are best explained by reality therapists. This is a form of psychotherapy that many psychologists use in their psychotherapeutic work. Reality therapy interprets how to create a good relationship, and the relationship will not be good if you try to control the other person, i.e. their behavior. The fundamental idea of reality therapy is that, regardless of what happened to us earlier in life, or what we did in the past, we can choose our behavior in the present, the one that will satisfy our needs better than before and improve the quality of our life [6].

3. RESEARCH METHODOLOGY AND RESULTS

Concerning the method of data collection, the process of data processing and analysis, the authors of the paper used a quantitative research methodology. A survey was conducted on members of fire brigades in the territory of the Republic of Croatia in the period from February 9 to March 13, 2023. The survey is the most used data collection technique in social research, particularly suitable for descriptive and causal research [1]. The survey can be conducted by telephone, mail, interview, and, in this case, online. The data collected by the survey is usually analyzed quantitatively, using different statistical procedures, although parts of the survey may contain open-ended questions, the processing of which requires a qualitative approach [1].

3.1. Research results

The research was conducted on 83.5% of male and 16.5% female respondents. Regarding the age structure, the dominating respondents were aged 21-40 (67%), under 20 (1%), and 41-60 (32%). Most of the respondents completed secondary education (68%), followed by those with a higher education (14%) and 11% of the respondents completed a university, while 7% of the respondents had a master's degree.

According to the data obtained, the largest percentage of the respondents perform shift work including night shifts, which can be mentally and physically exhausting.

A high percentage of the respondents work in Public Firefighting Brigades (PFB) (54%), followed by a smaller number of respondents who work in Volunteer Fire Fighters

Associations (VFFA) 30%, 1% of the respondents work in the State Fire Service School. For the variable under other, the respondents indicated that they work in different fire stations, the Ministry of Defence, county firefighting community and other.

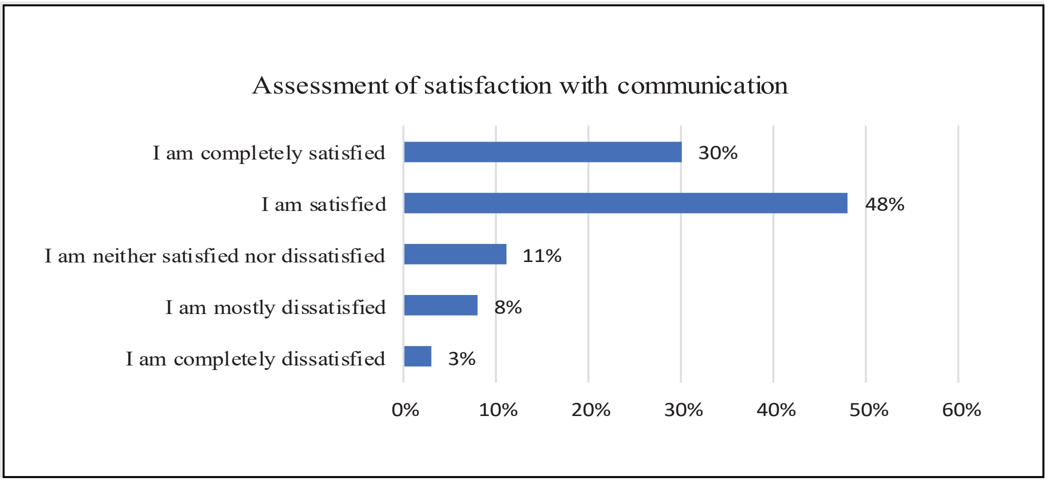


Chart 1. Communication satisfaction with the superiors

The results of the survey (Chart 1) show that the members of the firefighting departments are satisfied with communication with their superiors (48%), and this is crucial for the complete performance of working assignments inside or outside both PFBs or VFFAs.

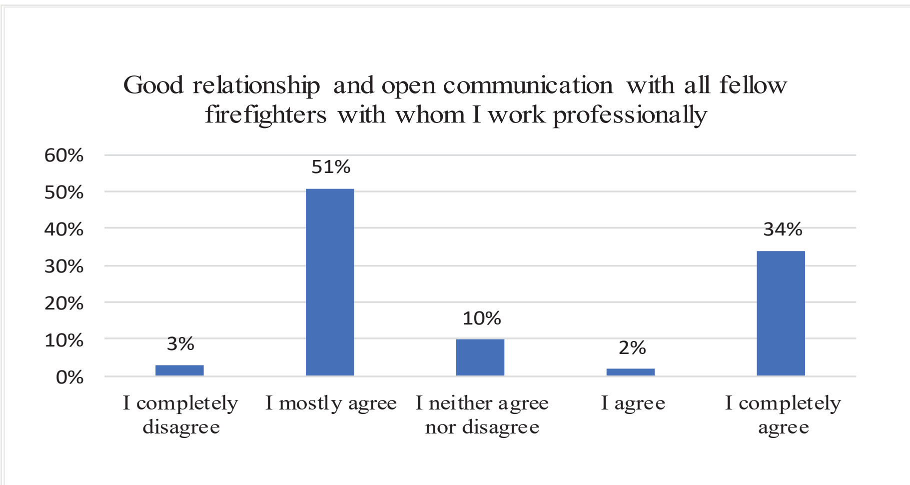


Chart 2. Good relationship and open communication with all colleagues

Having a good relationship with colleagues is crucial, mainly because firefighters are frequently exposed to risks. Over half of the respondents (51 %) agreed they had a good relationship and open communication with all of their colleagues.

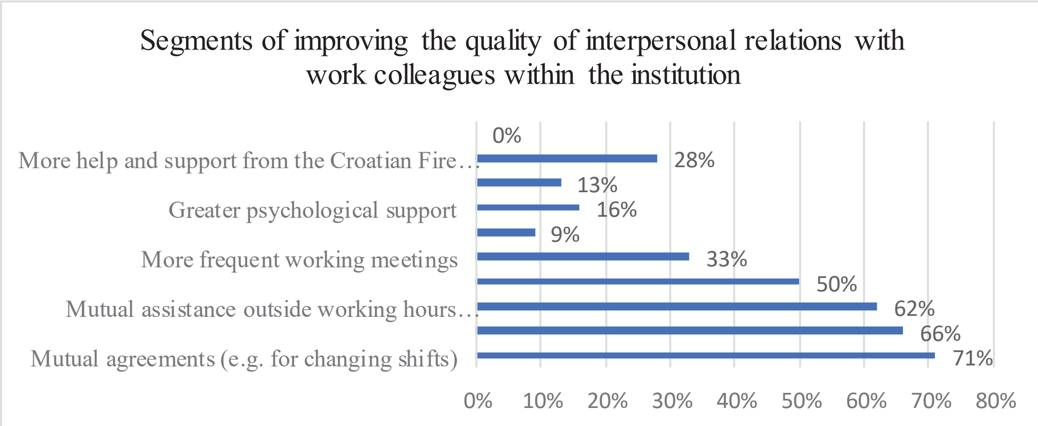


Chart 3. Segments of improving the quality of interpersonal relations with work colleagues

The results of the survey showed that out of the offered answers, interpersonal relations (71 %) are crucial for improving the quality of interpersonal relations followed by mutual helping outside the working hours (66 %).

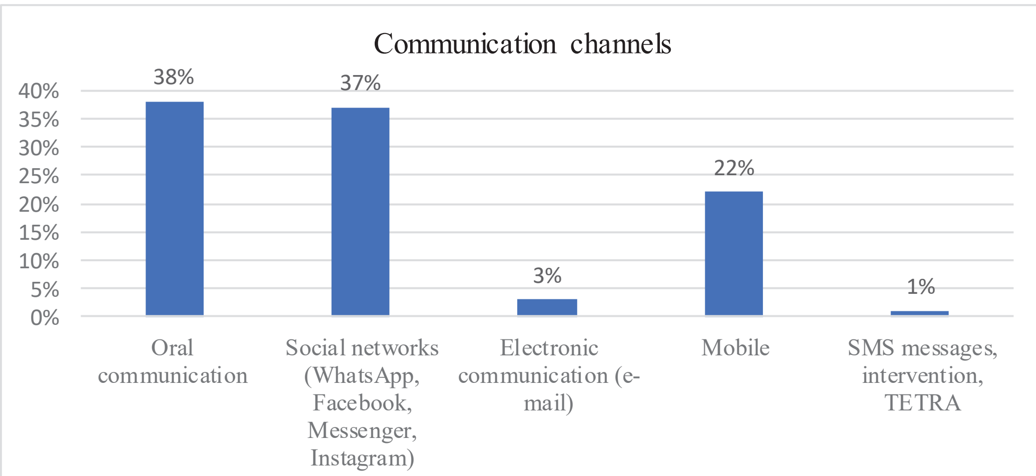


Chart 4. Communication channels

Verbal communication proved to be the most important communication channel for 38 % of the respondents, 37 % respondents agree that social networks and apps, such as Facebook Messenger or WhatsApp are an important communication tool, and 3 % of the respondents agree that e-mail communication is an important communication channel. Besides the mentioned channels, 22 % of the respondents indicated mobile phone calls and 1% of them indicated SMS, interventions, and TETRA under *Other*.

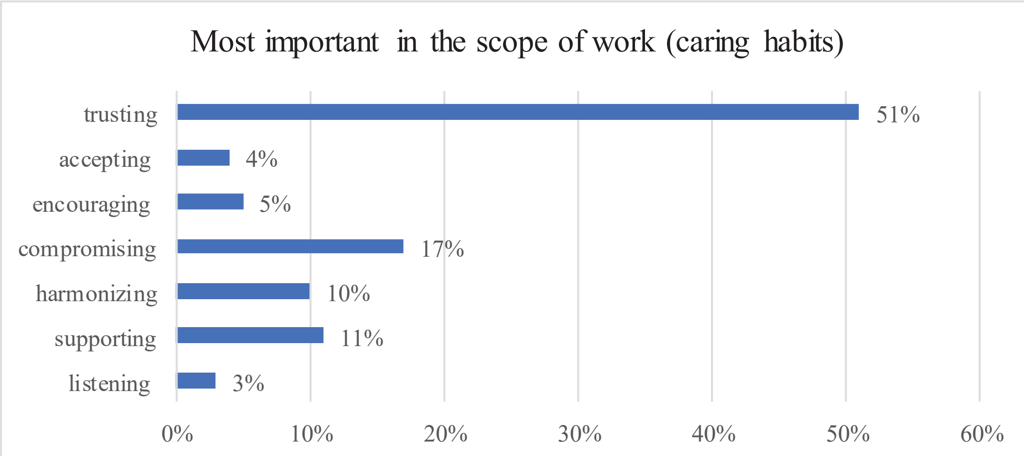


Chart 5. The most important segment in terms of caring habits

Trust is the most important segment regarding work when it comes to caring habits (51 % of the respondents), and listening is the least important (3 %).

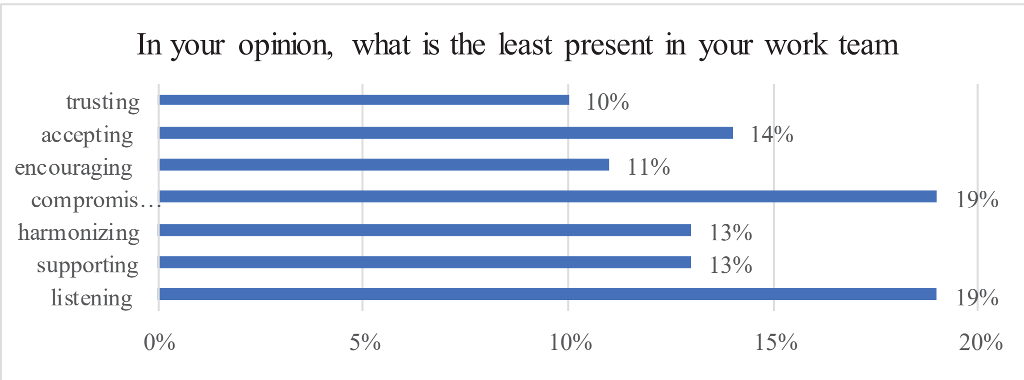


Chart 6. Determining what is least represented in the scope of firefighters' work

The one segment, that is the least present amongst the members of the fire brigades, is compromise and listening according to 19 % of the respondents. Therefore, it can be concluded that this segment is eligible for further progress and improvement in the future.

4. CONCLUSION

Being a member of a fire department is an extremely stressful occupation that requires continuous learning and acquisition of new knowledge. It is crucial how and in what way to communicate with superiors and colleagues. The research results showed that the most important caring habit is trust. In addition, members of the fire brigades believe that successful management of interventions is one of the key successes in developing caring habits and interpersonal relationships. At the same time, experts in the field of psychology encourage awareness of the need for continuous workshops in the form of reality therapy for members of fire departments. According to the conducted survey on the importance of interpersonal relationships and systematic work on them, they are of great importance for the successful implementation of firefighting interventions, but also for the psychophysical health of members of the firefighting units. Working with colleagues in a shift means staying together during all 12 hours of the shift. During this period, colleagues bond, communicate, discuss, and debate. In all these situations, the shift leadership plays a key role, i.e. the commander or leader, who acts as a mediator, motivator, and initiator of every important situation within the collective. Going through stressful situations together additionally contributes to bringing the team members closer together. Socializing outside of working hours is also of great importance for the healthy and productive functioning of the team. Such get-togethers are ideal for team members to get to know each other, which enables the recognition of personal weaknesses and virtues and building mutual trust. The advantage of knowing the weaknesses and strengths of the team members results in the efficient deployment of personnel where they can give their best in order to implement the intervention as efficiently as possible. Trust among team members provides security for the successful execution of tasks, as well as the resolution of crises in which human lives are often at risk. In the future, it is necessary to conduct longitudinal research to show the importance of communication in interpersonal relationships, which is crucial for the successful implementation of interventions.

LITERATURA

[1] Tkalac Verčić, A.; Sinčić Corić, D. i Pološki Vokić, N.: Priručnik za metodologiju istraživačkog rada, M.E.P., Zagreb,2010.
[2] Zakon o vatrogastvu (NN 114/22)
[3] Rouse, J. i Rouse, S.: Poslovne komunikacije – kulturološki i strateški pristup, Masmedia, Zagreb, 1.izdanje ur., Zagreb: Masmedia, 2005., ISBN:9531574596
[4] Pavlić, M.: "Stres kod profesionalnih vatrogasaca – istraživanje na djelatnicima Javne vatrogasne postrojbe Grada Zagreba", *Vatrogastvo i upravljanje požarima*, vol.II., br. 1., str. 4-12, 2012. [Online]. Available at: https://hrcak.srce.hr/103616. [Accessed: 08.05.2024.]
[5] Šimić, Z.: "Psihološka potpora vatrogasaca na strateškoj, taktičkoj i operativnoj razini vođenja i zapovijedanja", Vatrogastvo i upravljanje požarima, vol.III., 2013. br. 2., str. 4-13, [Online]. Available at: https://hrcak.srce.hr/112991. [Accessed: 08.05.2024.]
[6] Glasser, W.: Realitetna terapija u primjeni, Alinea, Zagreb, 2001., ISBN 953-180-096-0

9

MULTIDISCIPLINARY ASPECTS

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

ORGANIZATIONAL MAINTENANCE SYSTEM IN THE FUNCTION OF OCCUPATIONAL SAFETY AND HEALTH PROTECTION

Sarajko Baksa[1], Misel Mihalić[2], Ines Baksa[3]

[1] Međimurje University of Applied Sciences in Čakovec, Bana Josipa Jelačića 22a, Čakovec, Croatia, sarajko_baksa@yahoo.com

[2] Međimurje University of Applied Sciences in Čakovec, Bana Josipa Jelačića 22a, Čakovec, Croatia, misel.mihalic@student.mev.hr

[3] University of Applied Sciences in Security and Safety, Veslačka 2a, Zagreb, Croatia, ines_baksa@yahoo.com

Abstract: *From the maintenance point of view within the production facilities, maintenance is a key function which ensures that equipment, machines, and systems be in the optimum condition, in order to secure continuous production and minimized costs of repairs as its primary function that is attributed to work and health protection with the production system, therefore it positions a man in a function as a worker. Authors who carried out this research indicate that harmony, on the face of it is diametrically opposite, organizational system maintenance of work and health protection of employees on working places that results in synergistic effect in terms of increase productivity, and ultimately results in total increasing of quality of work of employee and quality, in both technical and technological segment, in the form of materially - financially assessment. When maintaining management of the above-mentioned processes it is necessary to realize them and to carry out on efficient and organized way, on the way like is shown in this work, on example of featuring functioning process maintenance within the realistic production line, and in accordance to norm ISO 9001 guidelines.*

Keywords: *maintenance, work protection, health protection, ISO 9001*

1. INTRODUCTION

Maintenance can be conceivably defined as a set of activities directed on preservation, repair, upgrade, or support for functioning of some object, system, or process in order to secure it long lasting, and efficient use. This includes regularly checking, cleaning, lubrication, repairs, replacements of parts, and promotion and improvement of the system or the object, in order to maintain or improve their functionality, security, and reliability. It was found that maintenance can be preventive (it focused on prevention of malfunctions), corrective (repair of malfunctions once they happens), or planned (systematic planning of maintenance regarding optimization of efficiency and reduction of expenses).

Occupational Health (OH) and Safety on Work (SoW) are key management aspects of working environment that aim for to ensure safety, health, and welfare of workers. Work protection refers to gathering of measures, rules and procedures that are applied to prevent accidents, injuries, and dangers on the work place. That includes risk assessment, training of employees, use of protective equipment, maintenance of work equipment and implementation of security policies [1].

2. ORGANIZATIONAL MAINTENANCE SYSTEM

From the principles of organizational system of maintenance, it is chiefly expected that machines, devices and working equipment have less breakdowns, that in general there is none of production process and the time spent on duration of repairs, and if they occurred, to be enormously short [2].

2.1. Goals and functions of system maintenance

Goals and functions of system maintenance within production facilities are;

- To insure optimal availability of acquired and installed equipment in production companies with less expenses,
- Realization of minimum costs of maintenance failures caused by unplanned failures that can lead to losses in production,
- To slow down of the obsolescence of the working system which represents a consequence in reduction of products qualities and appearance of scrap,
- Monitor the system operation, and to propose and carry out of system's modernization and modifications for the gaining the goal of improvements of working characteristic and extension of life of the equipment,
- Monitor impact of the equipment on environ., to find and eliminate weak spots,
- With correct and timely maintenance to achieve long life exploitation, and
- Maintenance in production facilities plays key role in providing efficiency, reliability, and security of the production processes [2].

2.2. Tasks and methods of the system of maintenance

Task of maintenance services is the maintenance of working gears in the production state. In addition, this work unit in the frame of the company performs improvements of work tools or changes of their functions, it creates a new working tool and takes care of the supply of energy sources. Depending on the type and the size of the company, about the type of machinery and facility which should be maintained there is requirements also with regards on a degree of automation and qualification structure of maintenance workers. Service maintenance can be organized as: a) Central maintenance, b) Individual maintenance, c) Combined maintenance, and d) Cooperative maintenance [3].

Every company strive to operate with the less stoppages in production as lower as possible and with lower expenses. Economy and quality maintenance depend on the choice of the very type of maintenance that it is based on five maintenance methods: 1. Corrective maintenance–repairing of tools of work after the origin of the malfunction appears, 2. Opportunistic maintenance-after initial malfunctions are introduced periodical examinations, 3. Preventive maintenance - this principle is based on the saying "better prevent than treat", and with regular examinations and repairs according to calendar we have as a goal prevention of origin of failure, 4. Predicted maintenance - is reported on predictable time of origin of malfunction and reacts just before the critical moment, 5. Maintenance according to condition-constantly tracking of machine condition and reacting according to the needs [4].

3. IMPACT OF OH AND SoW ON MAINTENANCE ACTIVITIES

Considering that recent maintenance have role of identifier in prevention and prediction of dangers, the obtained results confirm that organizational systems strive to offer information which can be efficiently use in systems based on risks decision to determine priority plans of maintenance, management of changes and suggesting the need for introduction of the new security measures in operation and maintenance, as a foundation for the strategic use of opportunistic actions during maintenance process. When they are considered, high levels of planning in maintenance, where there is a systematization of activities and assessment of fundamental causes of accident during repairs, or even those that are caused by irregular activities of maintenance, there is the comprehension that any of the minor local deviation could be multiplied, what will result in serious accidents and economic losses.

As can be seen on Figure 1, these arguments discover that production focused on safety and reliability establish important relationship between management of property, maintenance, and security, while those focused on performance still see safety exclusively as a cost. Maintenance operations can be completely or partially left to external contractors or subcontractors. Considering on operational levels of maintenance, which implements contractor, maintenance must be integrated into the current activities of companies to ensure health and safety of all included workers. On Figure 2 is shown influence of these activities on organizational system maintenance planning [5].

Figure 1. *Interactions of maintenance functions in the company.*

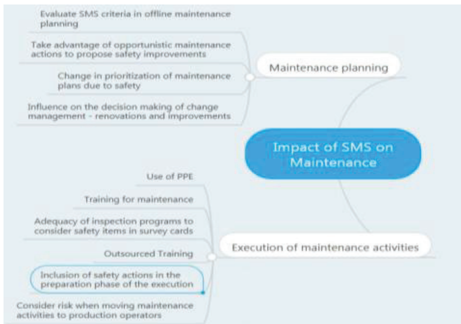


Figure 2. *Influence of security and health at work on maintenance elements.*

Causes of accident during maintenance are usually grouped into active errors and latent states, such as human actions, technically and structural factors of work places, and organizational factors like administration and supervision. Risk model assessment shows on levels of maintenance important elements about which we should take care in the course of the management assessed estimations, with management of work and protect of worker's health. Those elements mainly include; corrective and preventive organizational maintenance systems, changes, tasks, engineering orders, inspection programs, planning and performance of works maintenance, reporting, and technical and technological analysis [5]. Quality management system, often called QMS, is a set of documented procedures, and records. This collection of documentation defines set of internal rules which will prescribe how company makes and delivers product or service to the customer. Quality management system must be adapted to the company needs, and accompanied with ISO 9001 norm that provides guidelines of security applications is necessary for a successful QMS [6].

In context of the process requirements for maintenance, in accordance to the norm ISO 9001, the norm requires guidance maintenance records. That includes documentation plans of maintenance, record of performed maintenance activities, results of the inspection, repair or replacement of parts, and any kind of connected problems or irregularities. Within Figure 3 is given permissible insight into representation of investigated and implemented methods of organization of maintenance of the machinery park industrial plants Bloom Technologies Ltd., in accordance to adopted norm guidelines series ISO 9001; 2015.

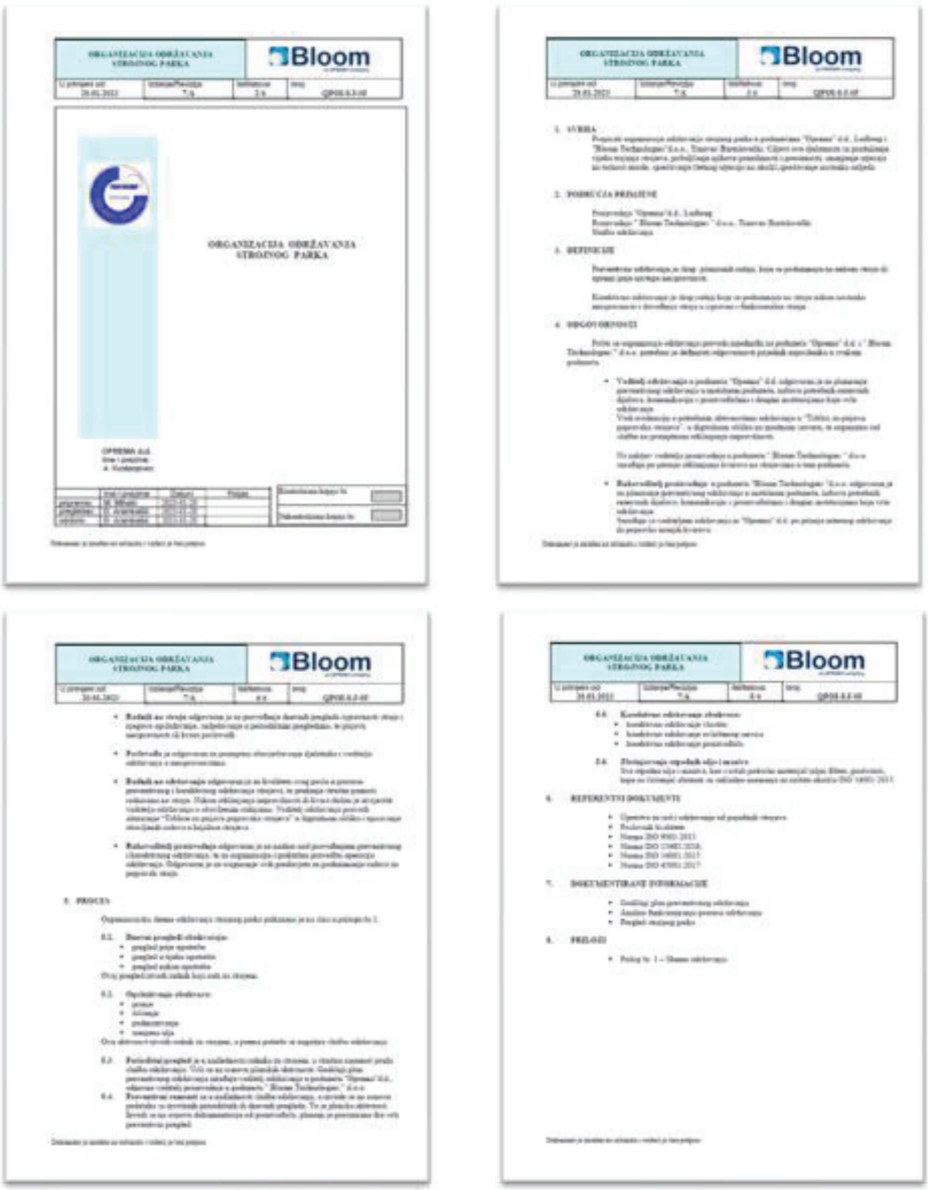


Figure 3: Organization of machinery park maintenance ISO 9001; 2015.

Conservation and improvement of working conditions within production plants, considering on material part of equipment and facilities is the responsibility of maintenance. Maintenance of installed security system; temperature, humidity, lights, and ventilation conditions; conditions of use of equipment and the usage of the whole structure which comprises a working environment. These factors demand keeping in line with the security legislation and norms to prevent them from accidents as the results of bad conditions to which the workers could be exposed.

Optimal organizational maintenance system must consider combination between different parameters of maintenance of operation, like the position of components which they need repair, losses due to downtime, minimal repair costs, preventive and corrective maintenance costs, and risk of malfunctions. Latter includes safety concept, since when the assessment risks is done are also considered consequences for people and the environment [5].

Following to the above, within Table 1 day is given tabular display of Reviews of realized expenses stemming from cost of maintenance elaborated, according to production machines for 2023, and within Tables 2 is given permissible insight into tabular display of an Annual preventive plan maintenance, elaborated according to production machines and devices, for company Bloom Technologies Ltd. in 2024.

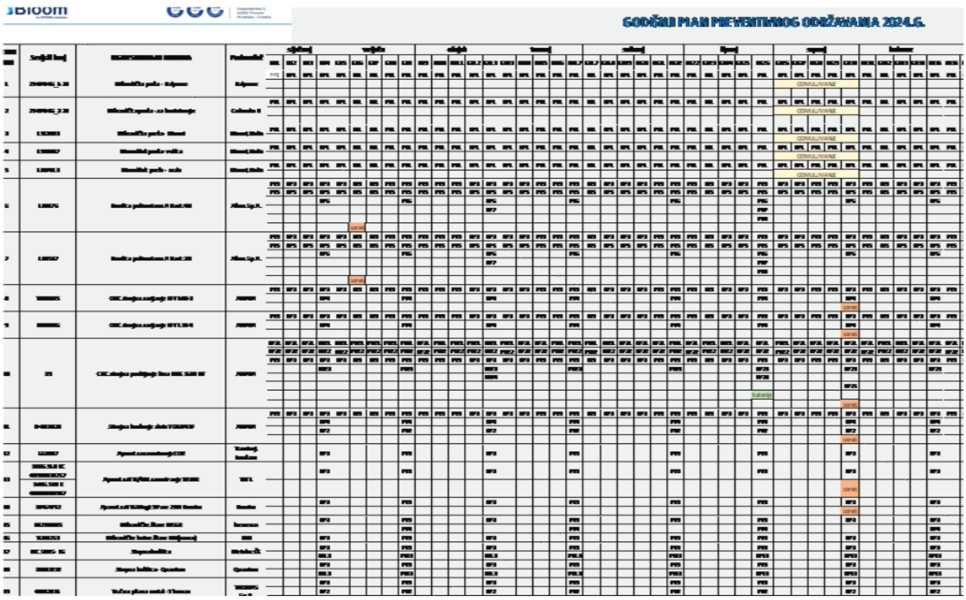
Table 1: Review of maintenance expenses per machine for 2023.

Analiza funkcioniranja procesa održavanja 2023.g.

NAPOMENA: U analizu je za svaki popravak prikazano utrošeno vrijeme na radovima, vrijeme zastoja uzrokovanog kvarom i trošak servisa ili popravka.

Naziv stroja	Kratki opis radova na opremi	Utrošeno vrijeme na radovima održavanja [h]	Trajanje zastoja u proizvodnji uzrokovanog kvarom [h]	Trošak servisa i rez. dijelova [kn]	Ukupni trošak servisa i rezervnih dijelova po stroju [kn]
Viličar SAMUK	popravak hidraulike	6		682,21 €	828,84 €
	servis viličara	4		146,63 €	
Viličar STILL	servis	3		139,75 €	139,75 €
Viličar TOYOTA	servis	6		174,88 €	294,88 €
	praćenje viličara			120,00 €	
AMADA EMK 3610 NT	service assistance			1.800,00 €	1.946,40 €
	dijelovi			146,40 €	
Tig aparat MAGIC WAVE	elektrode			48,98 €	65,57 €
				16,59 €	
Panel preše	crijeva			97,25 €	97,25 €
Monoblok preše	hidraulična crijeva			211,93 €	211,93 €
GALILEO	servis	16		9.303,44 €	9.303,44 €
ECOTEC	servis i rezervni dijelovi	8		2.137,00 €	2.137,00 €
Vijčani kompresor BOGE	servis sa zamjenskim dijelovima	6		2.968,03 €	4.299,81 €
	montaža sušača s dijelovima	6		1.331,78 €	
Perač poda KARCHER	zamjenski dijelovi			41,94 €	41,94 €
Plinski bojler BOSCH	servis	2		150,00 €	150,00 €
Stroj za skidanje izolacije KOMAX	set rezača			400,00 €	400,00 €
	set valjaka i skidač izolacije				
Horman vrata	servis			1.077,00 €	1.077,00 €
Ostalo	servis kamera			120,00 €	5.371,38 €
	nova guma za linije			1.392,00 €	
	priključci za propan			62,50 €	
	struja pogon			3.796,88 €	
UKUPNO		Utošeno vrijeme na radovima održavanja [h]	Trajanje zastoja u proizvodnji uzrokovanog kvarom [h]	TROŠAK SERVISA I REZ.DIJELOVA	UKUPNO
		57	0	26.365,19 €	**26.365,19 €**

Table 2: Annual preventive maintenance plan per machine for 2024.



4. CONCLUSION

As with this conducted research has shown, it was found that security of people in significant measures depends on the quality of machinery and devices maintenance, especially in context when analyzed factors in the dominant measures can make an effect on safety and health of people at work, therefore it is exceptionally important to continuously plans and implements maintenance to avoid potential risks threaten within production facilities. Established indicators point to organizational systems of maintenance that provide reliability and success easier when included in the management segment that questions security and health on work; with proactive behavior and with high level of interpersonal and intra-organizational communications, as well as maintained the way of thinking that values guided prevention initiatives. Here, the emphasis was put on importance of engineering knowledge and experiences to ensure continuously process for prevention accidents and necessary improvements.

REFERENCES

[1] Pavlović, M.: *Zaštita na radu*, Vel. u Rijeci, ISBN: 978-953-7177-28-7, Zagreb, (2009)
[2] Lisjak, D.: *Prezentacije, Nastavni materijal, Održavanje*, Ver. 17.10.2012., Zavod za industrijsko inženjerstvo, Sveučilište u Zagrebu, FSB
[3] Mijović, B.: *Održavanje strojeva i uređaja*, Veleučilište u Karlovcu, ISBN 978-953-7343-74-3, Karlovac, (2019)
[4] Lean Factories: *TPM Pillars—Eight Pillars of Total Productive Maintenance*, https://leanfactories.com/tpm-pillars-eight-pillars-of-total-productive-maintenance, 2024-03-24
[5] Fabiano, C.M.; Dalcanton, F.; Maria, C.S.; Salete V.S.; Aparecida, P.G.: Main. occupat. health and safety, *Gestão & Produção*, 27(2), e3922, (2020), pp. 1-17, ISSN 0104-530X
[6] Advisera: Što je ISO 9001?, Advisera Expert Solutions Ltd. 2024. *Available from*; https://advisera.com/9001academy/hr/sto-je-iso-9001/, *Accessed:* 2024-04-18

IMPACT OF THE FOURTH INDUSTRIAL REVOLUTION ON DEVELOPMENT OF PERSONAL PROTECTIVE EQUIPMENT

Marija Batak [1], Andreja Cesar Slegovac [2], Sanela Paskaš Dlugoš[3]

[1]HZJZ, R. Cimermana 64a, 10020 - Zagreb, Hrvatska, marija.batak@hzjz.hr
[2]HZJZ, R. Cimermana 64a, 10020 - Zagreb, Hrvatska, andreja.cesar-slegovac@hzjz.hr
[3]HZJZ, R. Cimermana 64a, 10020 - Zagreb, Hrvatska, sanela.paskas-dlugos@hzjz.hr

Abstract:
Every work activity implies risks for the safety and health of workers involved in work process. Development of technology and implementation of technological progress changes work processes as well as associated risks.
The goal of technological progress is not only to improve industrial production but also to achieve safe working environment.
One of the measures for elimination or reduction of risks is application of personal protective equipment (PPE). Technological progress brings a series of innovations and changes in this area. This paper will describe evolution of personal protective equipment throughout history and influence of The Fourth Industrial Revolution on the development of smart personal protective equipment.

Keywords: *technological progress 1, personal protective equipment 2, work safety 3.*

1. INTRODUCTION

Risks to safety and health of workers is present in every work process. The employer is obliged to provide workers with a safe working environment based on legal regulations. In order to achieve this, appropriate protection measures are at employer's disposal, which must be implemented according to the hierarchy of efficiency from technical and organizational measures to personal protective equipment. When implemented technical and organizational measures do not provide adequate protection, employers must, as a last resort, provide appropriate personal protective equipment for their workers and ensure that they use it.

Personal protective equipment is equipment that workers use at work and is intended to protect against specific work-related risks. Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment defines personal protective equipment (EU Regulation 2016/425) as [1]:

a) equipment designed and manufactured to be worn or held by a person for protection against one or more risks to that person's health or safety;
b) interchangeable components for equipment referred to in point (a) which are essential for its protective function;
c) connexion systems for equipment referred to in point (a) that are not held or worn by a person, that are designed to connect that equipment to an external device or to a

reliable anchorage point, that are not designed to be permanently fixed and that do not require fastening works before use.

Equipment that is placed on the market under the title of personal protective equipment (PPE) is subject to a series of legal regulations. EU Regulation 2016/425 refers to the design, production and marking of personal protective equipment. It defines legal requirements to ensure that PPE available at the European Union (EU) market provides the highest level of protection against possible risks. The CE mark is an integral part of personal protective equipment and proof of product compliance with current EU legislation [2]. Manufacturers, when placing their equipment on the EU market must comply with safety and health requirements according to European norms. Norms define guidance on how to meet the specific requirements of PPE for the purposes of general well-being, health and safety. Such requirements ensure compliance of PPE and standardize protection against specific risks.

Personal protective equipment must be selected to protect the worker from health and safety risks detected at workplace. Those risks should be defined in risk assessment document.

2. HISTORY OF PERSONAL PROTECTIVE EQUIPMENT

Throughout history, many technological inventions have been developed due to needs of the military industry and have found their application in other industries. The same is true for personal protective equipment. The history of personal protective equipment can be linked to the protective equipment soldiers used in fight back in antiquity. One example is body armor found near Mikena, Greece, in 15. c. B.C., which is the oldest preserved bronze armor made of folded panels, a proper personal protective equipment. In addition to the armor, the soldiers used headwear and face coverings to protect themselves against the enemy. Similar principles of protection continued their application over different periods accompanied by improvements due to technological progress. Protective equipment has come a long way, followed by development of civilizations and every technological revolution has contributed to the improvement of equipment [3]. Thorough history emergence and use of PPE went hand by hand with awareness of the potential risks. By performing different activities, people created different forms of protection. Often, use of protective equipment was considered optional and there was no legal basis to make the use of protective equipment mandatory. The invention of the steam engine at the end of 18. c. and the beginning of 19. c. influenced the development of factories, increasing numbers of people employed in factories. The beginning of The Industrial Revolution carried many unknowns and dangers that no one thought about. Hazardous working conditions and working longer than twelve hours a day, had contributed to frequent accidents and deaths at workplaces. Such events raised awareness and prompt adoption of The Law on factories and factory inspectors [4]. In mid-20. c., in many countries, awareness on safer working conditions was raised. Institutions for adoption, implementation of legal regulations and overseeing safe working conditions have been established. In The Republic of Croatia, occupational safety has been implemented since 1960., by the Act on Occupational Safety adopted at the federal level of former Yugoslavia at the time. Later, independent Republic of Croatia took over the existing regulations and developed new laws and regulations [5]. Today's safety at work legislation in Croatia is based on European regulations aimed at ensuring the safety and health of workers.

Technological progress, which has been intensified in recent decades, has conditioned changes in regulatory design. Occupational safety is a system that needs to adapt to new knowledge, technologies and needs of workers and employers.

3. WEARABLE TECHNOLOGIES

New digital technologies have been developing rapidly over the past two decades. Technological development influenced by digital technologies affects many areas, including occupational safety. In the field of security, digital technology has mainly a monitoring function, all with the aim of ensuring safety at the workplace. Monitoring is carried out using different technologies. One way is by connecting electronic components with other technologies, ensuring exchange of data via the internet. This method of connecting electronic components is called Internet of things (IoT). Introducing IoT's common network of connected devices, enables real-time monitoring of different parameters at the workplace. One form of monitoring workplace parameters is the installation of characteristic electronic components/sensors on existing personal protective equipment. The purpose of the modification is to design PPE that will monitor the condition and physiological parameters of workers, all with the aim of taking timely actions in the prevention of undesirable events. Technology where electronic components/sensors are embedded in personal protective equipment is called the Wearable Internet of things (WIoT) - wearable technologies, as well as, smart PPE [6].

4. MODIFICATION OF PERSONAL PROTECTIVE EQUIPMENT

4.1. Equipment for working at height

Personal protective equipment for working at heights consists of a number of different components which must be adapted to each specific workplace. Components must be dimensioned in a way to ensure the mobility of the worker but in the same time, if fall does occur, keep the worker in suspension. The basic components of personal protective equipment for working at heights are: whole body belts, ropes, connecting straps, connectors, fall arrester – absorbers, retractable/fall arrest devices and other elements.

Implementation of new technologies in existing PPE introduces a proactive approach to predicting and controlling the risk of falling from a height. Two key approaches are sensor-based surveillance and computer vision-based surveillance. The first mode enables the analysis of signals from equipment, body movements and physiological condition of construction workers. A computer-based approach facilitates the analysis of visuals (e.g. images and videos) to collect data on locations, distances, and movement at the workplace [7]. Figure 1. shows an example of a fall protection system with implemented sensors for detecting correct connection of equipment components and sensors for monitoring movement in a safe work area. Sensors are electronic components that monitor risk factors and if a defined level of risk is detected, the information is sent wirelessly (via Bluetooth) to the local database of a smartphone or smart watch. The application software automatically processes the data and forwards the information to the surveillance system via a wireless Internet network (Wi-Fi). The fall arrest rope is fitted with a sensor (B0), which, in combination with the sensor on the worker's belt (R), monitors worker's distance from the anchor point. When the estimated distance between worker and fall arrest rope is less than the specified distance, the harness can be considered correctly connected to the worker. Otherwise, wearable equipment sensors will send information about improperly installed fall arrest equipment.

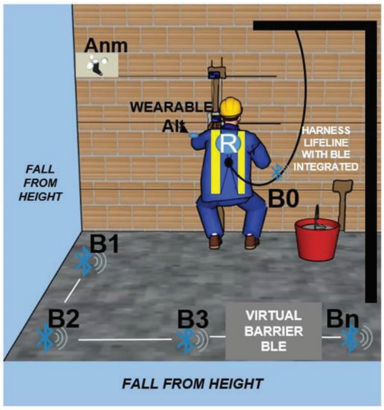


Figure 1. Surveillance system with sensors and wearable technologies

The second mode of supervision follows the movement of workers in the work environment. Sensors (B1-B2-B3-BN) are installed on the edge parts of the work surface to monitor the movement of the worker and detect his position. If the worker enters in dangerous areas during work, the sensors will register that and warn the worker, as well as the person in charge of occupational safety. In this way, a person in charge through the information collected via sensors has an insight into the current situation at work site and can take appropriate actions in the form of additional education and training of workers. From this example it's evident that the smart PPE is working on the principle of active monitoring and aims to ensure higher levels of safety in increased risk work activates.

4.2 Protective helmets

Protective helmets are essential equipment in head injuries protection. The Fourth Industrial revolution has transformed passive protection of protective helmet, into an active one. Sensors and cameras are installed in protective helmets with intention to warn workers of possible danger in their environment. Types of sensors can vary depending on the risks in work environment. The most commonly installed are sensors for detection of dangerous gases, humidity, temperature, illumination level and sensors that warn the worker on objects above his head he could hit. If the sensors detect deviations, information will be sent to the mobile device via Bluetooth. Mobile phone software collects information in phone data base and via Wi-Fi, forwards them to data processing software to be analyzed. Figure 2. shows an example of a smart helmet.

Figure 2. Protective helmet SmartHat

Depending on the requirements, helmet can be equipped with radio connection, which enables communicate between workers. Helmets can have built-in emergency switch that a worker can activate in case of danger. This will send wireless signal and activate flashing lights, instantly alarming everyone in worksite environment that some deviation has occurred [8]. The development of protective helmets is in full swing. A wide area of monitoring different parameters in specific industries will make protective helmets difficult to standardize.

4.3 Protective Gloves

Fingers are most frequently injured part of the body which shows how important protective gloves are. The Fourth Industrial Revolution is based on handling equipment with screens. Many industrial plants have implemented electronic equipment controlled by touch screens in their production processes. This requires gloves that are compatible with the touch screens and have antistatic properties. Gloves need to be as thin as second skin to conform with demand for high tactile sensibility and at the same time provide protection against cuts. [9]. The installation of electronic components in protective gloves is particularly challenging. Firefighter gloves are an example of equipment that must fulfill a wide protection range against heat, moisture, flames, sharp objects, etc., while providing good tactile properties. Protective gloves for firefighters in Figure 3. are made from high-tech materials resistant to thermal radiation. Gloves are equipped with a temperature sensor for measuring ambient temperature and IR sensor whit laser pointer for measuring radiation temperature. Installed LED light graph bar displays green, orange and red light to indicate a measured temperature range [10].

Figure 3. Protective gloves for firefighters whit implemented sensors

Thanks to the integrated electronics and sensors, the firefighter has the ability to see the temperatures in his immediate vicinity. In this way, he can perceive his environment more consciously and take necessary actions [11].

5. CONCLUSION

The application of wearable technology in personal protective equipment offers great potential, but also presents many challenges. Electronic components that are installed in the equipment must be light and of small dimensions so that their weight and position do not present aggravating circumstances for the worker. In order for the components to perform their function, they must have a suitable power source (battery), the size of which ultimately affects the overall weight of the equipment, but also its operating time. Specific working conditions in certain industries, such as construction, where dust, moisture and extreme temperature are present, can affect the performance of electronic components. Wearable technologies use wireless networks for data transfer, what opens up the possibility of information interception and hacker attacks [12]. An important issue arises concerning privacy and data confidentiality, especially regarding location tracking of workers. All data collected must comply with Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016. on the protection of natural persons with regard to the processing of personal data and on the free movement of such data [13]. Workers must be informed about what data is collected for what purpose and with what end result. Constant supervision can cause stress and anxiety in some people, which can lead to negative consequences on worker's health [12].

Placing PPE on the EU market is regulated by the EU Regulation 2016/425 on personal protective equipment and it is implied that the equipment is tested and certified. The main obstacle to placing smart PPE on the market is current lack of testing methods for these products in relation to EU Regulation 2016/425. [14].

The implementation of wearable technologies in PPE can contribute to higher level of safety at work places. Smart and traditional elements of PPE must work well together and not interfere with each other, to ensure best protection without reducing protective properties or causing new risks for the worker. It is important not to fall under the false sense of security technology can create. Workers must be aware that technology can be very helpful, but also it can have its flaws. Like with any technological development, the time will show all good and bad sides of The Fourth Industrial Revolution.

REFERENCES

[1] Official Journal of the European Union, Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment defines personal protective equipment; 31.3.2016., *Available from* https://eur-lex.europa.eu/legal-content/HR/TXT/PDF/?uri=CELEX:32016R0425 *Accessed*:2024-05-05

[2] European Commission, Personal protective equipment (PPE), https://single-market-economy.ec.europa.eu/sectors/mechanical-engineering/personal-protective-equipment-ppe_en *Accessed*:2024-05-05

[3] Risteski, S.; Srebrenkoska, V.: *Appearance of protective clothing over the centuries*; (January 2020)., *Available from* https://www.researchgate.net/publication/348291036_Appearance_of_protective_clothing_over_the_centuries *Accessed*:2024-05-05

[4] Conti L., Easton M., Carrodus G., Wilson J.*: Oxford Big Ideas Humanities & Social Sciences (WA Curriculum) - Year 9, Chapter-8-The-Industrial-Revolution,* Oxford University Press, ISBN:9780190307660, Melburne, Australia, (2017)

[5] Povijest Zakona o zaštiti na radu u Hrvatskoj – od SFRJ do danas – Blog o ZNR - 7. (July 2023), *Available from* https://anparo.hr/blog-o-znr/povijest-zakona-o-zastiti-na-radu-u-hrvatskoj-od-sfrj-do-danas/ *Accessed*:2024-05-05

[6] Adjiski V.; Despodov Z.; Mirakovski D.; Serafimovski D.: *System architecture to bring smart personal protective equipment wearables and sensors to transform safety at work in the underground mining industry*, The Mining-Geology-Petroleum Engineering Bulletin, UDC: 622.8 DOI: 10.17794/rgn. 2019.1.4

[7] Rey-Merchán M., López-Arquillos A., Soto-Hidalgo J. M.: *Prevention of Falls from Heights in Construction Using an IoT System Based on Fuzzy Markup Language and JFML,* Appl. Sci. 2022, 12(12), *Available from* https://www.mdpi.com/2076-3417/12/12/6057 *Accessed*:2024-04-20

[8] VIDI, I.S.: *SmartHat je najpametnija kaciga za građevinarce*, 03.12.2023. https://www.vidi.hr/Pop-Tech/SmartHat-je-najpametnija-kaciga-za-gradevinarce *Accessed*:2024-04-17

[9] Pelletier, D.: *Revolitionizing work gloves: High-tech solutions for safety and dexterity*, Thriveworkwear; *Available from* https://thriveworkwear.com/blogs/resources/work-gloves-high-tech-solutions *Accessed*:2024-05-07

[10] Manual SensPro® Protective gloves for firefighters, *Available from* https://www.senspro.cz/download/hi-res/manual-sens-pro_en.pdf *Accessed*:2024-05-07

[11] Science Museum, Health, safety and welfare at work, 10.01.2024., *Available from* https://www.sciencemuseum.org.uk/objects-and-stories/health-safety-and-welfare-work *Accessed*:2024-05-09

[12] Svertoka, E., Saafi, S., Rusu-Casandra, A., Burget, R., Marghescu, I., Hosek, J., & Ometov, A. (2021). *Wearables for Industrial Work Safety: A Survey.* Sensors, 21(11), 3844. doi:10.3390/s21113844, *Available from* https://www.mdpi.com/1424-8220/21/11/3844 *Accessed*:2024-05-07

[13] Official Journal of the European Union, L 119/1, *Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC*,4.5.2016, *Available from* https://eur-lex.europa.eu/eli/reg/2016/679/oj *Accessed*:2024-05-07

[14] Thierbach M: European Agency for Safety and Health at work, *Smart personal protective equipment: intelligent protection for the future*, Discussion paper, 2020. *Available from* https://osha.europa.eu/sites/default/files/Smart_personal_protective_equipment_intelligent_protection_of_the_future.pdf *Accessed*:2024-05-08

SAFETY ADVISER FUNCTION

Iva Čehak
Zagreb, CROATIA, ivacsehak@gmail.com

Abstract:

Each company - whose activities include the consigning of the carriage of dangerous goods by road, rail or inland waterways, or related packing, loading, unloading, loading, filling, or unloading - shall appoint one or more safety advisers. This paper lists/defines the tasks of adviser and highlights the legal frameworks for carrying out activities that include the carriage of dangerous goods. The basics of the carriage of dangerous goods, such as labels, examples of violations of legal regulations and the reasons and risks because of which it is necessary to comply with the said regulations, are covered in this paper. In the end, this paper mentions/highlights the reasons from which derives the need for training of a safety adviser.

Keywords: *safety adviser, carriage of dangerous goods, labels, training of safety adviser*

1. INTRODUCTION

In accordance with main legal regulations such as the Carriage of Dangerous Goods Act and the European Agreement Concerning the International Carriage of Dangerous Goods by Road, each physical and legal entity, whose activities include carriage of dangerous goods by road, rail or inland waterways, i.e., packing, loading, filling or unloading, must have at least one safety adviser. Although the function of a safety adviser is mostly in the shadows, the services of a safety adviser comprise information on the choice of packing, transport unit, labelling and marking, on the allowed roads and tunnels, ... and finally about the documentation that must accompany the aforementioned activities.

The adviser's basic responsibilities are the following:

- monitoring compliance with the requirements governing the carriage of dangerous goods;
- advising his company on the carriage of dangerous goods;
- preparing the annual report for his/her company's management or for the local public authority.

2. CARRIAGE OF DANGEROUS GOODS

2.1. Classification of dangerous goods

Dangerous goods are substances that can endanger human health, cause environmental pollution, or cause material damage. Those goods have dangerous properties for human health and the environment that - based on their nature or properties and condition, and in connection with carriage - may be dangerous for public safety or order, or the goods that have proven toxic, corrosive, irritating, flammable, explosive or radioactive effects. Raw materials from which dangerous goods and waste are produced are also considered dangerous goods if they have the properties of dangerous goods.

<u>The classes of dangerous goods according to the ADR are the following:</u>

Class 1 - Explosive substances and articles
Class 2 - Gases
Class 3 - Flammable liquids
Class 4.1 - Flammable solids, self-reactive substances, polymerizing substances, and solid desensitized explosives
Class 4.2 - Substances liable to spontaneous combustion
Class 4.3 - Substances which, in contact with water, emit flammable gases
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 - Miscellaneous dangerous substances and articles.

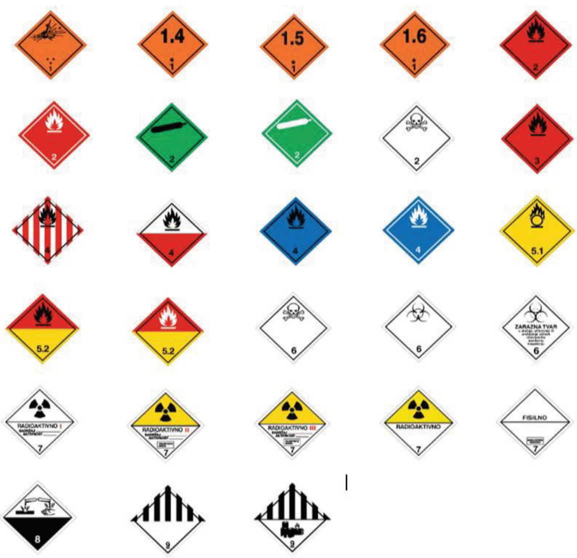


Figure 1: Labels

If the hazard characteristics of the substance, solution or mixture fall within more than one class or group of substances, then the substance, solution or mixture shall be classified in the class or group of substances corresponding to the major hazard based on the following Table of precedence of hazards (Figure 2).

Class and packing group	4.1, II	4.1, III	4.2, II	4.2, III	4.3, I	4.3, II	4.3, III	5.1, I	5.1, II	5.1, III	6.1, I DERMAL	6.1, I ORAL	6.1, II	6.1, III	8, I	8, II	8, III	9
3, I	SOL LIQ 4.1 3, I	SOL LIQ 4.1 3, I	SOL LIQ 4.2 3, I	SOL LIQ 4.2 3, I	4.3, I	4.3, I	4.3, I	SOL LIQ 5.1, I 3, I	SOL LIQ 5.1, I 3, I	SOL LIQ 5.1, I 3, I	3, I	3, I	3, I	3, I	3, I	3, I	3, I	3, I
3, II	SOL LIQ 4.1 3, II	SOL LIQ 4.1 3, II	SOL LIQ 4.2 3, II	SOL LIQ 4.2 3, II	4.3, I	4.3, II	4.3, II	SOL LIQ 5.1, I 3, I	SOL LIQ 5.1, II 3, II	SOL LIQ 5.1, II 3, II	3, I	3, I	3, II	3, II	8, I	3, II	3, II	3, II
3, III	SOL LIQ 4.1 3, II	SOL LIQ 4.1 3, III	SOL LIQ 4.2 3, II	SOL LIQ 4.2 3, III	4.3, I	4.3, II	4.3, III	SOL LIQ 5.1, I 3, I	SOL LIQ 5.1, II 3, II	SOL LIQ 5.1, III 3, III	6.1, I	6.1, I	6.1, II	3, III [a]	8, I	8, II	3, III	3, III
4.1, II			4.2, II	4.2, II	4.3, I	4.3, II	4.3, II	5.1, I	4.1, II	4.1, II	6.1, I	6.1, I	SOL LIQ 4.1, II 6.1, II	SOL LIQ 4.1, II 6.1, II	8, I	SOL LIQ 4.1, II 8, II	SOL LIQ 4.1, II 8, II	4.1, II
4.1, III			4.2, II	4.2, III	4.3, I	4.3, II	4.3, III	5.1, I	4.1, II	4.1, III	6.1, I	6.1, I	6.1, II	SOL LIQ 4.1, III 6.1, III	8, I	8, II	SOL LIQ 4.1, III 8, III	4.1, III
4.2, II					4.3, I	4.3, II	4.3, II	5.1, I	4.2, II	4.2, II	6.1, I	6.1, I	4.2, II	4.2, II	8, I	4.2, II	4.2, II	4.2, II
4.2, III					4.3, I	4.3, II	4.3, III	5.1, I	5.1, II	4.2, III	6.1, I	6.1, I	6.1, II	4.2, III	8, I	8, II	4.2, III	4.2, III
4.3, I								5.1, I	4.3, I	4.3, I	6.1, I	4.3, I	4.3, I	4.3, I	4.3, I	4.3, I	4.3, I	4.3, I
4.3, II								5.1, I	4.3, II	4.3, II	6.1, I	4.3, I	4.3, II	4.3, II	8, I	4.3, II	4.3, II	4.3, II
4.3, III								5.1, I	5.1, II	4.3, III	6.1, I	6.1, I	6.1, II	4.3, III	8, I	8, II	4.3, III	4.3, III
5.1, I											5.1, I	5.1, I	5.1, I	5.1, I	5.1, I	5.1, I	5.1, I	5.1, I
5.1, II											6.1, I	5.1, I	5.1, II	5.1, II	8, I	5.1, II	5.1, II	5.1, II
5.1, III											6.1, I	6.1, I	6.1, II	5.1, III	8, I	8, II	5.1, III	5.1, III
6.1, I DERMAL															SOL LIQ 6.1, I 8, I	6.1, I	6.1, I	6.1, I
6.1, I ORAL															SOL LIQ 6.1, I 8, I	6.1, I	6.1, I	6.1, I
6.1, II INHAL															SOL LIQ 6.1, I 8, I	6.1, II	6.1, II	6.1, II
6.1, II DERMAL															SOL LIQ 6.1, I 8, I	SOL LIQ 6.1, II 8, II	6.1, II	6.1, II
6.1, II ORAL															8.I	SOL LIQ 6.1, II 8, II	6.1, II	6.1, II
6.1, III															8, I	8, II	8, III	6.1, III
8, I																		8, I
8, II																		8, II
8, III																		8, III

SOL – Solid substances and mixtures
LIQ – Liquid substances, mixtures and solutions
DERMAL – Dermal toxicity
ORAL – Oral toxicity
INHAL – Inhalation toxicity
[a] *Class 6.1 for pesticides*

Figure 2: Table of precedence of hazards [1]

By intersecting a certain row with a column, one obtains in which class and packing group a certain substance or mixture should be classified.

2.2. Packing group vs transport category

[1] For packing purposes, substances that do not belong to the Classes 1, 2, 5.2, 6.2 and 7 and are not self-reactive in the Class 4.1, are included in the packing group in accordance with the degree of hazard they represent:

Packing group I: Substances representing a great hazard;

Packing group II: Substances representing medium hazard;

Packing group III: Substances representing low hazard.

Transport category, in relation to the packing group, defines the largest total quantity per transport unit. This means that if the quantity of dangerous goods carried on the transport unit does not exceed the values indicated in column 3 of the Table 1.1.3.6.3 (in this paper Figure 3) for the specified transport category, it is not subject to the provisions of the ADR.

Transport category (1)	Substances or articles packing group or classification code/group or UN No. (2)	Maximum total quantity per transport unit[b] (3)
0	Class 1: 1.1A/1.1L/1.2L/1.3L and UN No. 0190 Class 3: UN No. 3343 Class 4.2: Substances belonging to packing group I Class 4.3: UN Nos. 1183, 1242, 1295, 1340, 1390, 1403, 1928, 2813, 2965, 2968, 2988, 3129, 3130, 3131, 3132, 3134, 3148, 3396, 3398 and 3399 Class 5.1: UN No. 2426 Class 6.1: UN Nos. 1051, 1600, 1613, 1614, 2312, 3250 and 3294 Class 6.2: UN Nos. 2814, 2900 and 3549 Class 7: UN Nos. 2912 to 2919, 2977, 2978 and 3321 to 3333 Class 8: UN No. 2215 (MALEIC ANHYDRIDE, MOLTEN) Class 9: UN Nos. 2315, 3151, 3152 and 3432 and articles containing such substances or mixtures and empty uncleaned packagings, except those classified under UN No. 2908, having contained substances classified in this transport category.	0
1	Substances and articles belonging to packing group I and not classified in transport category 0 and substances and articles of the following classes: Class 1: 1.1B to 1.1J [a] /1.2B to 1.2J/1.3C/1.3G/1.3H/1.3J/1.5D [a] Class 2: groups T, TC [a], TO, TF, TOC [a] and TFC aerosols: groups C, CO, FC, T, TF, TC, TO, TFC and TOC chemicals under pressure: UN Nos. 3502, 3503, 3504 and 3505 Class 4.1: UN Nos. 3221 to 3224, 3231 to 3240, 3533 and 3534 Class 5.2: UN Nos. 3101 to 3104 and 3111 to 3120	20
2	Substances belonging to packing group II and not classified in transport categories 0, 1 or 4 and substances and articles of the following classes: Class 1: 1.4B to 1.4G and 1.6N Class 2: group F aerosols: group F chemicals under pressure: UN No. 3501 Class 4.1: UN Nos. 3225 to 3230, 3531 and 3532 Class 4.3: UN No. 3292 Class 5.1: UN No. 3356 Class 5.2: UN Nos. 3105 to 3110 Class 6.1: UN Nos. 1700, 2016 and 2017 and substances belonging to packing group III Class 6.2: UN No. 3291 Class 9: UN Nos. 3090, 3091, 3245, 3480, 3481 and 3536	333
3	Substances belonging to packing group III and not classified in transport categories 0, 2 or 4 and substances and articles of the following classes: Class 2: groups A and O aerosols: groups A and O chemicals under pressure: UN No. 3500 Class 3: UN No. 3473 Class 4.3: UN No. 3476 Class 8: UN Nos. 2794, 2795, 2800, 3028, 3477 and 3506 Class 9: UN Nos. 2990 and 3072	1 000
4	Class 1: 1.4S Class 2: UN Nos. 3537 to 3539 Class 3: UN No. 3540 Class 4.1: UN Nos. 1331, 1345, 1944, 1945, 2254, 2623 and 3541 Class 4.2: UN Nos. 1361 and 1362 packing group III and UN No. 3542 Class 4.3: UN No. 3543 Class 5.1: UN No. 3544 Class 5.2: UN No. 3545 Class 6.1: UN No. 3546 Class 7: UN Nos. 2908 to 2911 Class 8: UN No. 3547 Class 9: UN Nos. 3268, 3499, 3508, 3509 and 3548 and empty, uncleaned packagings having contained dangerous goods, except for those classified in transport category 0	unlimited

Figure 3: Quantity per transport unit [1]

For all dangerous goods, RID and ADR provisions define the use of inner and outer packaging in relation to the packing group as well as the use of packaging.

2.3. Transport unit labelling

Transport units carrying dangerous goods shall display two rectangular, orange-coloured plates. They shall be fixed one at the front and the other at the rear part of the transport unit.

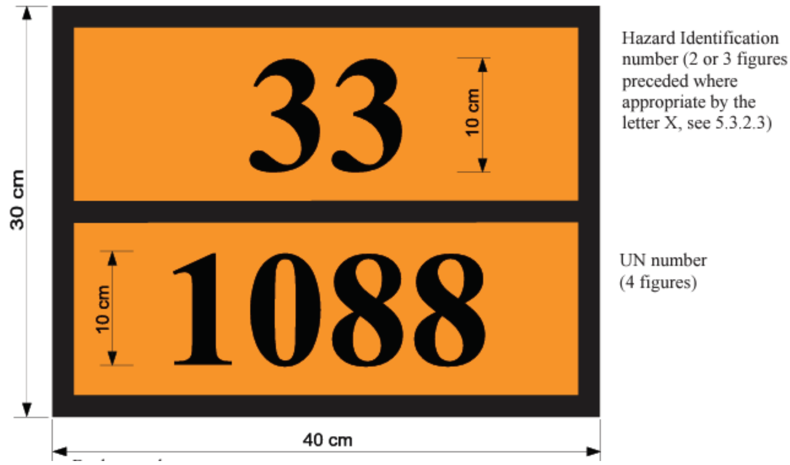


Figure 4: Example of orange-coloured plate with hazard identification number and UN number [1]

3. CONCLUSION

After explaining the most basic terms in the carriage of dangerous goods, it is very important to know how to interpret the ADR provisions, and in this case Table A, Dangerous goods list. UN number 1263 was taken an as example.

UN No.	Name and description	Class	Classification code	Packing group	Labels	Special provisions	Limited and excepted quantities		Packaging			Portable tanks and bulk containers	
									Packing instructions	Special packing provisions	Mixed packing provisions	Instructions	Special provisions
	3.1.2	2.2	2.2	2.1.1.3	5.2.2	3.3	3.4	3.5.1.2	4.1.4	4.1.4	4.1.10	4.2.5.2 7.3.2	4.2.5.3
(1)	(2)	(3a)	(3b)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9a)	(9b)	(10)	(11)
1259	NICKEL CARBONYL	6.1	TF1	I	6.1 +3		0	E0	P601		MP2		
1261	NITROMETHANE	3	F1	II	3		1 L	E0	P001 R001	RR2	MP19		
1262	OCTANES	3	F1	II	3		1 L	E2	P001 IBC02 R001		MP19	T4	TP1
1263	PAINT (including paint, lacquer, enamel, stain, shellac, varnish, polish, liquid filler and liquid lacquer base) or PAINT RELATED MATERIAL (including paint thinning and reducing compound)	3	F1	I	3	163 367 650	500 ml	E3	P001		MP7 MP17	T11	TP1 TP8 TP27

ADR tank		Vehicle for tank carriage	Transport category (Tunnel restriction code)	Special provisions for carriage				Hazard identification No.	UN No.	Name and description
Tank code	Special provisions			Packages	Bulk	Loading, unloading and handling	Operation			
4.3	4.3.5, 6.8.4	9.1.1.2	1.1.3.6 (8.6)	7.2.4	7.3.3	7.5.11	8.5	5.3.2.3		3.1.2
(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(1)	(2)
L15CH	TU14 TU15 TU31 TE19 TE21 TM3	FL	1 (C/D)			CV1 CV13 CV28	S2 S9 S14	663	1259	NICKEL CARBONYL
			2 (E)				S2 S20		1261	NITROMETHANE
LGBF		FL	2 (D/E)				S2 S20	33	1262	OCTANES
L4BN		FL	1 (D/E)				S2 S20	33	1263	PAINT (including paint, lacquer, enamel, stain, shellac, varnish, polish, liquid filler and liquid lacquer base) or PAINT RELATED MATERIAL (including paint thinning and reducing compound)

Figure 5: Part of Table A: Dangerous goods list [1]

In column 3.a, one has defined the class of dangerous good, i.e., that it is a flammable liquid, and in the next column that it is a flammable liquid with flash point at or below 60 °C. Furthermore, it is indicated that this substance represents a great hazard. Packaging labelling is a very important issue in carriage. In this case, the packaging must be marked with label no. 3. Further on, in the attached Figure 5: Part of the Table, the method of transportation is defined for each individual hazardous substance, what is required regarding the accompanying documentation, how waste must be transported (waste packaging resulting from the use of the dangerous goods), limited and exempted quantities of dangerous goods (which during carriage are not subject to the provisions of the ADR), packaging methods, eventual carriage by tanker trucks, the vehicle allowed for carriage of certain dangerous goods, tunnel restriction and certain additional provisions and hazard identification.

In accordance with the above data, the safety adviser has the responsibility to seek such information and apply it in practice as well as to be able to pass on his knowledge to all participants in the carriage of dangerous goods. It shows the importance of training for a safety adviser.

Safety adviser conducts training for other participants in transport chain. The mentioned training is one of preventive actions against the occurrence of an accident and/or an unwanted events related to the transport of dangerous goods.

With his/her knowledge, the adviser points out the importance of applying the aforementioned provisions, the ultimate goal of which is to prevent environmental pollution of soil, water and air, the occurrence of explosions and fires, as well as material damage and injuries to all participants in the carriage of dangerous goods.

The producer/distributor must know the of dangerous goods' properties and supervisory services must have insight into endangerment and potential danger. The carrier and emergency response units must - based on the written instructions on actions in case of an accident or adverse event and dangerous goods' transport document for emergency procedures in case of an accident or adverse event - know and act correctly, with regard to the danger-posing substances.

Safety adviser's basic obligations, mentioned in the introduction of this paper, also include monitoring the following practices and procedures related to the relevant activities of the company:

- procedures for compliance with requirements governing the identification of transported dangerous goods;

- company's practice related to possible special requirements regarding the transported dangerous goods that is taken into account when purchasing means of transport;

- procedures for checking the equipment used in connection with the carriage, packing, filling, loading, or unloading of dangerous goods;

- proper training of company's employees, including changes in the regulations and keeping records of such training;

- implementation of proper emergency procedures in case of an accident or incident that may affect safety during the carriage, packing, filling, loading, or unloading of dangerous goods;

- investigating and, where appropriate, preparing reports on serious accidents, incidents or serious infringements recorded during the carriage, packing, filling, loading, or unloading of dangerous goods;

- implementation of appropriate measures to avoid the recurrence of accidents, incidents, or serious infringements;

- taking care of legal provisions and special requirements related to the carriage of dangerous goods in selection and use of sub-contractors or third parties;

- checking whether the employees involved in consigning, carriage, packing, filling, loading, or unloading of dangerous goods have detailed operational procedures and instructions;

- introduction of measures to increase awareness of the risks inherent in the carriage, packing, filling, loading, and unloading of dangerous goods;

- implementation of verification procedures to ensure that transport units are equipped with documents and safety equipment that must accompany transport, as well as the compliance of such documents and equipment with the regulations;

- implementation of verification procedures to ensure compliance with the requirements governing packing, filling, loading, and unloading;

- existence of the security plan. [1]

One should keep in mind that the main provision defining the conditions for carriage of dangerous goods (in this case the Agreement Concerning the International Carriage of Dangerous Goods by Road) is a document of approximately 1,400 pages and it is amended every odd year.

Besides the responsibilities closely related to the ADR provisions, the safety adviser participates in the preparation of risk assessment. Risk assessment is made with the aim of determining the dangers, harms and efforts at work, the estimated level of risk, i.e., the possibility of injuries at work, occupational diseases, and work-related diseases, and to set possible corrective and preventive measures for the safety and health protection of workers. In addition to the harm caused by the transport of dangerous goods subject to the ADR provisions, safety adviser must also be familiar with the harm caused by packing, loading, unloading, filling, or unloading associated with such carriage.

Dangerous goods, in this case paints or paint-related items of the UN number 1263, contain organic compounds that may contain heavy metals (arsenic, cadmium, chromium) and pose danger to the human body and the environment. They are flammable, which is why extra caution is required when handling them. Solvents, thinners, and most paints are easily volatile liquids that can, depending on the composition, quantity, and concentration, have a harmful effect on human health during exposure. Depending on the concentration of solvent in the working environment, it has a harmful impact on the body in such a way that it dries the skin, damages the liver, brain, peripheral nervous system, irritates the eyes and respiratory tract and leads to inflammation of the same. When talking about prevention, the most important thing is to have the containers with these substances properly stored and closed, and to ensure sufficient air flow in the storage areas, extra caution when handling substances with a lower flash point temperature and, of course, the use of personal protective equipment. In addition to chemical hazards, there is also the danger of manual carrying, lifting, and lowering of loads, which requires a certain amount of physical effort. Furthermore, it might represent a load for certain muscles and joints of the body, as well as organs (heart), causing thus damage to the spine, tendons, joints, flat foot, and hernia. Every movement of the body involves the spine, so it is extremely important (especially with heavier loads) that the actions of lifting and lowering the load are performed correctly. For this reason, workers performing the abovementioned jobs are the workers whose main task involves carrying most of the cargo. Due to the preventive action, a series of instructions for working in a safe way, examination performed by occupational medicine specialist, training for working in a safe way and - in this case - the training of other participants in the transport process, especially a safety adviser, is needed.

REFERENCES

[1] The Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR), 2023.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

ARTIFICIAL INTELLIGENCE IN THE IMPROVEMENT OF SAFETY AT WORKPLACE

Damir Hodžić[1]; Ermin Bajramović[2]; Emir Bajramović[3];

[1] University of Bihać, Faculty of Technical Engineering, I.Ljubijankića bb, Bihać, BOSNIA AND HERZEGOVINA, damir.hodzic@unbi.ba

[2] University of Bihać, Faculty of Technical Engineering, I.Ljubijankića bb, Bihać, BOSNIA AND HERZEGOVINA, ermin.bajramovic@unbi.ba

University of Bihać, Faculty of Technical Engineering, I.Ljubijankića bb, Bihać, BOSNIA AND HERZEGOVINA, emir.bajramovic@unbi.ba

Abstract: *Artificial intelligence (AI) represents a technological advance that has the potential to transform various industries, including the field of occupational safety. In this research paper, we explore the application of artificial intelligence in improving occupational safety, we analyze how advanced techniques of machine learning, deep learning and data analysis can improve worker safety, identify workplace risks and improve preventive measures.*

Based on previous research and examples from practice, we see that the application of artificial intelligence can significantly reduce risks in the workplace, increase the speed of hazard detection and enable anticipatory planning and intervention to prevent injuries and accidents. In addition, the application of artificial intelligence can contribute to the optimization of resources, more effective risk management and better adaptation to changes in the working environment.

Keywords: *Artifical Intelligence, Improvement, Safety, Workplace*

1. INTRODUCTION

Artificial intelligence provides opportunities for introducing innovative and exciting changes in the workplace, as it ensures the increasing availability of data and large amounts of data and the capacity to process data with the help of algorithms, which leads to comprehensive and radical changes in the execution of work tasks. A number of applications and tools for assisted work and data analysis are based on artificial intelligence, which enable the automation of increasingly complex tasks and automated or semi-automated decision-making and management at workplaces. The application of artificial intelligence in work procedures is manifested in a number of examples, from the use of cobots, wearable technologies and tablet computers as work assistants on production lines, automated chatbots in factories, warehouses and call centers, as well as smart personal protective equipment equipment, to algorithmic procedures in applications intended for human resource management, among others for the purpose of analyzing data on employees and "gamification". Artificial intelligence could bring opportunities, but also new challenges for safety and health at work, management of safety and health at work and legal regulation of that area. Most discussions in the field of artificial intelligence are about the quantity of jobs, but the focus should also be on their quality, the key aspects of which are safety and health at work.

We are often hardly aware of how deeply AI has long penetrated our working world and our private lives. AI filters spam from our emails and directs us when shopping online. Cars and household appliances, accounting and PPE - everything is becoming intelligent and the range of AI services is becoming more impressive every day. AI deciphers ancient texts, AI finds a new antibiotic, AI recognizes depression by the sound of a voice - this list could go on for pages.

AI can do everything better - or not? Whether it's quality control or logistics, chess or evaluating X-ray images - wherever you look, AI is doing better than us. That's exciting and frustrating at the same time. Seeing, hearing, speaking, reading... AI can already do all of that really well (and imitate it). Thinking is still being worked on. Feeling is simulated at best and cannot be compared to human emotions or actual empathy.

While some people are stylizing AI as a beacon of hope for growth and prosperity, others are warning against slipping ever deeper into dependence on international tech giants. Both sides have good arguments, but predicting the future is impossible given the dynamic development of AI applications. At least for us humans, but AI can do this better too and has long since taken the lead in weather forecasts, traffic jam forecasts or stock analyses [1].

2. CONCEPT OF ARTIFICIAL INTELLIGENCE

Artificial intelligence is an umbrella term and there are many ways to realize it. With it, it is possible to make machines feel, think and act on given stimuli. To start talking about artificial intelligence, it is first essential to understand the concept of data, since artificial intelligence relies heavily on data collection and analysis. According to Luce Leanne (2019), data is generally "a raw set of information that requires some processing in order to have concrete meaning" and can be structured - when organized, making it easier for machines to make sense of organized or unstructured or unorganized free-form data, such as posts on the blog or email. A company may have a large set of data that can be either internal, generated within the organization such as the company's website or purchase orders, or external, which are those generated outside the company, such as social media or macroeconomic indicators [2].

The four main areas of artificial intelligence that are particularly relevant to the industry include machine learning, computer vision, natural language processing and robotics. If the ultimate goal of artificial intelligence is to make machines think, behave and react like humans, they should have the ability to learn from past experiences and apply that knowledge in future processes, just as human beings do. This is possible through machine learning, an extremely important field of artificial intelligence that aims to identify patterns in data previously fed into a machine, predicting the value of non-existent data, allowing machines to learn without manual programming [3].

There are two ways in which computers learn: supervised and unsupervised learning. Supervised learning takes existing data (input) and already known data responses (output), training the machine to predict other future outputs in cases of uncertainty, all based on evidence. When there is only input data and no prior responses, the machine learns through unsupervised learning, relying only on underlying patterns and inferences from the data set. The applications of each learning method will depend on the nature of the data available. The field of natural language processing studies and analyzes texts, oral and written, that arise naturally, without being done for the purpose of analysis and with the limitation that it is text that human beings use to communicate with other people. Using natural language processing, it was possible to develop applications such as Amazon Alexa, Apple Siri and Google Home [4].

3. ARTIFICIAL INTELLIGENCE IN OCCUPATIONAL SAFETY AND HEALTH PROTECTION

Do we think artificial intelligence is one of the most important technologies of the future? That's only half true, because this future has long since begun. The opportunities and risks of using artificial intelligence in a company also affect occupational safety. With the free release of a new "intelligent" chat system in November 2022, the hype about artificial intelligence (AI) has reached a new peak - not for the first time. Many want to benefit from the new tools such as ChatGPT, DALL-E & Co and have texts, images or videos generated. But this generative AI represents only a small part of today's AI applications [5].

3.1. AI can do everything better - or not?

Whether it's quality control or logistics, chess or evaluating X-ray images - wherever you look, AI is doing better than us. That's exciting and frustrating at the same time. Seeing, hearing, speaking, reading, AI can already do all of that really well. Thinking is still being worked on. Feeling is simulated at best and cannot be compared to human emotions or actual empathy.

While some people are stylizing AI as a beacon of hope for growth and prosperity, others are warning against slipping ever deeper into dependence on international tech giants. Both sides have good arguments, but predicting the future is impossible given the dynamic development of AI applications. At least for us humans, but AI can do this better too and has long since taken the lead in weather forecasts, traffic jam forecasts or stock analyses.

In addition to all the enthusiasm, there is also a lot of uncertainty. Not least fueled by an open letter from leading AI researchers who are calling for an immediate stop to the development of further artificial intelligence systems in March 2023. Has something gotten out of control? So far, the dystopias in which uncontrollable computers and intelligent robots threaten humanity have been dismissed as science fiction. Now the calls for regulation and limits for AI are getting louder and louder and not only the EU is working on a legal framework for the trustworthy and ethical use of artificial intelligence.

The fact is: AI is here and it is not going to disappear. We should learn to live with it and - where it makes sense - actively use the new tools. Even those who reject this for themselves will have to accept that AI will revolutionize the working world in many industries. From the point of view of the occupational health and safety officer - as with any new technology - there are two perspectives: how can AI tools be used specifically for occupational health and safety and what needs to be taken into account and how do AI applications affect safety, health and well-being in the workplace, and to what extent could acute hazards or stress arise?

German Social Accident Insurance (DGUV) assumes that the use of artificial intelligence can "increase safety and health at work". Some professional associations are already actively using artificial intelligence, here are two examples:

Accident forecasts: In June of this year German Statutory accident insurance institution for the construction sector BG BAU launched an AI project to support occupational safety supervision. An AI analyzes the data from company audits as well as the statistics from work accidents recorded over many years and uses this to determine which companies have a particularly high risk of work accidents.

Assessing the success of recourse claims: German Social Accident Insurance Institution for the energy, textile, electrical and media products sectors BG ETEM relies on AI to automate its recourse reporting process. If there are more than 500 work accidents per day, AI evaluates the available data and thus relieves the burden on staff in the district administrations. For example, the AI recognizes patterns for promising recourse claims or those with - from the BG's point of view - lower chances. It could be exciting if lawyers for the insured also use AI tools - which incidentally shows how valuable our data is, whether for a BG or for Google, Amazon, Facebook & Co.

Typical of these AI applications is that they involve large amounts of data. The more individual units of information have to be recorded, processed and viewed and evaluated in an overall view, the more the superiority of artificially intelligent systems becomes apparent. Therefore, AI applications that are useful "on a large scale" cannot easily be scaled down to a company. Depending on the question, the amount of data generated in a single company is too small to generate meaningful evaluations [1,5].

3.2. AI for occupational safety

But how can occupational safety on site also benefit from AI? Different approaches are being discussed for this:

Recognizing risks: AI could support prevention by predicting potential sources of danger. If as many influencing factors as possible are linked together, such as occupational safety data on accidents, malfunctions, absences, etc., other internal company data, for example from the sensors of smart buildings, machines, systems, processes, etc. as well a external parameters, such as the local weather, an AI could theoretically find new connections for accident factors. Algorithms in smart factories already calculate when and where which part needs to be serviced, repaired or replaced. For example, the AI system "knows" via sensors where a surface is hot or a noise limit has been reached, which container is leaking and which employee or forklift is where, etc.

Taking it a step further, an AI could also check whether the employee tasked with troubleshooting is qualified to do so, whether he is wearing suitable PPE, when he was last instructed, or whether the electrical supply was activated via lockout-tagout. All of these parameters have either long been available digitally or can be quickly obtained using increasingly "invisible" sensors combined with pattern, voice, and facial recognition.

Ideally, the responsible supervisor has all of the risk factors in view or in his head. But the more parameters that need to be taken into account and the greater the pressure to make quick decisions - machine downtimes are often expensive - the more an AI that is unfamiliar with stress and hecticness will play to its strengths.

However, such company-wide AI systems are not a sure-fire success; they must first be given access to the required data - via sensors, interfaces, etc. The data must also be reliable and as complete as possible. As long as, for example, work accidents, near-accidents, critical situations, etc. are not consistently and systematically documented, AI lacks the crucial prerequisites for analyzing accident risks. The required data protection can also limit the potential of AI (read more about data quality, data protection and other limits and pitfalls when using AI in the follow-up article in Safety Engineer 11–2023).

Simulation of dangerous situations: If an AI is able to anticipate potential dangerous situations, then this can also be used to test and train safe actions in such a situation. Mechanical engineers have long been simulating the performance of machines and systems in data models, so-called digital twins. In a similar way, architects use BIM (Building Information Modeling) to simulate the entire life cycle of buildings, from planning to demolition, from the building site to the fire alarms. Machine or machine hall, everything is planned digitally before the actual construction begins and - increasingly with the help of AI - tested.

Machines, construction sites, fire protection? At this point, every occupational safety officer is paying attention. Because a lot of data is generated that is highly relevant to their work. An AI could use such data to simulate risk situations, such as an incident. The future machine operator could test out his options for action and - without danger - practice how to behave in an emergency. A company fire department could use 3D glasses to practice firefighting procedures in a tricky area before the building is even built. Such virtual training scenarios have long been a reality, and AI-controlled they are becoming more powerful and closer to reality.

Autonomous vehicles and internal traffic flows: It is doubtful whether real self-driving systems for private transport will ever become a reality. However, such systems are already being used successfully in limited areas or on fixed routes, from small transport robots to self-driving aircraft tugs. This can relieve the burden on employees or make them completely unnecessary, and accidents due to human factors such as fatigue or alcohol should no longer occur.

4. CONCLUSION

Artificial intelligence offers a promising future where linguistic diversity and multiple risk factors compound vulnerability to poor understanding of workplace risks. AI technologies can be used to understand and address the needs of various occupational groups, better inform policy, and help formulate strategies to improve workers’ health and safety environment integrating AI in occupational health and safety offers benefits such as enhanced safety and productivity through predictive maintenance and real-time risk assessment. However, drawbacks include ethical concerns, data privacy considerations, and the need for regulatory compliance. Work organizations must balance innovation with respecting workers’ rights, investing in workforce education, building AI expertise, and collaborating with solution providers to seamlessly ensure a safe workplace that integrates AI and human ingenuity.

REFERENCES

[1] *Impact of Artificial Intelligence on Occupational Safety and Health*, European Agency for Safety and Health at Work, Policy Brief, 2021

[2] Hodžić, D.; Ramić, D & Džanić, A.: The Influence of Artificial Intelligence on Fashion Industry, *Proceedings of International Scientific-Professional Symposium TZG 2024 "Textile Science & Economy"*, pp 56-61, ISSN 2991-9207 (Online), Zagreb, January 2024.

[3] Luce, L.: *Artificial intelligence for fashion: How AI is revolutionizing the fashion industry*, Berkeley, CA: Apress, ISBN 978-1484239308, 2019

[4] Liddy, E.D.: *Natural Language Processing. In Encyclopedia of Library and Information Science*, CRC Press, ISBN 9781466552593, 2017

[5] Kring, F.: KI in Arbeitssicherheit und Gesundheitschutz, *Available from* https://www.sifa-sibe.de/organisation/digitalisierung/ki-arbeitssicherheit-gesundheitsschutz-smarter-arbeitsschutz/ *Accessed:* 2024-06-23.

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

GREEN CROSS RECORDS: TRACKING TOOL OF WORK SAFETY STATUS IN THE COMPANY

Alen Krivačić[1]
[1]Valinge Croatia d.o.o., Otok Oštarski 4K, Ogulin, Hrvatska, info@valinge.hr

Abstract : *In this short review, we want to describe the launch of a new production line and the start of new employees with the implementation of Green Cross records. Green Cross records have proven to be an extremely effective and simple tool for everyday application and monitoring of the state of safety and protection Monitoring the status of occupational safety by applying Green Cross records regarding statistical data and situations following work and work results which are entered into the records daily. By regularly reviewing the registration tables, we can react in a timely manner to situations that occurred during work, but also during work. Green Cross records gave a new segment of attitudes towards work, and when it happened the chart of stagnation had been an indicator of the need to upgrade the system through additional employee education. With quatre comparison of Green Cross records of the year 2023–2024 which is a result of general–related indicators for the further development of security and protection within the company. The entire Green Cross records are the result of the work of all employees as one team in which everyone has done their part of the task but also warned in time about shortcomings that can affect the deadline and quality of work.*

Keywords: *Production line, New employees, Green Cross records, Work monitoring*

1. INTRODUCTION :

Purpose of keeping green cross records when working in starting a new production line and starting the work of a new company have proven to be a simple tool for managing and monitoring the state of safety and safety at work.
During the design of production halls, the main goal is to meet all the requirements in order for the production line to give maximum effects. It is primarily and mandatory to include all segments that are a key part of the main project. When the production premises are properly dimensioned by the main design with all the parameters of construction, installation and technical requirements, the assembly and testing of the production line can be accessed. The production line consists of a complex assembly of interconnected units that are mounted and put into operation by the manufacturer. During installation, authorized fitters of the manufacturer are obliged to harmonize, test, and pay special attention to the safety parameters when operating the line. After the final testing of the production line and training of the employees who will handle it, all technical documentation is merged, and the handover is carried out. Safety and security work begins already during the interview for the employment of a new worker. Of utmost importance proved to be the correct presentation of the ethics of the company's

work, the desired goals and constant improvement of the system of work and production. To achieve the desired goal, it is necessary to have a good cooperation with an occupational medicine doctor who, in addition to a medical examination, conducts training for first aid (following the number of employees in the company in cooperation with the occupational safety service). After a positive finding of the medic-doctor of labour, a new employee approaches the training for work in a safe way, which consists of theoretical and practical part. Training for preventive measures and initial firefighting is also essential. For a period of 60 days, the new employee, under the supervision of a "mentor", is allowed to work independently and after completing the practical part of the training, he can perform his work independently. Training for preventive measures and initial firefighting is also essential. All important factors of occupational safety must be brought together by a common set that is training for work with a production line.

2. Implementation of Green Cross records

Many employees are encountering green cross records for the first time, as well as new business management systems. Therefore, for every occupational safety and safety professional, it is of utmost importance to be a good andragogy. Quality presentation of the desired goals, and constant work on improving the occupational safety system will give the desired results. At the beginning of the application of green cross records as a tool used for the purpose of conducting occupational safety, resistance from workers is encountered. Workers consider this type of record to be a direct control of their work and have a negative attitude. By constantly cooperating with workers and the presence of occupational safety experts at workplaces, the case can be directed to the right path.
Employees need to be given the right guidelines and examples in order to learn how to properly apply and fill out green cross records in a proper way. The approach adopted by Valinge Croatia d.o.o. is constantly being upgraded, and employees have held safety and safety meetings every Monday. Daily keeping of green cross records already in the first quarter of the year gave results. The recorded data is checked every day at production meetings and the necessary steps are taken to reduce or eliminate hazards.

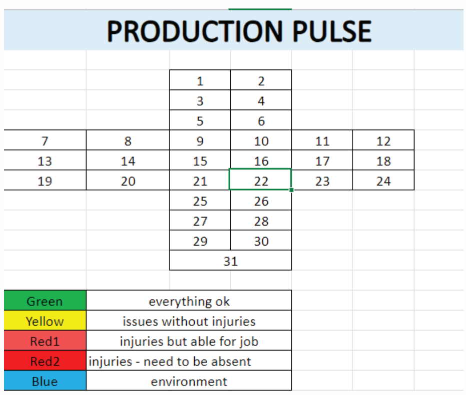


Figure 1. Green Cross evidence as part of the production plan

3. Monitoring the state of occupational safety by applying Green Cross records

All workers as well as all departments in the company are involved in keeping Green Cross records. Daily monitoring of records gives an insight into the present problem but also accelerates the solution of the problem. Comparison and analysis monthly give an insight into the speed of solving problems and is an indicator of the need for a rise or fall in security. Monthly records are the main indicator during one quarter of the production year. Furthermore, by uniting all months and quadrilles of the year, we directly get a statistical indicator of occupational safety and safety trends.

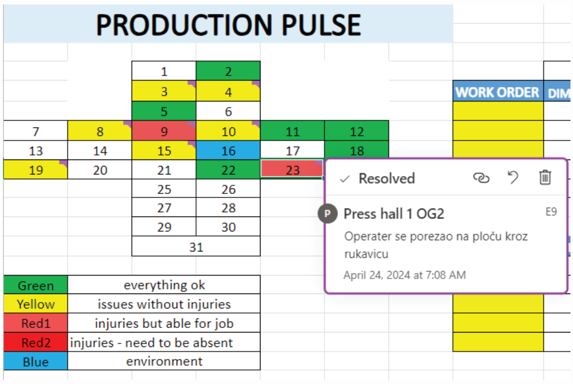


Figure 2 . Example of recorded cases on workdays

4. Statistical data and situation following work and work results

Statistical data are an indicator of the current state, the steps that need to be taken, and an indicator of communication and behaviour during the work. The concept of green cross records is divided by the colors that are inherent in each case that occurs when performing work. Of great importance is the correct choice of color for a particular case. For example, if we had an event that could have caused danger to the worker, then we put a yellow mark, but if we have an injury on the same day when working, then we set a red color mark, a case of higher priority prevails that day.

Standard colors are:

-dark red – injury where the worker sought emergency help and used sick days,

-bright red – light injury where the worker used funds from the first aid cabinet and continued to work,

-orange color-case where there is a possible danger to the worker,

-yellow color - a case of imminent danger to the worker but no injury occurred, -blue color - processes by which we can or affect the ecosystem and the environment during operation.

-green color - a safe day, a day without danger at the beginning of record keeping, workers often mistake color for a particular emergency, and communication and consultation with a safety engineer are important.

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Serious workplace accident	●		1	1									
Workplace accident	●			2	4	6	3	1	1	2	1	1	2
Serious incident, without personal injury	●									1			
Incident, incl RSVP incidents	●	6	17	10	12	15	22	19	6	23	24	31	15
Environmental incidents	●	2	7	1	4	9	4	6	2	8	11	7	10
TOTAL		8	25	14	20	30	29	26	9	34	36	39	27

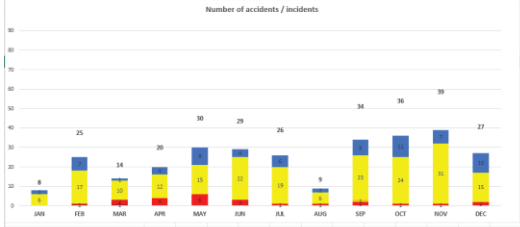


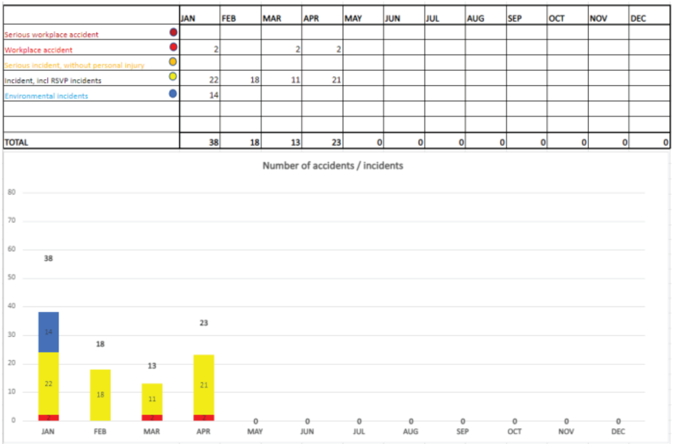
Figure 3. Graphical representation of monthly data from 2023.

Injury №	Date of injury	Description	Action taken	Nr of Sick leave days	Status of Sick leave
1	05.01.2023.	does not use protective gloves,independently removes the upper protective plates	o use personal protective equipment and handle plates	0	finished
2	12.01.2023.	dot using PPE	ed about the use of reflective vest-Belobrajdić/coop. Be	0	finished
3	12.01.2023.	do not use protective gloves	operators warned about the use of PPE	0	finished
4	17.01.2023.	leakage of smoke domes on the hall	covered-protected from the upper side	0	finished
5	23.01.2023.	clearing of attacking snow	cleared snow and access halls	0	finished
6	27.01.2023.	setting up a bridge for crossings over the profiler	bridge over the profiling line, easier movement around	0	finished
7	27.01.2023.	working with material without protective gloves	warn forklift driver	0	finished
8	31.01.2023.	crossing over buffer zone rollers	warned not to cross through buffer zone rollers	0	finished
1	01.02.2023.	the operator does not use hearing protection	warn-apply PPE	0	finished
2	01.02.2023.	operators do not use eye protection.	warn-apply PPE	0	finished
3	01.02.2023.	no water is provided for hand washing	fill handy water tanks for hand washing	0	finished
4	02.02.2023.	operators do not use eye protection.	warn-apply PPE	0	finished
5	03.02.2023.	chemical warehouse door-open	warn-close doors	0	finished
6	08.02.2023.	after a shift on the way to the place of residence participates in a traffic accident	increase attention when driving motor vehicles	8	finished
7	06.02.2023.	in the warehouse kem.placed an open bucket of varnish	warn-create instruction-set on door alert	0	finished
8	08.02.2023	operators do not use eye protection	warn-apply PPE	0	finished

Figure 4. Workday case description table

5. Chart of stagnation and indicator of the need to upgrade the system through additional employee education

Problems when keeping green cross records are manifested by stagnation of cases or frequent mixing of colors that mark cases. It's also a specific occurrence full of green days or reporting cases that aren't related to hazards. When we see that the graficon of green cross records has moved towards the trend of stagnation, rapid intervention is needed. By analyzing the entered data, we make a conclusion in which area we are not doing well. Then it is necessary to analyze the cases with the workers. Most often in the trend of stagnation, workers fill a lot of days with green or use blue color for example for external weather influences (storms or the flutter of animals in the workspace). When analyzing with workers, we must process each working day and give correct examples and explanations for the cases that workers encounter. Furthermore, at safety meetings, it is necessary to give examples of cases with whom workers may encounter during work. By choosing an example in the form of a short presentation, cases from occupational safety and fire protection are processed. One form of such presentation is the example of accidents or short animated films found on internet sites. During the presentation and after, the case seen is analyzed, and after a short time the same is positively maintained on the green cross records chart. When a worker is given good information problematic situations are clarified and ambiguities are reduced, the worker shows a different and more responsible attitude towards work. The same affects the overall working atmosphere in the company.



		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Serious workplace accident													
Workplace accident		2		2	2								
Serious incident, without personal injury													
Incident, incl RSVP incidents		22	18	11	21								
Environmental incidents		14											
TOTAL		38	18	13	23	0	0	0	0	0	0	0	0

Figure 4. An example of the tendency to stagnate the state of occupational safety.

6. Quatre comparison of Green Cross records of the year 2023–2024

By comparing quarterly and annual data from records of this type, the necessary steps in improvement, direction and tendencies of the state of safety at work in the company are visible. Certain situations during the work we can solve quickly and efficiently, and the recorded ones remain as a reminder and record of the situation. Green cross records began to be kept parallel to the beginning of the assembly of the production line and after a certain time the assembly of the pressing line began. Green cross records data that were recorded during the assembly and launch of the production line were used for the preparation and start of works on the assembly of the pressing line. Quarterly analysis shows that the cases recorded during the operation of the process line were not repeated during the assembly of the pressing line. The reason for this is that steps were taken in time that raised occupational safety to a higher level. In parallel with these steps, better coordination with external contractors has been achieved.

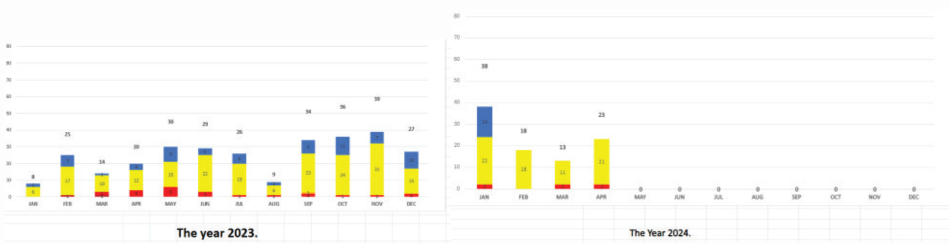


Figure 5. Comparison of records 2023–2024

7. General – related indicators

The work policy we apply during operation is "safety first". Each place of work must be kept neat and safe to operate. Before the start of work, a production meeting is held, and importance is given to safety and protection. Keeping Green Cross records helped enforce this requirement. Reducing and eliminating dangerous situations directly affects the production plan and total revenues generated from production. It is important to state that the use of the absence of workers due to sick leave was avoided and generally increased responsibility towards work and satisfaction with work. In the example of proper keeping of green cross records, the course of generation of production waste can also be withdrawn. Any situation listed in the records of the green cross if properly and on time processed should not be repeated in the future.

8. CONCLUSION

By implementing Green Cross records from the beginning of the factory's operation, an insight into the state and functioning of safety and safety at work is obtained. At the same time, additional education of all company employees is done on time, eliminating and solving potentially dangerous places where employees can be injured at work. A direct indicator of the proper function of this type of record is the direct impact on reducing risks during work and increasing the quality of the occupational safety and security system. In addition to regular recording and analysis of Green Cross records, communication with employees, job analysis and understanding of employee proposals are important. In communication with employees and during the study of problematic points from the records, employees gain a broader picture of dangers, receive quality guidelines on actions if there is a danger in the workplace and react properly in a dangerous situation. The occupational safety system must cover all parts of the company from production, and office work to maintenance of the entire work plant. The time of keeping records has shown us that employees feel the spirit of teamwork where their opinions and suggestions are taken into account, and the general conclusion is that Green Cross records are a good and functional tool that contributes to the quality of work within the company

REFERENCES

[1] Company records Valinge Croatia d.o.o., (2023.-2024.) Välinge Innovation AB | We are innovators (valinge.com)
[2] Standard operating procedures – Valinge Sweden – Valinge Croatia (2023.-2024.) Välinge Innovation AB | We are innovators (valinge.com)
[3] National safety council About NSC - National Safety Council

9th International Professional and Scientific Conference
OCCUPATIONAL SAFETY AND HEALTH
18-21 September 2024 Zadar, Croatia

BLUETOOTH IN OFFICE ENVIRONMENT

Krešimir Malarić[1], Bosiljka Šaravanja[2], Tanja Pušić[3],Ivan Leniček[4], Damir Ilić[5]

[1] Department of Communication and Space Technologies, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia, kresimir.malaric@fer.hr

[2] Department of Clothing Technology, Faculty of Textile Technology, University ofZagreb, Croatia, bosiljka.saravanja@ttf.unizg.hr

[2] Department of Textile Chemistry and Ecology, Faculty of Textile Technology,University of Zagreb, Croatia, tanja.pusic@ttf.unizg.hr

[4] Department of Electrical Engineering Fundamentals and Measurements, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia, ivan.lenicek@fer.hr

[5] Department of Electrical Engineering Fundamentals and Measurements, Faculty ofElectrical Engineering and Computing, University of Zagreb, Croatia, damir.ilic@fer.hr

Abstract: *This paper analyzes parameters of Bluetooth communications in office environments such as bit rate and signal strength where multiple Wi-Fi signals are present. Since both Bluetooth and WI-FI use similar frequency spectrum, the measured bit rate of Bluetooth file transfer was significantly smaller than expressed in the norms. Bluetooth is used in wireless headphones for cell phones, laptops, printers, wireless speakers, digital cameras, wireless keyboards, and mouse. It can also be used for data transfer as well. Bluetooth operates in the 2.4 GHz ISM band as well as Wi-Fi and thus interference is possible between the two systems. The measurements of the received signal strength presented in this paper were performed by using the android application called Bluetooth signal meter.*

Keywords: *Bluetooth, Wi-Fi, bit rate, signal strength*

1. INTRODUCTION

Bluetooth is a PAN (personal area network) technology originally described by the IEEE 802.15.1 standard [1]. Bluetooth is used in wireless headphones for cell phones, laptops, printers, wireless speakers, digital cameras, wireless keyboards and mouse, video games, etc.…It can also be used for data transfer as well. Bluetooth operates in the 2.4 GHz ISM band as well as Wi-Fi and thus interference is possible between the two systems.

Wi-Fi is the commercial name for wireless technology defined by IEEE 802.11 standards [2], with a range of up to 100 m. Along with Bluetooth, Wi-Fi is by far the most widespread wireless technology. It is found in smartphones, laptops, tablets, TVs, video accessories and home wireless routers.

Although most Bluetooth standards allow for data rate of 1 Mbps, in office environments this value tends to be lower due to the interference from the multiple Wi-Fi networks present in the same area where Bluetooth is used. Bluetooth communications in office environments was investigated in the past [3-6].

The measurements of the received signal strength presented in this paper were performed by using the android application called Bluetooth signal meter [7]. Next, the Bluetooth Range Estimator [8] and RFProp Radio Propagation Calculator [9] were alsoused for the analysis of Bluetooth communication link between two mobile phones.

2. BLUETOOTH THEORY

The Bluetooth also referred to as Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR), is a low power radio that streams data over 79 channels in the 2.4GHz unlicensed industrial, scientific, and medical (ISM) frequency band. It uses extended spectrum with Gaussian frequency hopping (GFSK), differential quadrature phase shift (DQPSK) or eight-phase differential phase shift keying (8DPSK). The basic data rate is 1 Mbps for GFSK, 2 Mbps for DQPSK and 3 Mbps for 8DPSK [10].

All versions of the Bluetooth standards support downward compatibility. That means that the latest standard covers all older versions.

Bluetooth has three power classes: class 3: 0 dBm (1 mW), class 2: 4 dBm (2.5 mW) and class 1: 20 dBm (100 mW). The limits are defined to lower interference to neighboring Bluetooth devices. Range can be from 1 m, 10 m to a maximum of 100 m, depending on theclass. Typical devices have the antenna gain from -10 dBi to +10 dBi, transmitting power from -20 dBm to + 20 dBm and receiver sensitivity from -103 dBm to -70 dBm.

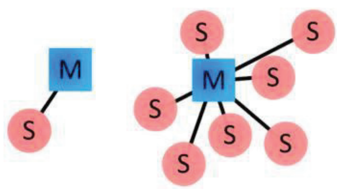


Figure 1: Bluetooth connection

Bluetooth operates at frequencies between 2.402 GHz and 2.480 GHz and 2.4 GHz to 2.483 GHz. It divides the transmitted data into packets and each packet transmits to one of 79 specific Bluetooth channels, 1 MHz wide. There are typically 1600 jumps per second, with adaptive frequency hopping (AFH) enabled. AFH tries to reduce interference by adjusting the jump sequence to avoid channels used by other devices operating in the same ISM band.

Bluetooth can have networks of up to seven devices, called piconets. Peer-to-peer communication is the most common type of communication. The connection is possible between the two devices (Master-M) and the slave (S), shown in the Fig. 1. on the left. A Piconet connection in which there is a Master (M) and slave (S) is also possible with a

Bluetooth network. In the piconet (Fig. 1. on the right), one main device can be connected to up to seven different slave devices. Any slave device in the piconet can connect to multiple masters (M), thus creating a scatternet.

3. MEASUEREMENTS AND SIMULATION RESULTS

The measurements were performed in an office at the Faculty of Electrical Engineering and Computing, University of Zagreb. Bluetooth connection between two mobile android phones (Samsung Galaxy A20e and NOA Fresh 4G) was analyzed.

The phones were connected via Bluetooth and the signal level in dBm was measured with Bluetooth Signal Meter [7] on the distances between the two phones from 0.5 m to 7.5 m. Larger distance was not possible in the office where the measurements took place and there was no signal available behind the office wall. Furthermore, a file was sent between the two mobile phones and the time that was needed to complete the transfer was measured with stopwatch. Thus, the data rate of the link was obtained. The obtained results were put into prospective by using The Bluetooth Range Estimator and RFProp Radio Propagation Calculator.

3.1. Bluetooth signal strength and data rate

Table 1: Bluetooth signal strength and data rate

Distance (m)	Received signal strength (dBm)	Data rate (kbps)
0.5	-40	21.82
1.0	-50	18.33
1.5	-53	21.15
2.0	-54	19.64
2.5	-58	21.82
3.0	-67	21.48
3.5	-71	17.19
4.0	-73	17.86
4.5	-75	17.95
5.0	-76	18.10

5.5	-78	18.09
6.0	-82	17.62
6.5	-85	16.56
7.0	-86	15.20
7.5	-87	15.80

Bluetooth signal strength was measured in dBm with Bluetooth signal application on android phone. The distance between two paired phones was changed from 0.5 m to 7.5 m in steps of 0.5 m. Furthermore, on each mentioned distance a file of 10 Mb was sent and thetime it took to reach other phone was measured in seconds and data rate was calculated accordingly (Mbps). Both results are shown in Table I.

The results show that although the Bluetooth data rate should be 1 Mbps, actual results show much smaller data rates due to the interference from the Wi-Fi signals. Data ratesvary from 15 kbps to around 22 kbps with distance not being so important even though the signal levels dropped from -40 dBm to about -87 dBm.

3.2. Bluetooth Range Estimator

The Bluetooth Range Estimator tool is an online calculator for the expected range between two Bluetooth devices in different environments. The tool can change parameters of physical layer such as transmit power, transmit and receiver antenna gains and receiver sensitivity. The environments that can be chosen are: Outdoor, Industrial, Office and Home.The result is a distance given in meters. The link input characteristics are receiver sensitivity: -90 dBm, transmitter and receiver antenna gain: 0 dB, transmitter power: +20 dBm and office environment. The result gave estimated range between 22 to 30 meters as isshown in Fig. 2.

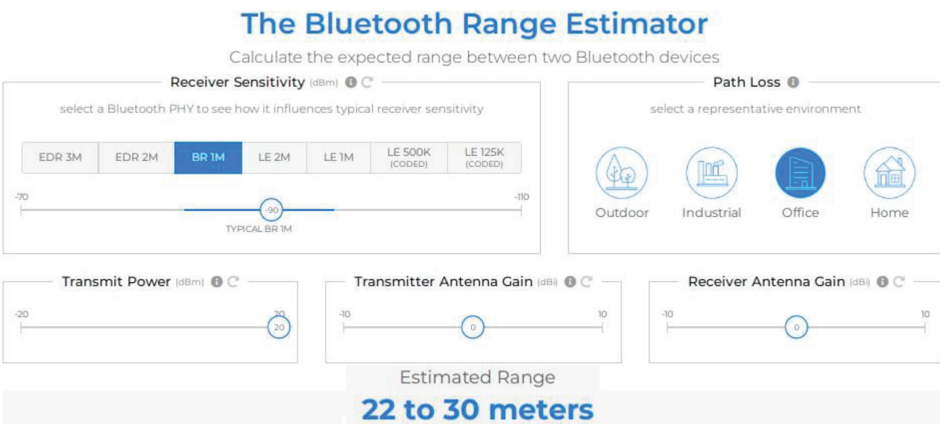


Figure 2: Bluetooth Range Estimator for Office Environment

3.3. RFProp Calculator

RFProp is a Windows propagation calculator for the transmission path between an RF transmitter and a receiver. It is used for calculation of free-space microwave communications. It can be used also for indoor calculation by adding up to 1 dB of loss for every meter of distance between the transmitter and the receiver to the free space loss [11]. The comparison of RFProp with Bluetooth signal meter results can be seen in Fig. 3.

The measurements are similar to the calculation with couple of dB difference. The conditions in the office change constantly since people are moving, going back and forth and so on, so the results can vary a lot.

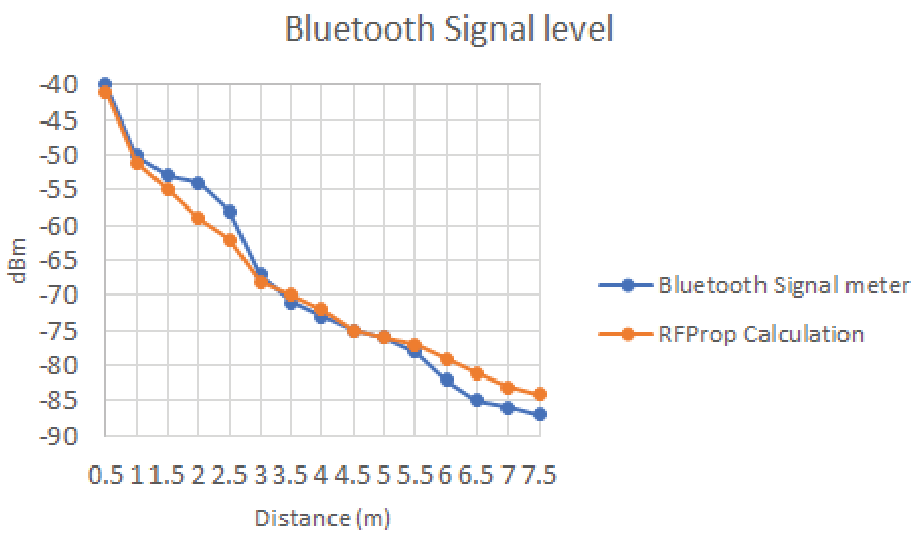


Figure 3: Comparison of Bluetooth signal meter and RFProp Calculation

3. CONCLUSION

The Bluetooth communication in the office was analyzed and the results showed that Bluetooth is strongly affected by the multiple Wi-Fi signals present since they both utilize the same frequency spectrum. Although the maximum bit rate could have been up to 1 Mbps, the actual results showed much lesser value of only about 20 kbps. The reason is repeated sending of packets due to the interference from Wi-Fi. Although the increased distance resulted in the decrease of the received signal level (from -40 dBm at 0.5 m to -87 dBm at 7.5 m) this did not affect the data bit rate dramatically. It changed from about 22 kbps to about 15 kbps. Further distance (>7.5 m) resulted in a signal loss and the connection was not possible or it was possible with lots of interruptions. There was no possibility of connection behind the concrete wall as well.

Bluetooth Range estimator showed the possibility of connection between 22 to 30m, but that result would be possible probably with fewer Wi-Fi signals in ideal conditions.

RFProp calculation showed the similar results with the measured ones differing in couple of dB. RFProp or any similar calculator can be a good tool for the prediction of the signal loss.

Finally, Bluetooth was never meant to be used for transfer of large amount of data. It is excellent for connecting headset for example or sensors and so on. However, it can still use data transfer for security reasons because both devices exchanging data do not depend on the network itself and can use their own resources only.

REFERENCES

[1] IEEE 802.15.1-2005, n.d., Accessed on: February 13th, 2024. [Online]. Available: https://standards.ieee.org/ieee/802.15.1/3513/

[2] The Evolution of Wi-Fi Technology and Standards, n.d., Accessed on: February 13th, 2024. [Online]. Available: https://standards.ieee.org/beyond-standards/the-evolution- of-wi-fi-technology-and-standards/

[3] A. Mohammed and T. Hult, "Evaluation of the Bluetooth link and antennas performance for indoor office environments by measurement trials and FEMLAB simulations," 2005 IEEE 61st Vehicular Technology Conference, Stockholm, Sweden, 2005, pp. 238-242 Vol. 1, doi: 10.1109/VETECS.2005.1543286.

[4] N. Langhammer and R. Kays, "Performance Evaluation of Wireless Home Automation Networks in Indoor Scenarios", IEEE Transactions on Smart Grid, vol. 3, no. 4, pp. 2252–2261, Dec. 2012.

[5] P. Di Marco, R. Chirikov, P. Amin and F. Militano, "Coverage analysis of Bluetooth low energy and IEEE 802.11ah for office scenario," 2015 IEEE 26th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Hong Kong, China, 2015, pp. 2283-2287, doi: 10.1109/PIMRC.2015.7343678.

[6] F. Gao and X. J. Li, "Effect of Construction Materials on Indoor Positioning System using Bluetooth Low Energy," 2022 32nd International Telecommunication Networks and Applications Conference (ITNAC), Wellington, New Zealand, 2022, pp. 82-87, doi: 10.1109/ITNAC55475.2022.9998330.

[7] Bluetooth Signal Meter, n.d., Accessed on: February 13th, 2024. [Online]. Available: https://play.google.com/store/apps/details?id=dev.egl.com.intensidadbluetooth

[8] The Bluetooth Range Estimator, n.d., Accessed on: February 13th, 2024. [Online]. Available: https://www.bluetooth.com/learn-about-bluetooth/key-attributes/range/#estimator

[9] RFProp Radio Propagation Calculator, n.d., Accessed on: February 13th, 2024. [Online]. Available: https://colinjs.com/software.htm#t_RFProp

[10] Bluetooth, n.d., Accessed on: February 13th, 2024. [Online]. Available: https://www.bluetooth.com/

[11] H. A. Obeidat et al., "An indoor path loss prediction model using wall correction factors for wireless local area network and 5G indoor networks," in Radio Science, vol. 53, no. 4, pp. 544-564, April 2018, doi: 10.1002/2018RS006536.

EXPLORING STRATEGIES FOR DEVELOPING SECURE AND TRANSPARENTCHAT APPLICATIONS

Matija Novosel[1], Alen Šimec[2], Lidija Tepeš Golubić[3]

[1] Tehničko veleučilište u Zagrebu, Vrbik 8, CROATIA, mnovosel@tvz.hr

[2] Tehničko veleučilište u Zagrebu, Vrbik 8, CROATIA, alen@tvz.hr

[3]Tehničko veleučilište u Zagrebu, Vrbik 8, CROATIA

Abstract: *This research endeavors to discern optimal strategies for developing efficient web- based chat applications in light of escalating apprehensions regarding data privacy breaches perpetrated by major corporations. Since the inception of the internet, chat applications have been a ubiquitous facet of online interaction, evolving from rudimentary platforms like AOL to contemporary giants such as Discord, WhatsApp, and Facebook Messenger. Nevertheless, mounting instances of private data theft and consequent user distrust underscore the imperative for heightened security measures. Consequently, a subset of dissatisfied users has begun championing open-source alternatives, prioritizing transparency in data handling and application functionalities. Driven by thisexigency, this study delves into methodologies for crafting chat systems that afford users enhanced security and transparency, thereby mitigating concerns surrounding data integrity in online communication.*

Keywords: *Data privacy, Security breaches, Open-source development, User trust, Online communication, Chat applications*

1. INTRODUCTION

As interpersonal communication among individuals remains a vital means ofunderstanding and connection, particularly in situations where physical proximity is not feasible, the necessity for such communication channels is paramount. Throughout the millennia, humanity has strived to maintain connectivity, facilitating this process in themost efficient manner possible. In contemporary times, this process has been significantly streamlined, enabling seamless contact with individuals thousands of kilometers awaywithin a matter of seconds.

The earliest incarnation of instant messaging emerged in the early 1960s at MIT, with the commercialization of internet messaging concepts beginning two decades later [1]. Concurrently with the rise of social networks such as Facebook, various messaging applications, including Messenger and WhatsApp (acquired by Facebook), proliferated. In their nascent stages, these applications offered fundamental features typical of messaging platforms, including:

- Real-time multimedia exchange
- Message encryption through hashing
- Search and archival functionalities for conversations with single or multiple users

Regardless of the robustness of an application's security measures or claims of user-centric design for safety, the potential for lapses exists, as exemplified by Facebook's handling of personal data [2]. Conversely, open-source applications mitigate such concerns,as their underlying architecture is transparent, allowing scrutiny by individuals knowledgeable in the field. Telegram, for instance, exemplifies this approach [3].

Telegram, an open-source messaging application, shares similarities with WhatsApp Web in terms of visual motifs and functionalities, reflecting a research-driven borrowing of design elements and features.

2. DESIGNING A COMPREHENSIVE MESSAGING SYSTEM WITH VUE AND FIREBASE

In the development of a user-friendly messaging system catering to diverse users, it is essential to incorporate both foundational and advanced functionalities. These functionalities encompass:

- **Intuitive User Interface**: A simplistic and easily understandable interface is crucialfor facilitating seamless user interaction.
- **Persistent Data Storage**: Ensuring the permanent storage of data guarantees the continuity and accessibility of conversations.
- **Private Messaging**: Facilitating private conversations between two users, allowingthe exchange of textual and multimedia content.
- **Message Encryption**: Implementing robust encryption mechanisms such as MD5 hashing and unique keys for user-specific content security.
- **Real-Time Content Exchange**: Leveraging web sockets for instantaneous content sharing.
- **Group Conversations**: Enabling discussions among multiple users with features suchas threaded messages and specialized channels for distinct topics.
- **Message Highlighting**: Marking messages as important, ensuring their prominent visibility within conversations (pinned messages).
- **User Customization**: Allowing users to personalize their experience by adjusting settings such as themes, background images, font styles, and restricting settings for other users.
- **User Permissions**: Empowering administrators to manage user privileges within group conversations, including message type restrictions and conversation prohibitions.
- **User Search and Invitation**: Facilitating user discovery and group participationthrough search functionality and invitation codes.
- **Browser Notifications:** Utilizing the Notifications API for timely user alerts andupdates.
- **Authentication and Authorization**: Implementing secure authentication andauthorization mechanisms to safeguard user accounts and data.
- **Personal Conversations**: Enabling users to engage in conversations with themselvesfor personal notes or multimedia sharing purposes.
- **Message Editing and Deletion**: Providing users with the ability to edit and delete messages for enhanced control over conversation content.
- **Conversation Archiving**: Allowing users to archive conversations for futurereference and retrieval.

The application is developed using the Vue framework for interface creation, complemented by Firebase services for backend functionalities. While Firebase offers expedited implementation 2 through pre-built services such as real-time database synchronization and authentication, its reliance on a non-relational database model poses challenges for complex data relationships and specialized data types. Despite these challenges, the integration of Vue and Firebase offers a pragmatic solution for crafting efficient and feature-rich messaging systems, empowering developers to streamline development processes and enhance user experiences. [5]

Firebase offers a user-friendly approach to integrating pre-built services into applications, sparing users the complexities of manual implementation. Some of these services include:

- **Database Management**: Firebase provides a robust database solution, simplifying data storage and retrieval processes for developers.
- **Real-time Data Synchronization**: With Firebase's real-time synchronization capabilities, applications can seamlessly update and display data across devices instantaneously.
- **Authentication and Authorization**: Firebase streamlines user authentication and authorization processes, ensuring secure access to application resources.
- **Monetization and Payment Integration**: Firebase offers tools for monetizing applications and integrating payment functionalities, facilitating revenue generation.
- **Advertising Solutions**: Firebase provides advertising solutions to help developers monetize their applications through targeted ads and analytics.

While Firebase's services offer ease of implementation, thinking outside the box and utilizing them for specialized use cases can be challenging. Developers may encounter limitations when attempting to apply these services in unconventional scenarios, despite their ease of implementation.[7] Firebase simplifies application development with its comprehensive suite of services, developers must carefully consider how to creatively leverage these tools to address unique and specialized requirements effectively.

3. PROGRESSIVE FRAMEWORK FOR STREAMLINED WEB DEVELOPMENT

Over the past few decades, the development of websites and applications has evolved to become increasingly sophisticated and complex, offering users a plethora of features that developers would otherwise spend countless hours implementing from scratch.

In contrast to frameworks like React and Angular, Vue.js stands out as a progressive framework developed not by a mega corporation, but by former Google employee Evan You. This departure from larger firms marked a significant step forward for the web development community. Vue.js is designed as a progressive framework for building user interfaces, distinguished by its incremental adaptability throughout the application development process.

Unlike monolithic frameworks, Vue.js focuses exclusively on the view layer of the three-tier web application architecture, making it straightforward to learn and integrate into existing projects. Its modular and incremental approach allows developers to incorporate Vue.js components seamlessly, enhancing project scalability and maintainability.

Vue.js empowers developers to build dynamic and interactive user interfaces with ease, offering a balance between simplicity and flexibility. Its growing popularity within the web development community attests to its effectiveness in streamlining the development processand fostering innovation in web application design.

4. FRAMEWORK SIMILARITIES AND DISTINCTIONS IN MODERN WEB DEVELOPMENT

In many aspects, all frameworks share similarities, as they leverage virtual DOM, enable reusable component usage, and boast large user communities that augment missing features such as routing and global application state management. React, for instance, utilizes JSX, a combination of HTML and JavaScript, in its syntax, while Vue and Angular adhere to the traditional layout of web pages: HTML templates, scripts, and CSS styles.

Angular, at its core, employs a strict application-writing system based on TypeScript, a superset of JavaScript that adds numerous capabilities such as data type definitions for enhanced code organization and execution stability. While other frameworks can alsoutilize TypeScript, it is strongly encouraged in Angular due to its significance in maintaining large codebases with clearly defined data models. Additionally, Angular distinguishes itself by offering built-in functionalities like routing and global application state management, whereas other frameworks rely on user-designed libraries for these features, presenting both strengths and weaknesses.

Despite these differences, the overarching goal of all frameworks remains consistent: to facilitate efficient and scalable web application development. Each framework offers unique advantages and trade-offs, catering to diverse developer preferences and project requirements in the ever-evolving landscape of web development.

Vue.js, renowned for its simplicity and versatility, offers a range of powerful features that streamline web application development:

- **Declarative Rendering**: Vue.js enables developers to describe the desired UI state, allowing for efficient and intuitive rendering of components.
- **Conditional Interface Rendering**: Developers can conditionally display elements based on specified criteria, enhancing the flexibility and adaptability of the userinterface.
- **Iterative Component Composition**: Vue.js facilitates the creation of dynamic interfaces through the use of loops, enabling the repetition of UI elements with ease.
- **Form Input Handling**: Vue.js simplifies the management of user input via forms and related elements, providing seamless interaction and data submission.
- **Component-based Architecture**: Vue.js promotes modularity and functionality granularization, allowing developers to build reusable and maintainable components.
- **Event Handling**: Vue.js offers robust event handling capabilities, allowing developers to respond to user actions efficiently and effectively.
- **Server-side Rendering**: Vue.js supports server-side rendering, enhancing performance and SEO optimization for web applications.
- **Data Reactivity**: Vue.js ensures data reactivity, automatically updating the UI in response to changes in data state, thereby providing a seamless and dynamic user experience.
- **Backwards Compatibility**: Vue.js maintains compatibility with older browsers, ensuring broader accessibility and usability across various platforms and devices.

These features collectively contribute to Vue.js's reputation as a user-friendly and powerful framework, empowering developers to create sophisticated web applications with ease and efficiency.[6]

5. APPLICATION OVERVIEW: WHATSAPP WEB WITH DISCORD-INSPIRED FUNCTIONALITIES

As previously mentioned, the application offers extensive capabilities and, in its final form, bears resemblance to WhatsApp Web, with a significant portion of functionalities inspired by the Discord messaging application.

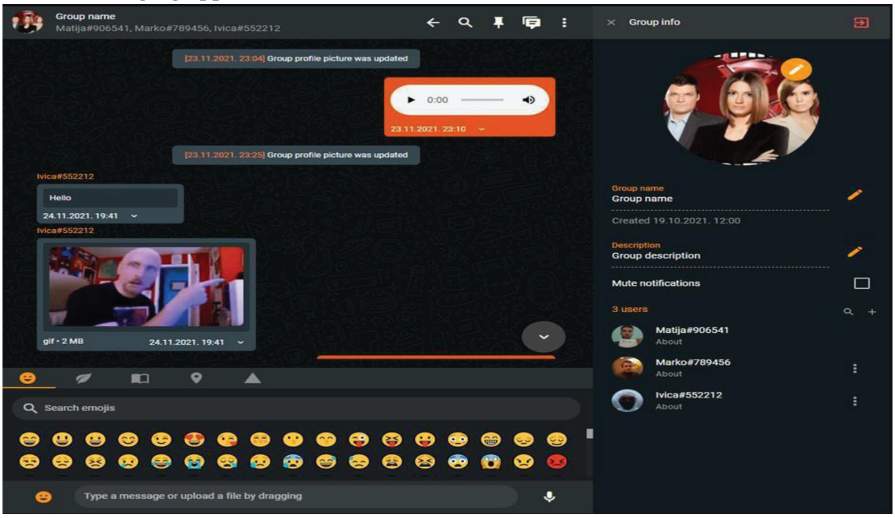


Figure 1 - group conversations are intuitively organized to facilitate seamless communication among participants

On the homepage, the left side features a list of conversations, while the central area constitutes the main part of the application - the conversations themselves. Users can initiate new conversations, adjust settings, create group chats, and more. Within groupchats, users have the ability to manage conversation privileges.

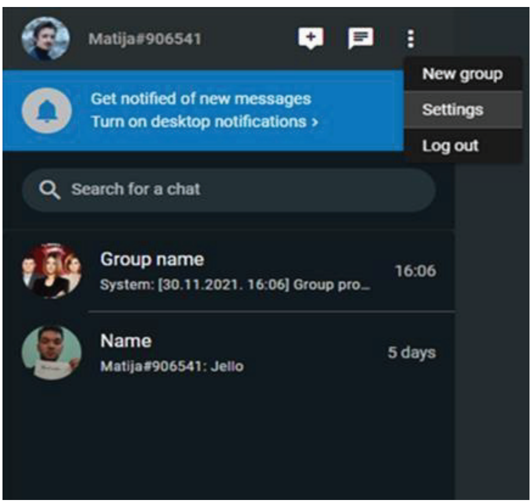


Figure 2 - the conversation list provides users with an organized overview of their ongoing and past conversations.

Conversation privileges pertain to the ability to send specific types of messages, send messages at all, and edit group details.

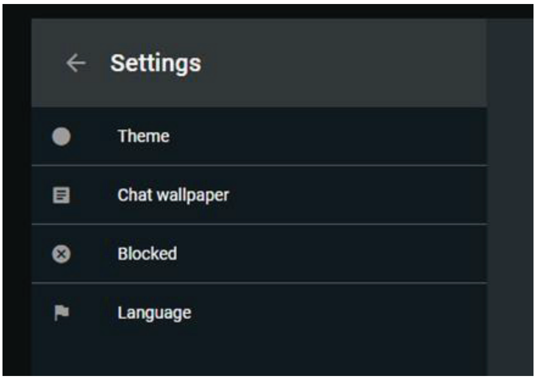


Figure 3 - The user settings section of the application offers users control over their individual preferences and configurations.

Some of the settings include language selection (English or Croatian), choice of dark or light theme for the application, a list of blocked users, and background image customization for conversations.

6. CONCLUSION

Through the conducted investigation, the process of developing a messaging web application and the technologies utilized have been documented. While the chosen technologies could facilitate the creation of a messaging web application, they may not necessarily be the optimal choice for the intended goal. Although Firebase offers a plethora of ready-made services and functionalities, they may not be suitable in specific cases, and it may be better to opt for "handcrafted" functionalities.

For instance, the primary challenge encountered during application development was the suboptimal selection of the database. A database with the capability to establish relationships would have been a much better choice for the system's structure. Similarly, a backend API supporting sockets would have provided greater control over real-time content monitoring. Nonetheless, the application developed fully aligns with the previously outlined requirements and can be seamlessly utilized for both personal and professional purposes.

While the process of developing a messaging web application revealed certain shortcomings in technology selection, the resultant application meets the specified criteria effectively. Despite the suboptimal choices in database and backend API, the application remains fully functional and suitable for private or professional use. Moving forward, a reassessment of technology choices may be beneficial to further optimize performance and functionality in future iterations.

REFERENCES

[1] Chau, G.; Vue.js 2 Web Development Projects, Packt Publishing, ISBN 978- 1787127463, (2017)

[2] Kumar, A.; Mastering Firebase for Android Development: Build real-time, scalable, and cloud-enabled Android apps with Firebase, Packt Publishing, ISBN 978- 1788624718, (2018)

[3] Hernandez, M. J.; Database Design for Mere Mortals: A Hands-On Guide to Relational Database Design, Addison-Wesley Professional, ISBN 978-0201752847, , (2003)

[4] Casciaro, M.; Mammino, L.; Node.js Design Patterns - Second Edition: Master best practices to build modular and scalable server-side web applications, Packt Publishing, ISBN 978-1785885587, (2016)

[5] Vemula, R.; Real-Time Web Application Development: With ASP.NET Core, SignalR, Docker, and Azure, Apress, ISBN 978-1484232699, (2017)

[6] Macrae, C.; Vue.js: Up and Running: Building Accessible and Performant Web Apps, O'Reilly Media, ISBN 978-1491997246, (2018)

[7] Mohammed, Z.K..; Angular Projects: Build nine real-world applications from scratch using Angular 8 and TypeScript, Packt Publishing, ISBN 978-1838559359, (2019)

[8] Date, C. J.: Introduction to Database Systems, An 8th Edition, Pearson, ISBN 978-0321197849, (2003)

POTENTIAL RISKS OF INVASIVE ALIEN PLANTS IN HISTORIC CENTRE OF KARLOVAC

Marko Ožura[1], Nina Popović[1], Zrinka Mesić[1]

[1]Karlovac University of Applied Sciences, Trg J. J. Strosmayera 9, Karlovac, Croatia
(marko.ozura@vuka.hr)

Abstract: *Cultural and historical parts of cities often include areas of collapsed or severely neglected buildings, where invasive plants can occur. Establishment of invasive alien plants in urban historic centres is not considered to be a significant problem because the majority of IAS plants are successfully controlled. However, property-unmanaged sites in historic town centres can pose a risk for the spread of IAS to natural habitats. The aim of this research was to investigate occurrence and spread of invasive plants in urban historic centre of Karlovac, their potential impact on buildings and structures, and also to detect critical points and corridors of expansion into natural habitats. A total of five invasive plant species were recorded, whose numbers increased till 2023. Management of invasive plants in historic centre of Karlovac should continue to consist in removal and safe disposal of the target species.*

Keywords: *invasive plants, cultural heritage, urban forestry, Karlovac*

1. INTRODUCTION

The protection of cultural heritage is a complex process, and on most of the buildings in historical parts of the city it is possible to see the layering of time epochs and the residents' living needs [1,2]. Living in urban historic centres also has certain limitations in the use of modern elements and materials in the maintenance-reconstruction of buildings. The protection conditions of the Ministry of Culture and Media, the complexity of ownership and the financial limitations of residents result in inadequate reconstruction or the abandonment of buildings. The negative impact of moisture in the walls cause various damages on the buildings and favorable conditions for the growth of invasive alien species on walls and roofs [3].

Areas of collapsed or severely neglected buildings, in Croatia especially after the earthquakes in 2020 and 2021, are recognized as hotspots of invasive alien species. Compared to data from 2016 number of IAS species and individuals in the historical centre of Karlovac increased [4]. Woody IAS species in park areas are not considered to be a significant problem because parks are regularly maintained. However, property-unmanaged sites in historic town centre can become a focal point for the spread of IAS to natural habitats. The location of the protected Karlovac cultural and historical urban complex (Z – 2993) is just 2000 m apart from natural habitats of the rivers Korana and Kupa.

2. MATERIALS AND METHODS

Field survey was carried out during October 2023 in the southeastern part of the city of Karlovac, in the area of the historical centre of the city of Karlovac and the surrounding area of the uninhabited periphery towards the rivers Kupa and Korana. We surveyed the same sites from 2016 [5] onwards and analysed changes in the diversity of IAS plants, with focus on woody species. To analyse the direction of spread of IAS plants we added the information on dispersal strategies.

3. RESULTS

A total of five invasive plant species were recorded. The invasive species whose numbers increased till 2023 are: *Acer negundo* L. (93 occurrences in 2016 vs. 208 in 2023), *Robinia pseudoacacia* L. (82 in 2016 vs. 195 in 2023) and *Ailanthus altissima* (Mill.) Swingle (5). We also detected occurrence of two perennial taxa: *Reynoutria* sp. and *Amorpha fruticosa* L.. After mapping of IAS plants, potentially critical points and corridors of expansion were determined (Fig. 1.).

The increase in the number of individuals does not have as much impact as the way of maintenance. What has also been recorded in the field is inadequate destruction of plant material. Corridors between the urban center, enriched with green areas and woody plantations, with the peri-urban ring of natural habitats (lawns and rivers) represents a source of danger for the spread of invasive alien plant species through traffic and horticulture.

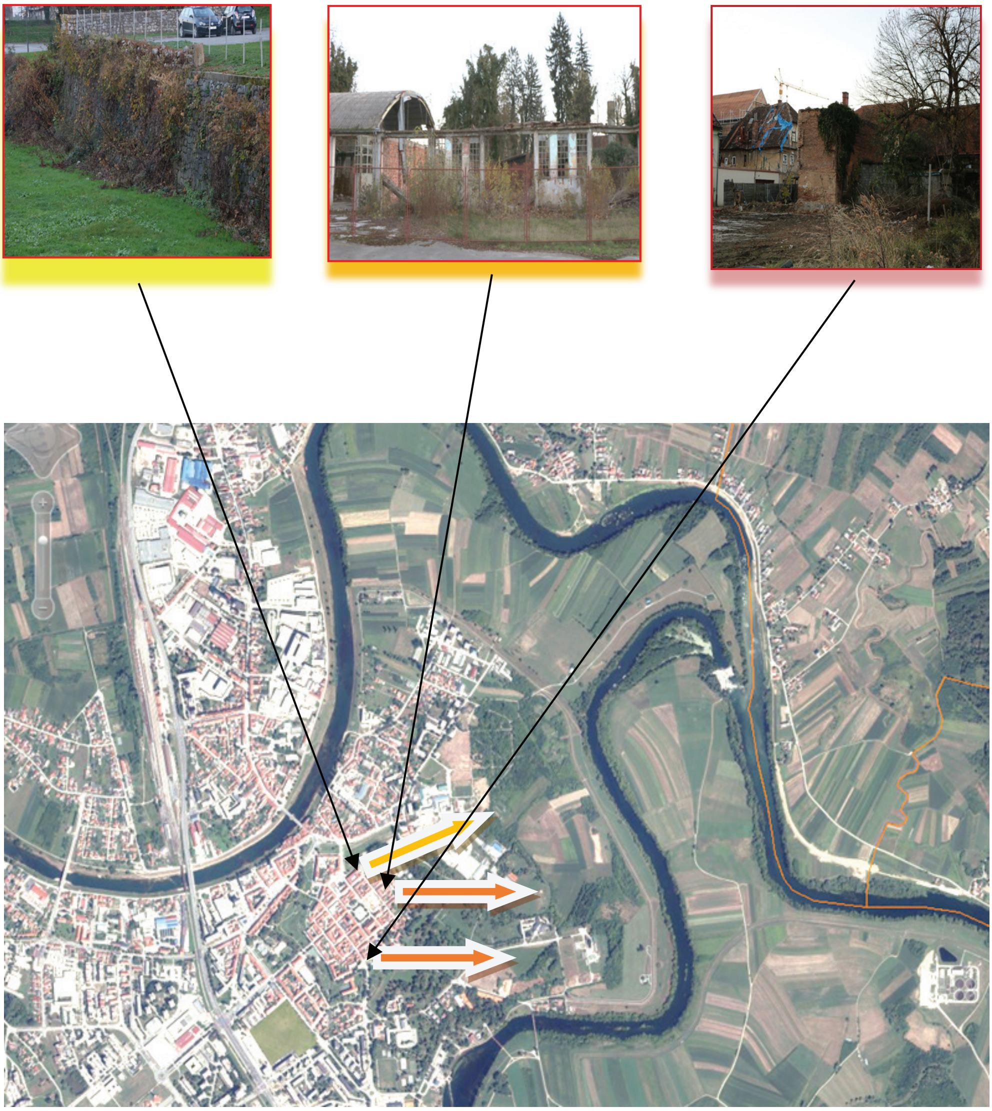


Figure 1: Schematic representation of the locality in historic centre and the corridor of IAS expansion into the natural habitat along the rivers

3. CONCLUSION

IAS plants generally do not pose a significant risk in urban areas with planned management and constant monitoring. The occurence of *Amorpha fruticosa* along the Korana river is a result of spread due to floods that frequently occur in the Karlovac area. Neglected private areas and construction sites are proven hotspots for spreading of IAS plants into natural habitats. It is necessary to monitor the identified corridors in order to prevent spread of problematic species. Management of invasive plants in culturally protected centre of Karlovac should continue to consist in removal and safe disposal of the target species. Also, the education of municipal workers, workers from the water protection and management sector contributes to controlling the spread of IAS species.

Research and education will not completely eliminate the problem of invasive alien plant species, but only slow down their spread into natural habitats. The broad environmental tolerances of IAS plants enables rapid spread.

REFERENCES

[1] Shackleton, R. T.; Bertzky, B.; Wood, L. E.; Bunbury, N.; Jager, H.; Van Merm, R.; Sevilla, C.; Smith, K.; Wilson, J. R. U.; Arne, B. R.; • Richardson, D. M.: Biological invasions in World Heritage Sites: current status and a proposed monitoring and reporting framework, *Biodiversity and Conservation* Vol. (2020) No. 29.

[2] Celesti-Grapow, L.; Ricotta, C.; Plant invasion as an emerging challenge for the conservation of heritage sites: the spread of ornamental trees on ancient monuments in Rome, Italy, *Biol Invasions* Vol. (2021) No. 23.

[3] Marinković,V.: Dioklecijanova palača i srednjovjekovna jezgra grada Splita – Priručnik za održavanje povjesnih građevina i postupanje u kriznim situacijama, Htvatski restauratorski zavod, Zagreb, (2023)

[4] Ožura, M., Popović, N., Mesić, Z.: The occurrence of invasive alien species (IAS) in protected historic town centres as a source of threat to natural habitats, Book of Abstracts, 5th Croatian Symposium on Invasive Species Zagreb, Croatia, 27-28. XI 2023.

[5] Ožura, M, Šag M. Drvenaste invazivne vrste gradskih područja u Karlovcu. Zbornik radova Međimurskog veleučilišta u Čakovcu. 2018;9(1):59-64. Dostupno na: https://hrcak.srce.hr/202077

FIRE RESEARCH USING FIRE DYNAMICS SIMULATOR SOFTWARE PACKAGES

Dušica J. Pešić[1], Darko N. Zigar[2], Srđan M. Glišović[3], Aca V. Božilov[4]

[1]University of Niš, Faculty of Occupational Safety in Niš, Čarnojevića 10a, Niš, SERBIA, dusica.pesic@znrfak.ni.ac.rs

[2]University of Niš, Faculty of Occupational Safety in Niš, Čarnojevića 10a, Niš, SERBIA, darko.zigar@znrfak.ni.ac.rs

[3]University of Niš, Faculty of Occupational Safety in Niš, Čarnojevića 10a, Niš, SERBIA, srdjan.glisovic@znrfak.ni.ac.rs

[4]University of Niš, Faculty of Occupational Safety in Niš, Čarnojevića 10a, Niš, SERBIA, aca.bozilov@znrfak.ni.ac.rs

Abstract: *Nowadays, Computational Fluid Dynamics (CFD) modelling is used in studies of turbulent flows such as fire. Fire Dynamics Simulator (FDS), an open-source CFD software package, is widely used for fire-related studies, because it is suitable for a wide range of thermally driven flow scenarios both outdoors and inside a built environment. It can be used for investigation of fire dynamics, design of fire protection systems, and fire forensics. Fire dynamics research includes the analysis of basic fire parameters. FDS is applied to predict the fire spread and smoke flow in order to select the appropriate fire alarm and extinguishing systems. In forensic research, it is used in the reconstruction of fire accidents. In addition to indoor fire simulation, upgrades to the FDS package can also be used for simulating outdoor fires, especially forest fires (WFDS – Wildland-Urban Interface Fire Dynamics Simulator), as well as for calculating the required time of safe evacuation of people from a fire-affected area (FDS+Evac).*

Keywords: *fire, CFD modeling, Fire Dynamics Simulator software package*

1. INTRODUCTION

With the advancement of technology, the risk of fires has significantly increased due to its increased complexity. Nowadays, fires are present in all activities, often accompanied by human casualties, substantial material damage, and environmental pollution. To avoid or minimize these accidents to the greatest extent possible, it is necessary first and foremost to assess the risk of their occurrence, and then to implement measures to reduce the probability of their occurrence, as well as to mitigate their consequences.

For the purpose of risk assessment, it is essential to understand fire dynamics and all the parameters associated with it. In fire protection engineering, these parameters are accounted for with varying levels of accuracy, ranging from simplified analyses using theoretical models, strictly empirical models, and semi-empirical models to sophisticated investigative methods. The computer technology growth has led to the development of numerous computational models applied to fire studies. Since the deterministic numerical methods, such as Computational Fluid Dynamic (CFD) techniques, are fast and the results can be obtained at almost no cost, they have been widely used across disciplines such as thermodynamics, fluid mechanics, combustion science, fire engineering, environmental engineering, etc.

CFD techniques include the Reynolds-averaged Navier-Stokes equation (RANS) method, Direct Numerical Simulation (DNS), and Large Eddy Simulation (LES). While most numerical studies use the RANS approach, there is a consensus on the fact that LES is more accurate for modelling fire-induced flow, because it is a CFD method, which is capable of predicting unsteadiness in turbulent flows [1]. In the past decades, several commercial CFD software packages, such as Ansys Fluent, Ansys CFX, Phoenics, Smartfire, etc., have been developed for fire modelling. In fire engineering, Fire Dynamics Simulator (FDS) software package has become a commonly used CFD code for fire dynamics modelling and simulation of fire-induced environments.

2. FIRE DYNAMICS SIMULATOR

FDS is an open-source 3D CFD software package developed by the National Institute of Standards and Technology [2]. Since FDS is a model of fire-driven fluid flow, it numerically solves a form of the Navier-Stokes equations approximated for low-speed thermally-driven fluids. The governing equations are the following: conservation of mass, which can be expressed either in terms of the density or the mass fractions of the individual gaseous species; conservation of momentum; conservation of energy, which is written in terms of the sensible enthalpy; and equation of state for an ideal gas.

The equations presented above can be treated as the DNS or the LES method. For DNS, the dissipative processes of thermal conductivity and material diffusivity are computed directly. In LES, the large-scale eddies are resolved while those smaller than the grid cell sizes, also known as sub-grid scale eddies, are modelled. Consequently, LES is more accurate for investigating fire accidents.

3. USING THE FIRE DYNAMICS SIMULATOR IN FIRE RESEARCH

Within the last few years, FDS has been widely applied to a wide range of fire scenarios both inside built environments and in outdoor spaces. It can be used for investigation of fire dynamics, design of fire protection systems, and fire forensics.

3.1. Fire dynamics

Fire dynamics in the compartment is largely dependent on the quantity of fire load mass and the heat release rate during the fire. The heat produced by fire affects the heating and ignition of surrounding flammable materials that can significantly affect the speed of fire spread. FDS is widely used to simulate building fire dynamics (Fig. 1) [3].

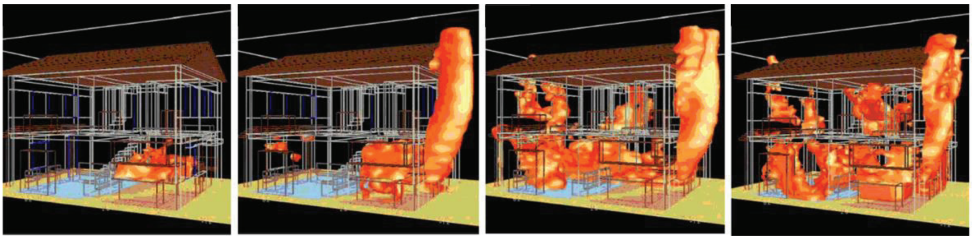


Figure 1: Fire dynamics in a building

A building fire can also be a significant source of air pollution when the compartment fire becomes fully developed and its plume ejects from the openings after the window glass is broken. The adhered fire plume is formed along the external wall of the building. When there is no wind, the spill buoyancy-driven plume rises vertically upward along the building wall and leaves the street top. However, when the wind velocity reaches critical value, the fire products touch the walls of the buildings on both sides of the street and heavily pollute the air (Fig. 2) [1]. The numerical results can be used for air pollution level assessment; risk assessment for the health of occupants in building compartments and pedestrians on the ground level of the street; and air quality control strategies.

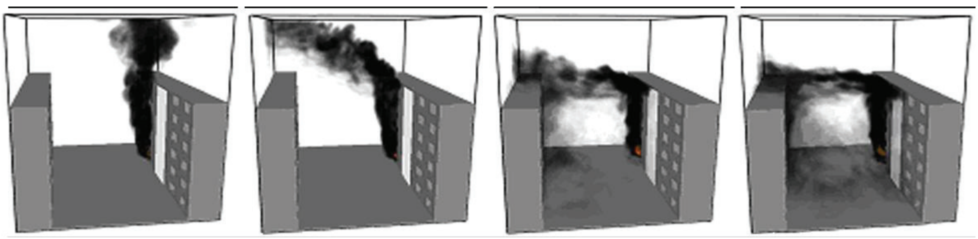


Figure 2: Air pollution inside a street due to a fire accident

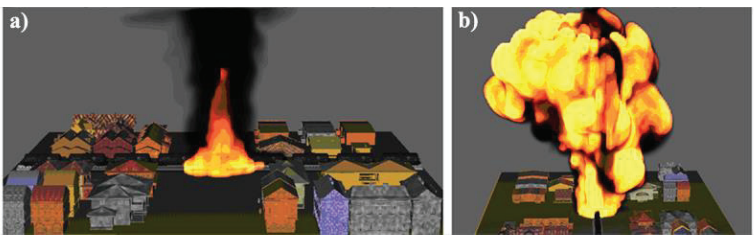


Figure 3: Possible accidents during petrol rail transport: (a) Pool fire; (b) "BLEVE"

Transport of fuel and chemicals through heavily populated areas and towns occurs regularly in many regions worldwide because it is often nearly impossible to find alternative supply routes. The potential dangers caused by chemical accidents and their effects on both inhabitants and the environment of urban settlements can be predicted using FDS. Simulations of pool fire and BLEVE (*Boiling liquid expanding vapour explosion*) of flammable liquids are presented in Fig. 3.

3.2. Fire protection

Determination of optimal safe distance between buildings is a task of many safety and economic analyses. Generally, it is known that increasing separation distance increases the fire protection of an adjacent building, but decreases the cost effectiveness of urban solutions. Therefore, based on the critical heat flux value of 12.6 kW/m^2 adopted in many building codes [4, 5], FDS can be used to determine optimal separation distance required for preventing fire spread between multi-storey buildings (Fig. 4) [6] or residential houses (Fig. 5) [3]. The numerical results can be used in spatial planning of cities and design of buildings to determine the safe separation distance between buildings for the purpose of fire protection.

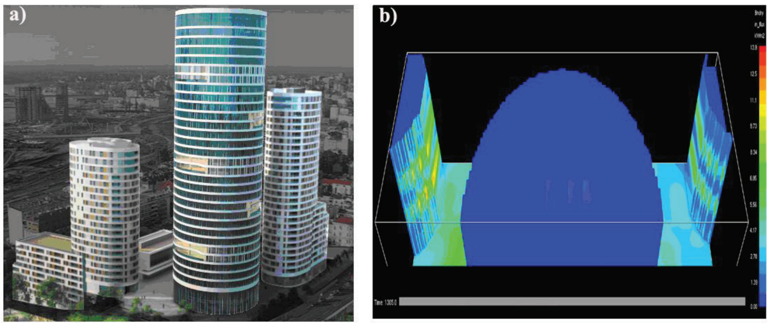


Figure 4: (a) Real high-rise buildings (b) Intensities of heat fluxes on the façades of buildings

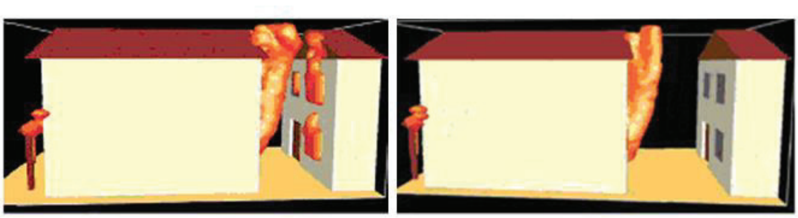


Figure 5: Determination of optimal safe distance between two-storey houses

Deployment of active fire protection, i.e. effective fire alarm and suppression systems, are an important aspect of the fire safety design of building structures. One of the most challenging issues in fire protection engineering is the design of suitable fire alarm systems. FDS is widely applied to predict the fire spread and smoke flow in order to select the detector's position (Fig. 6) and smoke detector response time (Table 1) [7].

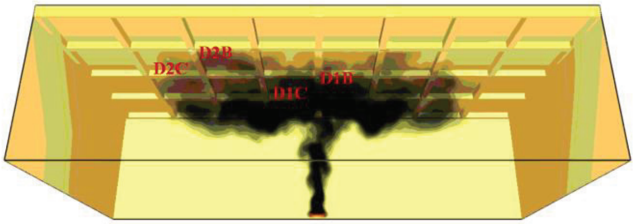


Figure 6: Determination of optimal position of fire detectors

Table 1: Smoke detectors response time

Time [s]	Obscuration [%/m]		Time [s]	Obscuration [%/m]	
	D1B	D1C		D2B	D2C
54.01	6.87	**23.01**	**70.22**	19.17	**26.50**
66.60	**52.82**	62.33	**84.60**	**53.36**	47.43

FDS can also be a useful and accurate tool for modelling smoke production and sprinkler activation times (Fig. 7) [8]. Simulation results of the effects of a sprinkler system in a model of a garage showed that the activation of the sprinklers retarded temperature rise and delayed the occurrence of flashover. Therefore, the sprinkler systems provide a significant advantage for egress time and tenability conditions for fires, and the period of structural integrity for the supporting garage construction members.

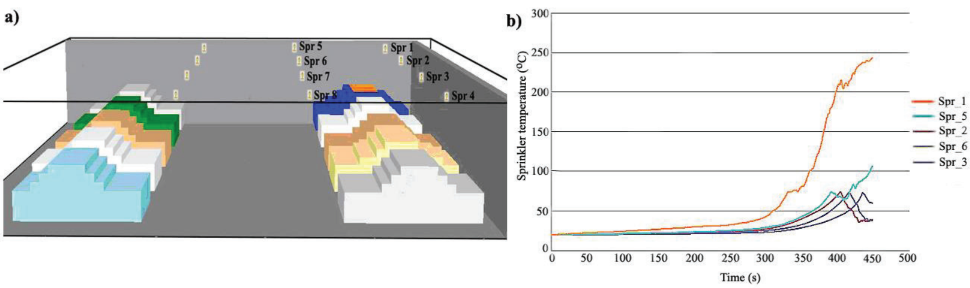


Figure 7: Sprinkler system: (a) Numerical model; (b) Sprinkler activation times

3.3. Forensic fire research

While the use of computational models to simulate fire dynamics is relatively common, forensic analysis of fire causes is less common. However, FDS is currently one of the most popular software tools, with excellent application in researching such events. Numerical simulations of various fire scenarios, based on photos and video recordings from surveillance cameras, along with on-site evidence analysis and firefighter reports, provide a better understanding of fire sources and dynamics (Fig. 8).

Figure 8: (a) Real fire (b) Simulated fire

4. CONCLUSION

In fire engineering, understanding fire dynamics is crucial for implementing preventive fire protection measures.

However, rapid evacuation of occupants is equally vital during fire incidents. Human evacuation, particularly from upper floors of high-rise buildings, poses significant challenges and becomes a major safety concern. Hence, the FDS+Evac program has been developed, integrating field modelling and psychophysical characteristics of individuals to calculate the necessary evacuation time from fire-affected areas [9].

In addition to simulating fires in enclosed spaces, buildings, tunnels, etc., CFD models can also be used to simulate fires in outdoor environments, especially for forest fire simulations. For example, WFDS (Wildland-Urban Interface Fire Dynamics Simulator) is a specialized enhanced version of FDS created by adding specific algorithms for modelling surface and high vegetation into the program's base code [10]. WFDS has been used extensively in studies of forest fires dynamics, fire investigation, preparation of firefighting plans and tactics, as well as assessment of potential consequences of forest fires.

The paper is supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (contract no. 451-03-66/2024-03/200148).

REFERENCES

[1] Pesic, D.J., Zigar, D.N., Anghel, I. & Glisovic, S.M.: Large Eddy Simulation of wind flow impact on fire-induced indoor and outdoor air pollution in an idealized street canyon, *Journal of Wind Engineering and Industrial Aerodynamics,* 155 (2016), pp. 89-99, ISSN 0167-6105

[2] McGrattan, K., Hostikka, S., Floyd, J., McDermott, R., Vanella, M., Mueller, E.: *Fire dynamics simulator (Version 6) technical reference guide, volume1: Mathematical model*. NIST Special Publication, Gaithersburg, (2023)

[3] Pesic, D., Zigar, D., Raos, M. & Anghel, I.: Simulation of Fire Spread between Residential Buildings Regarding Safe Separation Distance, *Technical Gazette,* 24 (2017) 4, pp. 1137-1145, ISSN 1848-6339

[4] NFPA 80A: Recommended Practice for Protection of Buildings from Exterior Fire Exposure. National Fire Protection Association, Quincy, 2022.
[5] Approved Document, Part B: Fire safety. The Building Regulations 2010, 2019 edition. Department for Communities and Local Government, London, 2019.
[6] Pešić, D.J., Blagojević, M.Đ. & Zigar, N.D.: Heat Flux as a Parameter of Vulnerability of Multi-storey Building Structures Exposed to Fire – a Numerical Study, *Structural Integrity and Life*, 22 (2022) 1, pp. 29–35. ISSN 1451-3749
[7] Zigar, N.D., Blagojević, M.Đ., Pešić, D.J., Božilov, A.V. & Nikolić V.D.: Smoke Detector Placement at Compartments with Honeycomb Ceiling – a Numerical Study, *Thermal Science* 27 (2023) 3, pp.2489-2500, ISSN 0354-9836
[8] Pesic, D.; Blagojević, M.; Milošević, L. & Milojević, M.: Garage Fire with and without Sprinklers Using FDS, *Proceedings of Safety of Technical Systems in Living and Working Environment - STS 2011,* Petković, D. (Ed), pp. 61-66, ISBN 978-86-6093-035-6, Niš, 27-28, 2011, Faculty of Occupational Safety in Niš, Niš (2011)
[9] Hostikka S., Korhonen T., Paloposki T., Rinne T., Matikainen K. & Heliövaara S:. *Development and validation of FDS+Evac for evacuation simulations*, VTT Technical Research Centre of Finland (2007)
[10] Rehm, R.G. & McDermott, R.J.*: Mathematical Modeling of Wildland-Urban Interface Fires*, National Institute of Standards and Technology, Gaithersburg, (2011)

THE IXODES RICINUS TICK – THE VECTOR OF HUMAN BABESIA IN CROATIA AND EUROPE

Krunoslav Pintur[1], Tomislav Dumić[1], Relja Beck[2]

[1] Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9, Karlovac, CROATIA, krunoslav.pintur@vuka.hr

[2] Croatian Veterinary Institute, Savska cesta 143, Zagreb, CROATIA, beck@veinst.hr

Abstract: *Babesiosis is a worldwide tick-borne zoonosis caused by hemoprotozoan parasites of the genus Babesia. Zoonotic babesiosis is described as an emerging disease. Many species of the genera Babesia parasitize in domestic and wild mammals. The causative agents of human babesiosis in Europe are B. divergens, B. venatorum, B. microti and B. crassa-like. In Croatia, the species B. divergens and B. microti have been confirmed in humans. The primary vector of babesia in Europe and Croatia is the Ixodes ricinus tick. Reservoirs of babesia are small mammals, domestic and wild ruminants (cervids).*

Keywords: *Babesia, zoonosis, tick, Ixodes ricinus*

1. INTRODUCTION

Ticks are obligate hematophagous ectoparasites and important vectors of viruses, bacteria, rickettsiae and protozoa, of human and veterinary significance (4,24,39). Beck et al. (2016) emphasize that ticks are after mosquitoes, the most important vectors of human and animal diseases in the world. Thus, *Ixodes ricinus* ticks transmit numerous pathogens, including the bacteria *Anaplasma phagocytophilium*, *Rickettsia helvetica*, *R. monacensis*, *Borriela burgdorferi sensu lato*, tick-borne meningoencephalitis virus and protozoa of the genus *Babesia* (19,24,33,39). *Ixodes ricinus*, known as the sheep, deer or forest tick is the most common species in Europe (10,21,24). This specie of tick is widespread throughout Croatia (4,10,12,24,26). This tick is a generalist and is adapted to a wide range of environmental conditions, with its range of distribution determined by environmental and climatic conditions (28). In Croatia, it has been recorded in all three biogeographic regions - Mediterranean, Alpine and continental (39). It feeds on blood of various wild and domestic animals and its primary habitats are moist deciduous or mixed forests. During recent years and related to climate changes, ticks have expanded their distribution limits within Europe, both in altitude and in geographical range (1,14,28). The change in the distribution of certain tick species in regions where they were not previously present carries the risk of transmission of various types of pathogens carried by ticks (1,34).

In addition to bacteria, rickettsia and viruses, ticks can also transmit parasites, protozoa from the genus *Babesia*. They are obligate intracellular protozoa of humans and animals. In the carrier, they parasitize exclusively in erythrocytes. They have a very complex developmental cycle that, apart from the asexual phase, also includes the sexual phase that takes place in the tick (25). Mammals are parasitized by numerous species of babesia that are variously pathogenic, with four species of babesia recognized as the causative agents of human babesiosis in Europe: *B. divergens*, *B. venatorum*, *B. microti* and *B. crassa*-like (15,23). Babesia is usually transmitted to humans through ticks and rarely through blood transfusion, perinatally or organ transplantation. The course of the disease can vary, from completely subclinical, through mild non-specific manifestations to fatal, multisystem disease (2). Clinical symptoms in humans are the result of merozoite release and erythrocyte lysis, and include chills, sweating, headache, myalgia, hemolytic anemia, jaundice, hemoglobinuria, obstruction of renal arterioles, and renal failure (15). In Europe, most severe cases of human babesiosis are related to splenectomy, rudimentary spleen and hyposplenism or some immunosuppressive comorbidities such as hematological malignancies (15).

2. PATHOGENS OF HUMAN BABESIOSIS

Parasites from the genus *Babesia* have been the subject of research since 1888, but only the application of molecular research based on the analysis of the 18S rRNA gene gave a clear insight into the true genetic diversity of *Babesia* (13,22). It has been proven that the traditional divisions based on the morphology of the parasite, the specificity of the causative agent towards a certain carrier, geographical distribution, specificity of the vector and antigenic properties of babesia are completely insufficient (13,22). Although babesiosis is highly specific towards its carriers, in addition to domestic and wild animals, more than 60 cases of human babesiosis have been proven in Europe with *B. divergens*, being the most frequently mentioned as the causative agent and which is also the babesiosis of domestic and wild ruminants (16). Namely, *B. divergens* has been identified as the cause of 70% of human babesiosis cases in Europe (15).

The first case of fatal human babesiosis in Europe and in the world, most likely caused by *B. divergens*, was described by Škrabalo and Deanović (1957) in Croatia, in a 33-year-old farmer who lived near Zagreb and was splenectomized after a traffic accident. At that time, they assumed that it was *B. bovis*, but since it is not present in Europe, the assumption was that it was *B. divergens*.

Recent research has established that in Europe, in addition to *B. divergens*, babesiosis in humans is caused by *B. venatorum* (previously called *Babesia sp*. EU-1), *B. microti*, which is the most significant cause of babesiosis in the USA (13,15) and *B. crassa* – like (23). In Croatia, human infections with the species *B. divergens* and *B. microti* have been proven (2, 24).

Human infections with *B. venatorum* have been reported in Germany, Italy, Poland, Austria and Sweden, also in splenectomized patients, whereby Hildebrandt et al. (2021) state that roe deer is the common reservoir of this Babesia in Europe.

The species *B. divergens* and *B. venatorum* in cervids and ticks in Europe were proven by Casati et al. (2006), Blaschitz et al. (2008), Skotarczak et al. (2008), Malandrin et al. (2010), and in the Croatia by Beck et al. (2008), and Pintur et al. (2022).

B. microti in humans in Europe was confirmed for the first time in Germany. It was a mild disease in a patient who had an intact spleen, but was immunocompromised (15).

After that, more mild and asymptomatic cases were described, which points to the fact that this babesia is present in Europe but is not as contagious or pathogenic to humans as it is in the USA, where it causes about 2000 cases of babesiosis in humans annually. The reservoirs of this babesia are small mammals, and its presence among small rodents in Croatia was confirmed by Beck et al. (2011). In Europe, 13 imported cases of human babesiosis caused by *B. microti* were also described (15).

Two cases of human infection with *B. crassa*-like species have been described in Europe, in Slovenia (37) and France (11). It is a babesia of lower pathogenicity, whose vector, mode of transmission and geographical extension have not yet been fully elucidated. This species was confirmed in humans in China and in ticks of the species *I. persulcatus* and *H. concinna* that fed on sheep (18), in sheep in Iran (35), in goats and ticks in Turkey (31,32), ticks in Hungary (17) and red deer in Croatia (30).

3. BABESIA BIOLOGY

The species of the genus *Babesia* are pear-shaped, round, oval, elongated or amoeboid in shape. They are usually 1.0-4.0 μm long and are obligate intraerythrocytic parasites (9). An important characteristic of babesia are the three stages of reproduction: merogony in erythrocytes, gametogony in the cells of the tick's intestine and sporogony in various organs, and finally in the ovaries and salivary glands of the tick.

3.1. Merogony

About 48-72 hours after the start of bloodsucking, the invaded ticks inoculate the sporozoites of the host into the bloodstream of vertebrates, which is followed by reproduction by double division in erythrocytes (9). Babesia enter erythrocytes by endocytosis, where the entry process itself can be divided into three phases:

1. recognition and acceptance on the erythrocyte membrane by sporozoites;
2. twisting of erythrocytes around the sporozoite without the formation of a parasitophorous vacuole;
3. closing of the erythrocyte membrane after the end of sporozoite invasion.

Merozoites inside erythrocytes appear as single, round, oval, elongated or amoeboid forms, sometimes irregular in shape or pear-shaped in pairs. Based on the size of the merozoite, babesia are divided into small (most often from 1.0 to 2.5 μm) and large (most often from 2.5 to 5.0 μm) (9).

3.2. Gametogony

Once the merozoites reach the tick's intestine, they are phagocytosed by the intestine cells. The first developmental form occurs in the form of a corpuscle that cleaves in the cells of the intestinal epithelium. As it increases, the nuclear material is dispersed in the form of small round formations that grow and develop into gametocytes, which contain gametes (structures that look like an arrow and a long tail) (9). The fused gametes develop into zygotes which develop into kinetes (size 11-15 μm), leave the intestines and enter various organs by hemolymph (29). Considering that kinetes are very mobile in the hemolymph, they can be found already after a few days.

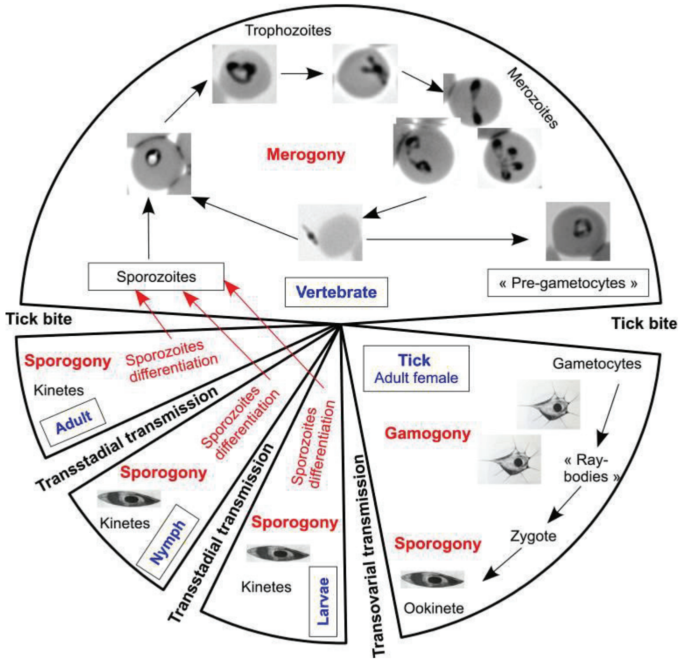


Figure 1: Schematic representation of the life cycle of Babesia (9)

3.3. Sporogony

The process of repeated sporogony and the formation of new kinetes takes place in hematocytes, ovaries, Malphigian tubules, peritracheal tissue and muscles. Once inside the tick egg, the developmental stages continue to reproduce in the egg yolk (transovarial transmission). The daughter cells invade the gut epithelium of the developing larva, where the new generation produces kinetes similar to those in the hemolymph of the parent, which are then disseminated throughout the larval tissues. When the larva begins to feed, the kinetes enter the cells of the alveoli of the salivary glands, where sporozoites are formed. The process of sporogony in salivary glands begins with the double division of the kinetes, which lose their typical organelles, and their three-layer envelope turns into a single membrane and becomes round. Soon, the nucleus also divides, creating two cells. The process is repeated many times during which sporozoites, the invasive stages of the parasite are formed (9).

4. VECTOR BIOLOGY

Ixodes ricinus is a tick of the Palearctic region. The primary habitats of this tick in Europe are moist deciduous or mixed forests, where oak (*Quercus* spp.) and beech (*Fagus sylvatica*) forests are particularly suitable. Its life cycle lasts from two to six years, during which it undergoes an incomplete transformation that includes four stages (egg, six-legged larva, eight-legged nymph and adult form). Larvae and nymphs feed on small mammals (rodents, lizards, etc.), while adults feed on medium and large mammals (domestic and wild animals, humans). They take a blood meal during each developmental stage. The change of carrier during feeding during each developmental stage, as well as the fact that in addition to transstage transmission, transovarian transmission (*B.divergens*) has also been proven in some babesia, makes this tick an ideal vector of babesia (23). To find a host to feed on, ticks climb low vegetation where they wait for an opportunity to attach themselves to the host. After taking a blood meal, they detach and fall into vegetation or leaves, where the adult female lays eggs (2000-3000) (21). After laying the eggs, the female dies.

The layer of leaves on the ground offers ticks optimal humidity (more than 80%) and the possibility of being shielded from direct sunlight (drying). Such moist microhabitats enable ticks to survive long intervals between blood meals. Periods of tick activity throughout the year are bimodal with peaks of activity in spring and autumn (21). In addition to temperature, tick activity is strongly influenced by humidity in the environment and the state of water in the tick's body, especially at high temperatures (21). Developmental diapauses are regulated by the photoperiod, that is, by shortening the length of the day. *I. ricinus* feeds on more than 300 different species of vertebrates, including mammals, birds and reptiles (20). Cervids are very important for the maintenance of tick populations in most habitats, since all developmental stages of ticks can feed on them (21). Tick survival is affected by cold winters without snow and also by long hot and dry periods during summer (sensitivity to desiccation).

5. CONCLUSION

Human babesiosis in Europe is caused by *B. divergens*, *B. venatorum*, *B. microti*, *B. crassa* - like. In Croatia, human infections with the species *B. divergens* and *B. microti* have been proven. The presence of all types of babesia that cause human babesiosis in Europe has been confirmed in animals in Croatia. Babesia reservoirs for humans are small (rodents) and large mammals (domestic and wild ruminants). The two most significant risk factors for human babesiosis are exposure to the *I. ricinus* tick, splenectomy, or immunocompromise of the patient. More than 60 years have passed since the last described case of human babesiosis in Croatia. In that period, no new cases of human babesiosis were described, which does not mean that there were none, especially if we take into account the fact that in Croatia all types of babesiosis that cause human babesiosis in Europe have been confirmed in animals and that the vector is *I.ricinus*, dominant species of tick, present throughout Croatia. This type of tick also most often feeds on humans.

REFERENCES

[1] Alkishe, AA., Peterson, AT., Samy, AM. (2017) Climate change influences on the potential geographic distribution of the disease vector tick Ixodes ricinus. PLoS ONE 12(12): e0189092. https://doi.org/10.1371/journal.pone.0189092

[2] Bajer, A., Beck, A., Beck, R., Behnke, J.M., Dwużnik-Szarek, D., Eichenberger, R.M., Farkas, R., Fuehrer, H.P., Heddergott, M., Jokelainen, P., Leschnik, M. (2022): Babesiosis in Southeastern, Central and Northeastern

Europe: an emerging and re-emerging tick-borne disease of humans and animals Microorganisms, 30;10 (5), pp. 945, doi: 10.3390/microorganisms10050945.

[3] Beck, R. (2015.): Vektorima prenosive bakterijske i parazitarne zoonoze. Zbornik radova Klasične bakterijske i parazitarne zoonoze – Što nas očekuje? Željko Cvetnić (ur.). Zagreb., 60-65.

[4] Beck, R., Bosnić, S., Brezak, R., Šarić, T., Kostelić, A., Lohman Janković, I. (2016.): Krpelji Dalmacije i njihov vektorski potencijal. Zbornik radova 6. Hrvatskog veterinarskog kongresa sa međunarodnim sudjelovanjem. Harapin, I. (ur.). Zagreb., 299-304

[5] Beck, R., Vojta, L., Ćurković, S., Kusak, J., Mrljak, V., Marinculić, A. (2008): Molecular detection of piroplasms infecting cervids in Croatia // Proceedings of the "Xth European Multicolloquium Of Parasitology". Pariz: Société Française de Parasitologie, pp. 198-198.

[6] Beck, R., Vojta, L., Ćurković, S., Mrljak, V., Margaletić, J., Habrun, B. (2011): Molecular survey of Babesia microti in wild rodents in central Croatia // Vector borne and zoonotic diseases (Larchmont, N.Y.), 11, 1; 81-83. doi: 10.1089/vbz.2009.0260

[7] Blaschitz, M., Narodoslavsky-Gfoller, M., Kanzler, M., Stanek, G., Walchnik, J. (2008): *Babesia* Species Occurring in Austrian *Ixodes ricinus* Ticks. Applied and Environmental Microbiology, Vol. 74 (15): 4841-4846.

[8] Casati, S., Sager, H., Gern, L., Piffaretti, J.C. (2006): Presence of potentially pathogenic *Babesia* sp. for human in *Ixodes ricinus* in Switzerland. Ann. Agric. Environ. Med., 13: 65-70.

[9] Chauvin, A., Moreau, E., Bonnet, S., Plantard, O., Malandrin, L. (2009): Babesia and its hosts: adaptation to long-lasting interactions as a way to achieve efficient transmission. Vet. Res., 40(37):1-18.

[10] Cvek, M., Broznić, D., Puškadija, D., Blagonić, B., Kirin, I., Pustijanac, E., Landeka, N., Stojanović, A., Ožanič Bučar, M., Tomić Linšak, D. (2023): Investigation and Spatial Distribution of Hard Ticks by Geographical Information System (GIS) in the Region of Istria, Croatia. *Appl. Sci.*, *13*, 9483. https:// doi.org/10.3390/app13169483

[11] Doderer-Lang, C., Filisetti. D., Badin, J., Delale, C., Clavier, V., Brunet, J. *et al*. (2022): Babesia crassa–Like Human Infection Indicating Need for Adapted PCR Diagnosis of Babesiosis, France. Emerg Infect Dis., 28(2):449-452.

[12] Dumić, T (2021): The ecological and genetic characteristics of ectoparasites of wild ungulates from different habitats in Croatia. Dissertation, Faculty of Agrobiotechnical Sciences Osijek, University of Osijek.

[13] Herwaldt, B.L., Caccio, S., Gherlinzoni, F., Aspock, H., Slemenda S.B., Piccaluga, P., G. Martinelli, G., Edelhofer, R., Hollenstein, U., Poletti, G., Pampiglione, S., Loschenberger, K., Tura, S., Pieniazek, N.J. (2003): Molecular Characterization of a non- *Babesia divergens* organism causing zoonotic babesiosis in Europe. Emerg.Infect.Dis., 9: 942-948.

[14] Hornok, S., Farkas, R. (2009.): Influence of biotope on the distribution and peak activity of questing ixodid ticks in Hungary. Medical and Veterinary Entomology 23: 41-46.

[15] Hildebrandt, A., Zintl, A., Montero, E., Hunfeld, K.P., Gray, J. (2021): Human Babesiosis in Europe. *Pathogens*, *10*, 1165. https://doi.org/10.3390/pathogens10091165

[16] Hildebrandt, A., Gray, J., Montero, E. (2023): Characteristics of Human Babesiosis in Europe. *Pathogens*, *12*, 323. https://doi.org/10.3390/pathogens12020323

[17] Hornok, S., Takács, N., Kontschán, J., György, Z., Micsutka, A., Iceton, S. *et al*. (2015): Diversity of *Haemaphysalis*-associated piroplasms of ruminants in Central-Eastern Europe, Hungary. Parasit Vectors., 8:627.

[18] Jia, N., Zheng, Y.C., Jiang, J.F., Jiang, R.R., Jiang, B.G., Wei, R., Liu, H.B., Huo, Q.B., Sun, Y., Chu, Y.L., *et al.* (2018): Human Babesiosis Caused by a *Babesia crassa*-Like Pathogen: A Case Series. *Clin. Infect. Dis.*, *67*, 1110–1119.

[19] Jongejan, F., Uilenberg, G. (2004.): The global importance of ticks. Parasitology 124:3-14.

[20] Gern, L, Humair, P.F. (2002) Ecology of *Borrelia burgdorferi* sensu lato in Europe. In: Gray JS, Kahl O, Lane RS, Stanek G (Eds) Lyme Borreliosis: Biology, Epidemiology and Control. CABI, 149–174. doi: 10.1079/9780851996325.0149

[21] Kahl, O., Gray, J.S. (2023):The biology of *Ixodes ricinus* with emphasis on its ecology. Ticks and Tick-borne Diseases 14, 1-11. https://doi.org/10.1016/j.ttbdis.2022.102114

[22] Kjemtrup, A.M., Conrad, P.A. (2000): Human babesiosis: an emerging tick-borne disease. Int. J. Parasitol**., 30:** 1323–1337.

[23] Kumar, A., O'Bryan, J., Krause, P.J. (2021): The Global Emergence of Human Babesiosis. *Pathogens*, *10*, 1447. https://doi.org/10.3390/ pathogens10111447

[24] Kapo, N., Zuber Bogdanović, I., Gagović, E. *et al.*(2004)*:* Ixodid ticks and zoonotic tick-borne pathogens of the Western Balkans. *Parasites Vectors* 17, 45. https://doi.org/10.1186/s13071-023-06116-1

[25] Kjemtrup, A. M., Thomford, J., Robinson, T., Conrad P. A. (2000): Phylogenetic relationships of human and wildlife Piroplasm isolates in the western United States inferred from the 18S nuclear small subunit RNA gene. Parasitology, 120: 487–493.

[26] Krčmar, S. (2012): Hard ticks (Acari, Ixodidae) of Croatia. ZooKeys 234: 19–57.
doi: 10.3897/zookeys.234.3658

[27] Malandrin, L., Jouglin, M., Sunc, Y., Brisseau, N., Chauvin, A. (2010): Redescription of *Babesia capreoli* (Enigk and Friedhoff, 1962) from roe deer (*Capreolus capreolus*): Isolation, cultivation, host specificity, molecular

characterisation and differentation from *Babesia divergens*. International Journal for Parasitology, 40: 277-284.

[28] Medlock, J.M., Hansford, K.M., Bormane, A., Derdakova, M., Estrada-Pena, A., George, J.C., Golovljova, I., Jaenson, T.G.T., Jensen, J.K., Jensen, P.M., Kazimirova, M., Oteo, J.A., Papa, A., Pfister, K., Plantard, O., Randolph, S.E, Rizzoli, A., Santos-Silvac, MM, Sprong, H., Vial, L., Hendrick, Zeller, H., Bortel, WV. (2013): Driving forces for changes in geographical distribution of Ixodes ricinus ticks in Europe. Parasit.Vectors, 2:6:1.

[29] Melhorn, H., Schein, E. (1998): Redescription of *Babesia equi* Laveran, 1901 as *Theileria equi* Melhorn, Schein. Parasitol. Res., 84: 467-475.

[30] Pintur, K., Dumić, T., Beck, R. (2022): Genetic characterization of piroplasms infecting cervids in Croatia // 10th International Deer Biology Congress Book of Abstracts / Konjević, Dean ; Bujanić, Miljenko ; Škvorc, Nikolina (ur.). Osijek: Veteriranrski fakultet Sveučilišta u Zagrebu, pp. 139-140.

[31] Ozubek, S., Aktas, M. (2017): Molecular evidence of a new *Babesia* sp. in goats. Vet Parasitol.,233:1–8.

[32] Orkun, Ö., Karaer, Z. (2017): Molecular characterization of *Babesia* species in wild animals and their ticks in Turkey. Infect Genet Evol., 55:8–13.

[33] Punda-Polić, V., Petrovac, M., Trilar, T., Duh, D., Brdarić, N., Klismanić, Z., Avšić-Županc, T. (2002.): Detection and identification of spotted fever group Rickettsiae in ticks colected in southern Croatia. Experimental and Applied Acarology 28: 169-176.

[34] Randolph, S.E., Rizzoli, A., Santos-Silva, M.M., Sprong, H., Vial, L., Hendrickx, G., Zeller, H., Van Bortel, W. (2013.): Driving forces for changes in geographical distribution of *Ixodes ricinus* ticks in Europe. Parasites & Vectores 6: 1.

[35] Schnittger, L., Yin, H., Gubbels, MJ., Beyer, D., Niemann, S., Jongejan, F., *et al*. (2003): Phylogeny of sheep and goat *Theileria* and *Babesia* parasites. Parasitol Res.,91:398–406.

[36] Skotarczak, B., Adamska, M., Sawczuk, M., Maciejewska, A., Wodecka, B., Rymaszewska, A. (2008): Coexistence of tick-borne pathogens in game animals and ticks in western Poland. Veterinarni Medicina, 53 (12): 668-675.

[37] Strasek-Smrdel, K., Korva, M., Pal, E., Rajter, M., Skvarc, M., Avsic-Zupanc, T. (2020): Case of Babesia crassa–Like Infection, Slovenia, 2014. Emerg Infect Dis., 26(5):1038-1040.

[38] Škrabalo, Z., Deanović, Z. (1957): Piroplasmosis in man. Report on a case. Doc. Med. Geogra. Trop., 9: 11-16.

[39] Vilibic-Cavlek, T., Janev-Holcer, N., Bogdanic, M., Ferenc, T., Vujica Ferenc, M., Krcmar, S., Savic, V., Stevanovic, V., Ilic, M., Barbic, L. (2023): Current Status of Vector-Borne Diseases in Croatia: Challenges and Future Prospects. *Life*, *13*, 1856. https://doi.org/ 10.3390/life13091856

SECURITY IN THE IMPLEMENTATION OF TELECOMMUNICATIONS INFRASTRUCTURE

Marko Štajner[1], Kristina Štimac[2], Bruno Štajner[3]

[1] ZITEL EURO CONTROL d.o.o., Bolnička cesta 94, Zagreb, CROATIA, marko@zitel.hr
[2] ZITEL EURO CONTROL d.o.o., Bolnička cesta 94, Zagreb, CROATIA, kristina.stimac@zitel.hr
[3] ZITEL EURO CONTROL d.o.o., Bolnička cesta 94, Zagreb, CROATIA, bruno@zitel.hr

In the telecommunications industry, where infrastructure installations form the backbone of global communications networks, ensuring safe working conditions is not only a requirement for compliance, but a fundamental operational necessity. The intricate process of setting up telecommunications infrastructure involves a variety of risks, from high-altitude work to complex electrical installations. Addressing these challenges directly with complex safety protocols is imperative to protect workers and ensure the integrity of the infrastructure being put in place.
This professional paper is the result of research conducted while working as an occupational safety coordinator at separate workplaces for the maintenance of telecommunication systems. By analyzing the existing situation on the construction site and collecting statistical data on injuries caused by failures in the implementation of protection measures, a methodology for the implementation of occupational safety measures during the maintenance of telecommunication systems was developed. The proposed methodology primarily refers to the organization of occupational safety activities in the mentioned jobs, but it is also applicable to other works performed at high altitudes.

Key words: Complex security protocols, Global communications networks, Occupational safety, Safety measures implementation, Statistical data on injuries, Telecommunications industry, Worker protection

1. INTRODUCTION

Once the telecom towers have been erected, maintenance activities include reinforcing the structure, painting the steel structure, fixing equipment failures, upgrading antennas, and installing new antennas on existing poles. The maintenance of telecommunications towers and antenna systems requires strict safety measures and adherence to specific conditions to protect the health and safety of workers. Workers are exposed to a variety of risks arising from working at high heights, handling work equipment, and working in often unpredictable weather conditions. Therefore, it is essential to ensure that workers meet certain conditions to minimize the risks of injury or death. According to the available (online) statistics, the main accident risks were: falling objects; falling from a height; electric shock; and animal attacks. The main causes of worker injuries were related to the failure to implement the prescribed occupational safety measures (80%).

Aim of the paper
The presented research aimed to analyze and assess the risks of falling on telecommunication transmitters and to provide a proposal for measures that need to be applied to eliminate or reduce the risks of falls.

Working method
This professional paper is based on research conducted as an occupational safety coordinator at separate workplaces for the maintenance of telecommunication systems. By analyzing the existing situation on the construction site and collecting statistical data on injuries caused by failures in the implementation of protection measures, a methodology for the implementation of occupational safety measures during the maintenance of telecommunication systems was developed. The research was conducted on the transmitters listed in Table 1.

Table 1: Transmitters by Location*

Location	Height of execution (m)	Access to the workplace	Number of executors
1	2	3	4
Učka	50	From the inside of the tower (ladder), a platform at 52 m	6
Sljeme	150	From the inside of the tower (elevator + ladder), platform at 152 m	8
Srđ (Dubrovnik)	55	From the inside of the tower (elevator), platform at 53 m	5
Labinština	45	From the inside of the tower (ladder), a platform at 47 m	5

*Column 1 shows the transmitter locations; column 2 lists the heights at which work is being performed; column 3 describes how to access the work site; column 4 shows the number of contractors who worked on the system restoration.

Access to the workplace
Access to the workplace is provided depending on the location and height of the transmitter, by elevator, external or internal ladders, or climbing frames. Every 10 meters, a platform was set up for workers to rest. On the landing, fall protection measures are provided with a protective fence that prevents or protects workers from falling from the platform. As a rule, workers climb to a plateau located above the workplace itself, and access to the workplace is provided by descending with a rope.
Where work at height cannot be avoided, falls are prevented by implementing technical measures by selecting the appropriate type of equipment and educating workers.
The level of risk of falling is determined based on the synergistic action of the assessed risks according to the types of hazards, harmfulness, and efforts to which the worker is exposed.

Technological process
A good knowledge of the technological process and the works that will be carried out at height is a prerequisite for starting a risk assessment. As the risk of falling increases with the height from which the works are performed, it is clear that it will be necessary to harmonize the implementation protection measures accordingly.
After the implementation of measures to eliminate or reduce the risk, the level of residual risk is assessed. If the remaining risk is not acceptable, additional protection measures should be implemented.

2. DESCRIPTION OF THE TECHNOLOGICAL PROCESS

Replacement of the existing antenna system, installed 30 years ago, needs to be substituted with a new one. The new system will be installed on the existing steel tower. The new structure has the same size and weight as the old system, but it is modern in shape and designed to meet the new standards.
Replacing antennas on a telecommunications tower is a complex process that involves several key stages. Each stage requires careful planning and execution to ensure worker safety and successful replacement. There are 6 phases of work, namely: preparatory work, installation of lifting equipment (winch), dismantling of the existing antenna system, installation of new antennas, installation work, and finishing works.

2.1 Stages of work and protection measures

A good knowledge of the phases of work is crucial for the safety, efficiency and quality of performance when replacing antennas on telecommunication towers. Table 2 shows the phases of work with characteristic risks and the method of protection.

Table 2: Phases of works and protection measures

Stage of works	Description of work	Dangers	Safety measure
Preparatory work	Preparing the construction site, checking tools and equipment, securing the working area.	Slipping, falling, faulty equipment.	Secure the work area, use protective equipment (helmets, gloves, safety shoes), check the correctness of tools and equipment.
Setting up the lifting equipment (winch)	Installation and testing of winches for lifting heavy equipment.	Incorrect installation, equipment failure, equipment fall.	Train workers to work with the winch, check the correctness of the winch, use seat belts and protective helmets.

Dismantling the existing antenna system	Removal of the old antenna system with the use of a winch and other tools.	Falling from a height, falling dismantled parts, injuries from tools.	Use protective equipment, set up safety nets, ensure proper handling of tools and equipment.
Antenna mounting	Installation of new antennas on the tower with the help of a winch and other tools.	Drop from a height, electric shock, tool or antenna drop.	Use protective equipment, check electrical installations, ensure safe handling of antennas and tools.
Installation work	Connecting antennas to existing infrastructure, testing the system.	Electric shock, fall, equipment failure.	Use insulating gloves, check the correctness of installations before work, use seat belts.
Finishing works	Final check and ensuring that the system is fully functional, cleaning the construction site.	Falling, cleaning injuries, residual electrical hazards.	Use protective equipment, check that all work is completed and equipment is turned off, handle waste and tools with care.

2.2 Protection of Workers

The measures that need to be implemented to protect workers from injuries at work are specific to each phase of work. Primarily, technical protection measures are implemented, which cannot be functional without worker education. As these are specific works at height, in addition to being trained to work in a safe manner, workers are also required to meet the conditions prescribed by special regulations and rules. Table 3 shows the specific conditions applicable to the worker and a description of the implementation of these measures.

Table 3: Special conditions for contractors

Condition	Description
Training for work at height	Workers must receive specialized training for working at height, including safety measures and proper use of equipment.
Medical examination	All workers must undergo regular medical examinations to ensure their physical fitness to work at height.
Psychological stability	Workers must be psychologically stable and not have a fear of heights.
Knowledge of security protocols	Workers must be familiar with safety protocols and procedures for working at height, including evacuation plans.

Correct use of protective equipment	Workers must use all necessary protective equipment (helmets, seat belts, goggles, gloves, etc.).
Communication skills	Workers must have good communication skills to coordinate effectively with colleagues and supervisors.
Experience	Workers should have previous experience of working at height or in similar conditions.
Regular training and improvement	Workers must regularly attend additional training and upskilling to keep up to date with the latest safety standards and techniques.
Knowledge of first aid	Workers must be trained to provide first aid in the event of an accident.
Checking the equipment	Workers must be able to check and ensure the correctness of their protective equipment before starting work.
Work experience of teamwork	Workers should have experience working in a team to ensure effective collaboration and coordination.
Physical fitness	Workers must be in good physical condition to be able to perform demanding physical tasks.

2.3 Fall risk assessment

Once the stages of the work and the conditions relating to the worker himself have been determined, a risk assessment must be carried out. Risk assessment for work at height includes the identification, analysis and evaluation of all potential risks that may affect the safety of workers. It also includes recommendations for safeguards to reduce or eliminate identified risks. The residual risk assessment was done according to the Fine-Kinney method, and the risk was calculated according to the formula:

$$R = V \, x \, P \, x \, U \qquad (1)$$

where: V - probability of injury, U - frequency and time of exposure to hazards/efforts, P - consequences, i.e. severity of possible injury or disease.

Table 4 lists the elements covered by this tower fall risk assessment.

Table 4: Activity to be assessed

Danger	Activity being performed Dangerous situation	Risk assessment			
		Probability (V)	**Frequency (U)**	**Consequences (P)**	Risk level H x U x P

Falling from a height	Work at height on the tower, dismantling of equipment, installation of new equipment, cabling	6 (possibly)	6 (daily)	6 (serious injury, fatal consequences)	216

From the above calculation, the risk level is 216, which falls into the category of high risk. For such a high level of risk, it is necessary to implement measures to reduce this risk to the level of medium risk before the start of the works.

2.4 Risk Mitigation Action Plan

Where and when it is possible to carry it out, the work must be carried out from the basket. Despite this, the danger cannot be eliminated. The basic principles of fall protection prescribe those technical achievements should primarily be used in preventing risks at the source, which does not exclude the possibility of falling. When planning and implementing fall protection measures, it is necessary to comply with the hierarchies of protective measures.

Sequencing of measures:

1. Risk elimination: prevention of the risk of falling at the source (preparatory and assembly work of the structure carried out on the ground)
2. Replacement: access to the work site by hydraulic platform or basket
3. Technical measures: lifting the load with a car crane, installation of permanent anchorages at the place of work, securing 3 anchor points
4. Organizational measures: development of a work plan, continuous education of workers, give priority to younger workers, shorten the working hours of the worker
5. Personal protective equipment: use only certified equipment, regular inspection of equipment, education in the use of equipment

4. CONCLUSION

An analysis of the assessed risks can conclude that fall hazards cannot be fully implemented. For this reason, it is necessary to develop a methodology for the implementation of occupational safety measures during the maintenance of telecommunication systems, which would include the following elements:

1. Risk assessment: identify potential hazards (working at height, electrical risks, etc.) and prioritize the implementation of measures

2. Planning and preparation: develop written procedures for the safe execution of works

3. Safety measures in the field: place safety signs and fences around the work area, check and turn off the power supply before working on electrical systems, use the prescribed PPE

5. Supervision and communication: appoint a work manager responsible for safety, establish a communication system between workers, regularly carry out safety checks during work

6. Emergency procedures: develop and train emergency plans, ensure the availability of first aid and rescue equipment

7. Documentation and reporting: keep records of the protection measures implemented, report and analyze all incidents and incidents, regularly update the risk assessment and safety procedures

8. Continuous improvement: carry out regular revisions of safety instructions and procedures, implement new technologies and methods to improve safety, conduct periodic training of workers to work in a safe manner

The proposed methodology can significantly increase the safety of workers and ensure that the works are carried out safely.

LITERATURE:

[1] The Professional Guide to Tower Maintenance, Available on *https://galooli.com/tower-maintenance/ ,* Retrieved: 2024-05-22

[2] Occupational safety risks during maintenance of telecommunication towers, Available on https://www.researchgate.net/publication/354181612_Occupational_safety_risks_during_maintenance_of_telecommunication_towers/link/61ba834ffd2cbd7200a2e554/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19, accessed: 2024-05-24

[3] U.S. Department of Labor Occupational Safety and Health Administration (OSHA). Regulations (Standards – 29CFR) 1910.268 - Telecommunications. Washington, DC: OSHA. Available at *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDAR DS&p_id=9867*, Retrieved: 2024-05-22

[4] Bruno Štajner, Marko Štajner, Ivana Štajner, 8th International Professional and Scientific Conference, Risk assessment methodology for height when performing assembly works, Karlovac university of applied sciences, ISSN 2623-6435, page: 529-536

[5] Tower Climbing Safety, Available at https://www.scribd.com/presentation/534242689/Tower-Climbing-Safety, Retrieved: 2024-05-28

MATHEMATICAL MODELS IN OCCUPATIONAL SAFETY

Ivan Štedul[1], Mario Fanjak[2], Merima Arnaut[3]

[1] Karlovac University of Applied Sciences, J. J. Strossmayera 9, Karlovac, Croatia, ivan.stedul@vuka.hr

[2] Medicinska škola Karlovac, Andrije Štampara 5, 47000, Karlovac, Croatia, mfanjak@yahoo.com

[3] Mješovita industrijsko-obrtnička škola Karlovac, Struga 33, Karlovac, Croatia, merimaaaa@gmail.com

Abstract: *Occupational safety is crucial for maintaining worker health and preventing accidents. Mathematical models play a significant role in predicting, assessing, and mitigating risks in various occupational settings. This paper reviews the application of statistical methods, stochastic models, optimization techniques, and machine learning approaches in occupational safety. By integrating findings from several key studies, this review highlights the strengths and limitations of different mathematical models and suggests future research directions.*

Keywords: *Occupational safety, mathematical models, Statistical Methods, Predictive analysis*

1. INTRODUCTION

Ensuring occupational safety is essential for the well-being of employees and the efficiency of organizations. Mathematical models offer robust frameworks for understanding and managing workplace risks. These models provide systematic approaches to identifying potential hazards, assessing risks, and implementing preventive measures. This paper reviews various mathematical models used in occupational safety, emphasizing their applications and effectiveness.

Occupational safety is a critical aspect of any work environment, aimed at preserving the health and safety of workers. Mathematical models and methods provide quantitative tools for analyzing, assessing, and managing risks. These models enable precise prediction and control of potential accidents and injuries, which is essential for developing effective safety strategies.

The book "Applied Statistics in Occupational Safety and Health" [1] provides occupational safety and health professionals with an introductory guide to basic statistics and data analysis.

A significant body of research has focused on the mathematical aspects of occupational risk and its classification, considering statistical indicators. The study "Mathematical Aspects of Occupational Risk and its Classification Considering Statistical Indicators" presents a detailed examination of how statistical methods can be applied to categorize and manage occupational risks. This study highlights the importance of integrating mathematical models with statistical data to enhance the accuracy and reliability of risk assessments [2].

In this paper, we explore various mathematical models used in occupational safety, their applications, and relevant scientific studies that support them. We pay special attention to practical examples and research that demonstrate how these models can be effectively used to improve safety standards in different industries.

Mathematical models in occupational safety include statistical methods, stochastic models, optimization techniques, and machine learning approaches. Each of these models has its strengths and limitations, and their application depends on the specific context of the occupational environment. This paper aims to provide a comprehensive review of these models.

2. MATHEMATICAL MODELS IN OCCUPATIONAL SAFETY

Mathematical models used in occupational safety can be categorized into several types:

1. Statistical models for risk analysis
2. Stochastic models for risk analysis
3. Optimization models for risk analysis

2.1. Statistical models for risk analysis

Statistical methods are fundamental in occupational safety for analyzing data and identifying trends. These methods help in understanding the frequency and severity of workplace incidents and in predicting future occurrences. The study "Application of Statistical Methods on Occupational Health and Safety Management in the Mining Industry in Ezhou City, China" provides a comprehensive review of various statistical techniques applied to occupational safety, demonstrating their effectiveness in improving workplace safety standards [3].

Key statistical modeling techniques:

1. **Descriptive statistics:** Descriptive statistics such as mean, median, and standard deviation are used to summarize the central tendency, dispersion, and overall trends in safety data. For instance, summarizing the frequency of different types of accidents helps identify the most common hazards.
2. **Inferential statistics:** Inferential statistics, including hypothesis testing and confidence intervals, are employed to make inferences about the broader workforce based on sample data. For example, testing whether a new safety intervention significantly reduces accident rates.
3. **Regression analysis:** Used to identify and quantify factors affecting workplace accidents. For example, regression analysis can reveal how working hours or worker experience influence accident rates, providing insights into variable relationships and outcome predictions based on historical data
4. **Time-series analysis:** Time-series analysis examines data points collected or recorded at specific time intervals to identify trends, seasonal patterns, and

potential cyclical behaviors in accident data. Predicts future accidents based on historical data, enabling the planning and implementation of preventive measures. Time-series analysis helps identify seasonal patterns and trends, aiding in better decision-making regarding work schedules and preventive activities.

2.2. Stochastic models for risk analysis

Stochastic models are used to incorporate randomness and uncertainty into risk assessments. These models are particularly useful in environments where risks are not constant and can change rapidly, such as in construction or chemical industries. The study "Elaboration of Stochastic Models to Comprehensive Evaluation of Occupational Risks in Complex Dynamic Systems"[4] provides a comprehensive approach to evaluating occupational risks in dynamic and complex systems. This study highlights the effectiveness of stochastic models in predicting the probability of accidents under varying conditions

Key Stochastic Modeling Techniques:

1. **Monte Carlo Simulation:** This technique uses repeated random sampling to simulate various scenarios and predict the probability distribution of different outcomes. It is widely used in assessing the likelihood and impact of safety incidents.
2. **Markov Chains:** Markov models represent systems that transition between different states over time, with probabilities assigned to each transition. These models are useful in predicting the progression of safety incidents and identifying critical intervention points.
3. **Poisson Processes**: Poisson models are used to predict the number of events occurring within a fixed period. They are particularly effective in modeling rare events, such as serious workplace accidents.

Applications in Occupational Safety

Stochastic models are applied in industries with high variability and unpredictability. For example, in the oil and gas industry, Monte Carlo simulations are used to assess the risk of major accidents, incorporating uncertainties in equipment performance and environmental conditions. In the construction industry, Markov models help predict the likelihood of accidents based on different phases of a project, enabling proactive safety management.

The study "Elaboration of Stochastic Models to Comprehensive Evaluation of Occupational Risks in Complex Dynamic Systems" provides valuable insights into the application of these models in dynamic environments. The researchers developed stochastic models to evaluate occupational risks in systems where traditional deterministic models might fall short due to the complexity and variability of the factors involved.

By integrating stochastic models into safety management practices, organizations can better anticipate potential risks and implement more effective preventive measures. This proactive approach enhances the overall safety and reliability of operations in complex and dynamic systems.

3. APPLICATION OF MATHEMATICAL MODELS

Mathematical models are applied in various aspects of occupational safety:

1. **Risk assessment:** Identifying potential hazards and assessing their impacts. For example, risk models can predict the frequency of accidents in specific industries, enabling organizations to recognize and mitigate hazards before accidents occur.
2. **Planning preventive measures:** Developing strategies to reduce risks, such as optimizing the schedule of safety inspections to minimize accidents. Preventive measures include worker training, regular inspections, and equipment maintenance, all of which can be optimized through mathematical models.
3. **Evaluating effectiveness:** Analyzing the effectiveness of existing safety measures, such as evaluating the impact of worker training on reducing accidents. Evaluation helps organizations adjust their strategies to ensure that safety measures remain relevant and effective.

4. ADVANTAGES AND LIMITATIONS

Advantages:

1. Provide quantitative risk analysis.
2. Aid in optimizing resources and making informed decisions.
3. Enable simulation and prediction of various scenarios.
4. Offer a foundation for objective and systematic decision-making.

Limitations:

1. Model accuracy depends on data quality.
2. Model complexity may require high expertise.
3. Unpredictable factors can affect prediction accuracy.
4. Models can be expensive to implement and maintain, especially for smaller organizations.

5. CASE STUDIES AND PRACTICAL APPLICATIONS

5.1. Construction Industry

In the construction industry, where workers are often exposed to high risks, mathematical models assess the safety of construction processes and schedules. Models help identify critical points and optimize worker and equipment deployment. The construction industry has seen notable applications of these models. [5] applied stochastic models to simulate construction safety outcomes, enabling the prediction and prevention of accidents. Their work emphasizes the importance of these models in high-risk and dynamic environments. By simulating various construction scenarios, these models help safety managers identify potential risks and develop strategies to mitigate them.

"Finally, the number of accidents that may occur on construction site in a period is studied macroscopically based on Poisson process, and the probability distribution of time interval between adjacent accidents and the time of the *n*th accident are calculated respectively" [5].

5.2. Manufacturing

In manufacturing plants, models assess risks associated with machine operations and material handling. Incident data analysis provides a better understanding of accident causes and the design of safety procedures to minimize risks.

5.3. Healthcare

In healthcare facilities, where workers are exposed to biological and chemical risks, mathematical models assess the effectiveness of protective measures and plan interventions during outbreaks or other crisis situations.

5.4. Amazon Warehouses

Several organizations have successfully implemented mathematical models to enhance their safety protocols. For example, Amazon uses real-time tracking systems in their warehouses, coupled with robust machine learning models, to mitigate injury risks significantly. These systems monitor worker movements and identify patterns that might lead to injuries, enabling timely interventions. The integration of AI and IoT technologies has allowed Amazon to reduce injury rates and improve overall safety

"The integration of real-time tracking and machine learning in workplace safety protocols has led to significant reductions in injury risks in large organizations like Amazon." [6]

6. FUTURE DIRECTIONS AND RESEARCH

The field of occupational safety is continually evolving, and future research should focus on several key areas to enhance the effectiveness of mathematical models. One promising direction is the integration of various modeling techniques to develop comprehensive safety management systems. Combining statistical methods, stochastic models, optimization techniques, and machine learning can provide a more holistic approach to risk assessment and mitigation.

Moreover, there is a need for more extensive data collection and sharing across industries. Collaborative efforts to create large, standardized databases of workplace safety incidents can significantly improve the accuracy and applicability of mathematical models. Additionally, research should explore the ethical implications of using advanced technologies in occupational safety, ensuring that the implementation of these models respects workers' privacy and autonomy.

The development of user-friendly software tools that incorporate these mathematical models can also facilitate their adoption in various industries. These tools should be designed to be accessible to safety managers and practitioners who may not have specialized knowledge in mathematical modeling.

7. CONCLUSION

Mathematical models play a vital role in enhancing occupational safety. Statistical methods, stochastic models, optimization techniques, and machine learning provide robust tools for analyzing risks and developing effective safety measures. By reviewing and integrating findings from key studies, this paper has highlighted the strengths and limitations of different mathematical models and their applications in various industries. Future research should focus on integrating these models to create comprehensive occupational safety management systems and developing user-friendly tools to facilitate their adoption.

REFERENCES

[1] C. A. Janicak, "Applied Statistics in Occupational Safety and Health Third Edition Lanham • Boulder • New York • London."

[2] Sh. Abikenova, R. Marcelloni, and Sh. Aitimova, "Mathematical aspects of occupational risk and its classification considering statistical indicators," *BULLETIN OF THE L.N. GUMILYOV EURASIAN NATIONAL UNIVERSITY. Mathematics. Computer science. Mechanics series*, vol. 145, no. 4, pp. 23–34, Dec. 2023, doi: 10.32523/2616-7182/bulmathenu.2023/4.3.

[3] B. Jiangdong, "Application of Statistical Methods on Occupational Health and Safety Management in the Mining Industry," Accessed: Jul. 26, 2024. [Online]. Available: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1216868&dswid=5943

[4] A. P. Bochkovskyi, "Elaboration of stochastic models to comprehensive evaluation of occupational risks in complex dynamic systems," *Journal of Achievements in Materials and Manufacturing Engineering*, vol. 104, no. 1, pp. 31–41, Jan. 2021, doi: 10.5604/01.3001.0014.8484.

[5] Z. Zhang, W. Li, and J. Yang, "Analysis of stochastic process to model safety risk in construction industry," *Journal of Civil Engineering and Management*, vol. 27, no. 2, pp. 87–99, Feb. 2021, doi: 10.3846/jcem.2021.14108.

[6] J. Pavelko, "Integrating Technology in Workplace Safety: The Role of AI and IoT." https://ohsonline.com/Articles/2024/07/17/Integrating-Technology-in-Workplace-Safety-The-Role-of-AI-and-IoT.aspx *Accessed:* 2024. 07. 17.

AUTHORS ADRESSES

Dragana Agić
Institute IPI Engineering,
Zenica, Bosnia and Herzegovina

Merima Arnaut
Mješovita industrijsko-obrtnička
škola Karlovac, Struga 33,
47000 Karlovac, Croatia
E-mail: merimaaaa@gmail.com

Danijela Avramović
University of Niš, Faculty of
Occupational Safety,
Čarnojevića 10 a, 18106 Niš, Serbia

Luka Babić
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: luka.babic@student.vuka.hr

Esad Bajramović
Tehnical faculty of University of Bihac,
Dr. Irfana Ljubijankica bb,
77000 Bihac, Bosnia and Herzegovina
E-mail: bajramovic_e@yahoo.com

Emir Bajramović
University of Bihać,
Faculty of Technical Engineering,
I.Ljubijankića bb, 77000 Bihać,
Bosnia and Herzegovina
E-mail: emir.bajramovic@unbi.ba

Ermin Bajramović
University of Bihac, Technical
faculty Bihac, Dr. Irfana Ljubijankica bb,
77000 Bihac, Bosnia and Herzegovina
E-mail: bajramovic.ermin@mail.com

Ines Baksa
University of Applied Sciences in
Security and Safety, Veslačka 2a,
10000 Zagreb, Croatia
E-mail: ines_baksa@yahoo.com

Sarajko Baksa
Međimurje University of Applied
Sciences in Čakovec,
Bana Josipa Jelačića 22a,
40000 Čakovec, Croatia
E-mail: sarajko_baksa@yahoo.com

Marija Batak
HZJZ, R. Cimermana 64a,
10020 Zagreb, Croatia
E-mail: marija.batak@hzjz.hr

Relja Beck
Croatian Veterinary Institute,
Savska cesta 143, 10000 Zagreb, Croatia
E-mail: beck@veinst.hr

Asmira Bećiraj
University of Bihać, Faculty of Law,
Džanića mahala 68, 77000 Bihać,
Bosnia and Herzegovina
E-mail: asmira_beciraj@yahoo.com

Dijana Benko
Hrvatske šume d.o.o.,
Put Davorina Trstenjaka 1,
47000 Karlovac, Croatia
E-mail: lovacki-dom-muljava@hrvatskesume.hr

Andrija Berislavić
Karlovac University of Applied Sciences,
Student at the Mechanical
Engineering Study,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: berislavic.andrija@gmail.com

Jasmina Bešlagić
Law faculty of University of Bihac,
Dzanica mahala,
77 000 Bihac, Bosnia and Herzegovina
E-mail: jasmina.beslagic@unbi.ba

Ana Bijelić
University of Niš, Faculty of
Occupational Safety, Čarnojevića 10a,
18000 Niš, Serbia
E-mail: ana.miltojevic@znrfak.ni.ac.rs

Marijan Binički
Croatian Post, Poštanska ulica 9,
10410 Velika Gorica, Croatia,
E-mail: marijan.binicki@posta.hr

Draženka Birkić
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: dbirkic@vuka.hr

Ana Blažević
University of Applied Sciences of Rijeka,
Vukovarska 58, 51000 Rijeka, Croatia
E-mail: ablazevic0406@gmail.com

Marijana Blažić
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: mblazic@vuka.hr

Slavica Bogović
University of Zagreb Faculty of
Textile Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia,
E-mail: slavica.bogovic@ttf.hr

Ana Marija Bonić
Karlovac University of Applied Sciences,
J. J. Strossmayera 9,
47000 Karlovac, Croatia

Marina Borić
Ministry of Labour, Pension System,
Family and Social Policy,
Ulica grada Vukovara 78,
10000 Zagreb, Croatia
E-mail: marina.boric@mrosp.hr

Tomislav Božić
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: tomislav.bozic@vuka.hr

Aca V. Božilov
University of Niš, Faculty of Occupational
Safety in Niš,
Čarnojevića 10a, 18000 Niš, Serbia
E-mail: aca.bozilov@znrfak.ni.ac.rs

Blaženka Brlobašić Šajatović
University of Zagreb, Faculty of
Textile Technology,
Prilaz brauna Filipovića 28,
10000 Zagreb, Croatia
E-mail: blazenka.brlobasic@ttf.unizg.hr

Marija Bubaš
Ministry of Health,
Ksaver 200a, 10000 Zagreb, Croatia

Slobodan Bundalevski
International Slavic University „St.Nicholas“,
Marsal Tito 77, Sveti Nikole,
North Macedonia

Krunoslav Capak
Croatian Institute of Public Health,
Rockfellerova 7, 10000 Zagreb, Croatia

Tihana Cegur Radović
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia,
E-mail: tcradovic@vuka.hr

Andreja Cesar Slegovac
HZJZ, R. Cimermana 64a,
10020 - Zagreb, Croatia
E-mail: andreja.cesar-slegovac@hzjz.hr

Mirjana Cibulka
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: mirjana.cibulka@vuka.hr

Ines Cindrić
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: icindric@vuka.hr

Petra Cvetić
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: petra.cvetic@vuka.hr

Neno Čabraja
Student of Karlovac University of
Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: neno.cabraja@student.vuka.hr

Katarina Čavlović
Karlovac University of Applied Sciences,
Trg J. J, Strossmayera 9,
47000 Karlovac, Croatia
E-mail: katarina.cavlovic@zelenilo.hr

Iva Čehak
Zagreb, Croatia
E-mail: ivacsehak@gmail.com

Tatjana Čumpek
Senior Advisor of Civil Protection
E-mail: tcumpek@mup.hr

Minka Ćehić
University of Bihać, Pape Ivana Pavla II 2/2,
77000 Bihać, Bosnia and Herzegovina
E-mail: minka.cehic@unbi.ba

Mirsada Ćehić
University of Applied Sciences in
Security and Safety,
Veslačka 2a, 10000 Zagreb, Croatia
E-mail: mirsada@vss.hr

Žarko Ćojbašić
Faculty of Mechanical Engineering,
Aleksandra Medvedeva,
18000 Niš, Serbia
E-mail: zcojba@ni.ac.rs

Monika Ćubela
Aspira University of Applied Sciences,
Ulica Domovinskog rata 65,
21000 Split, Croatia
E-mail: monikacubela774@gmail.com

Sonja Damjanović Dešić
Croatian Institute for Public Health, 10000
Zagreb, Croatia

Sandra Debeljak
University of Applied Sciences of Rijeka,
Vukovarska 58, 51000 Rijeka, Croatia
E-mail: sdebeljak@veleri.hr

Tihana Dekanić
University of Zagreb Faculty of
Textile Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia
E-mail: tihana.dekanic@ttf.unizg.hr

Ksenija Doležal
University of Zagreb Faculty of
Textile Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia
E-mail: ksenija.dolezal@ttf.unizg.hr

Marin Dugina
„Ivan Seljanec" Križevci Secondary School,
Trg Svetog Florijana 14.b,
48260 Križevci, Croatia
E-mail: mm.dugina@gmail.com

Tomislav Dumić
Karlovac University of Applied Sciences, Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: tdumic@vuka.hr

Kristina Dundović
University of Applied Sciences of Rijeka,
Vukovarska 58, 51000 Rijeka, Croatia
E-mail: kdundovic@veleri.hr

Mario Fanjak
Medical school Karlovac,
Andrije Štampara 5,
47000 Karlovac, Croatia
E-mail: mfanjak@yahoo.com

Tamara Fehervari
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: tamara.fehervari@vuka.hr

Nikola Findrik
Faculty of Law, University of Bihać,
Džanića Mahala,
77000 Bihać, Bosnia and Herzegovina
E-mail: findrik_nikola@yahoo.com

Sandra Flinčec Grgac
University of Zagreb Faculty of Textile Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia
E-mail: sflincec@ttf.unizg.hr

Srdjan Glisović
University of Nis, Faculty of Occupational Safety,
Carnojevica 10a, 18000 Nis, Serbia
E-mail: srdjan.glisovic@znrfak.ni.ac.rs

Tatjana Golubović
Faculty of Occupational Safety,
Čarnojevića 10a, 18000 Niš, Serbia
E-mail: tatjana.golubovic@znrfak.ni.ac.rs

Jadranka Grbinić
State Inspectorate,
Šubićeva 29, 10 000 Zagreb, Croatia
E-mail: jadranka.grbinic@dirh.hr

Ivana Grgurić
Technical school Karlovac,
Ljudevita Jonkea 2a,
47000 Karlovac, Croatia
E-mail: grguric.ivana@gmail.com

Marija Grozdanovska
Faculty of Law, International Slavic University
St. Marsal Tito, Sveti Nikole,
North Macedonia
E-mail: marija.grozdanovska@msu.edu.mk

Alojzije Grzelja Iveta
HŽ Infrastruktura d.o.o.,
Mihanovićeva 12,
10000 Zagreb, Croatia
E-mail: alojzije.grzeljaiveta@hzinfra.hr

Jasna Halambek
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47 000 Karlovac, Croatia
E-mail: jasna.halambek@vuka.hr

Atif Hodzic
Tehnical faculty of University of Bihac,
Dr. Irfana Ljubijankica bb,
77 000 Bihac, Bosnia and Herzegovina
E-mail: atif.hodzicc@gmail.com

Damir Hodžić
University of Bihać,
Irfana Ljubijankića bb,
77000 Bihać, Bosnia and Herzegovina
E-mail: damir.hodzic@unbi.ba

Alex Honn
Boise State University, Idaho, USA

Ria Horvat
Preventa d.o.o.,
Čakovečka 1, 42000 Varaždin, Croatia
E-mail: rhorvat@veleri.hr

Jasminka Horvatić
Open Mind Ltd.,
Savski gaj IX. 2a,
10000 Zagreb, Croatia
E-mail: jasminka.horvatic@gmail.com

Josip Hoster
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: jhoster@vuka.hr

Renata Hrženjak
University of Zagreb, Faculty of
Textile Technology,
Prilaz brauna Filipovića 28,
10000 Zagreb, Croatia
E-mail: renata.hrzenjak@ttf.unizg.hr

Anica Hursa Šajatović
University of Zagreb, Faculty of
Textile Technology,
Department of Clothing Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia
E-mail: anica.hursa@ttf.unizg.hr

Damir Ilić
Department of Electrical Engineering
Fundamentals and Measurements,
Faculty of Electrical
Engineering and Computing,
University of Zagreb, Croatia
E-mail: damir.ilic@fer.hr

Ivana Ilić Krstić
University of Niš, Faculty of
Occupational Safety,
Čarnojevića 10 a,
18106 Niš, Serbia
E-mail: ivana.ilic@znrfak.ni.ac.rs

Aida Imamović
Faculty of Engineering and Natural Sciences,
University of Zenica,
Bosnia and Herzegovina
E-mail: aida.imamovic@unze.ba

Rui Isidoro
Polytechnic University of Beja, Life Quality
Research Center (LQRC), Portugal
E-mail: rui.isidoro@ipbeja.pt

Suan Islamović
Faculty of Law, University of Bihać,
Džanića Mahala,
77000 Bihać, Bosnia and Herzegovina
E-mail: suan.islamovic@gmail.com

Fadil Islamović
Faculty of Technical Engineering,
University of Bihać,
Irfana Ljubijankića,
77000 Bihać, Bosnia and Herzegovina
E-mail: fadil.islamovic@unbi.ba

Jelena Ivančan
INA Plc., Avenija Većeslava Holjevca 10,
10000 Zagreb, Croatia
E-mail: jelena.ivancan@ina.hr

Dario Javor
University of Niš,
Faculty of Occupational Safety,
Čarnojevića 10a, 18000 Niš, SERBIA
E-mail: dario.javor@znrfak.ni.ac.rs

Anđela Jevtić
Faculty of Occupational Safety,
University of Niš, Čarnojevića 10a,
18000 Niš, Serbia
E-mail: andjela.jevtic@znrfak.ni.ac.rs

Lidija Lj. Joleska Bureska
International Slavic University St. Nikola,
Marsal Tito 77,
Sveti Nikole, North Macedonia
E-mail: lidija.joleskabureska@msu.edu.mk

Evica Jovanović
Faculty of Occupational Safety,
University of Niš, Čarnojevića 10a,
18000 Niš, Serbia
E-mail: evica.jovanovic@znrfak.ni.ac.rs

Željko Jovanović
Faculty of Health Studies,
Viktora Cara Emina 5,
51000 Rijeka, Croatia
E-mail: zeljko.jovanovic@uniri.hr

Domagoj Jurčić
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: domi.jurcic@gmail.com

Dinko Jurjević
Polytechnic in Rijeka, Vukovarska 58,
51000 Rijeka, Croatia
E-mail: dinko.jurjevic@gmail.com

Omer Kablar
ArcelorMittal Zenica,
Zenica, Bosnia and Herzegovina

Kristijan Kalcina
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia

Damir Karabaić
Juraj Dobrila University of Pula,
Faculty of Engineering, Zagrebačka 30,
52100 Pula, Croatia
E-mail: damir.karabaic@unipu.hr

Anamarija Kirin
Karlovac University of Applied Sciences,
Trg J. J, Strossmayera 9,
47000 Karlovac, Croatia
E-mail: akirin@vuka.hr

Snježana Kirin
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: snjezana.kirin@vuka.hr

Tomislav Kljak
University of Zagreb,
Faculty of Transport and Traffic Sciences,
Vukelićeva 4, 10000 Zagreb, Croatia
E-mail: tomislav.kljak@fpz.unizg.hr

Bojana Knežević
Clinical hospital center Zagreb,
Kišpatićeva 12, 10000 Zagreb, Croatia

Danijel Knežević
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: danijel.knezevic@student.vuka.hr

Ivana Kolić
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47 000 Karlovac, Croatia
E-mail: ivana.kolic@vuka,.hr

Tomislav Kos
University of Zadar, Odjel za ekologiju,
agronomiju i akvakulturu. Trg kneza Višeslava
9., 23000 Zadar, Croatia
E-mail: tkos@unizd.hr

Tihana Kostadin
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: tkostadin@vuka.hr

Igor Kovačev
Sveučilište u Zagrebu, Agronomski fakultet.
Svetošimunska cesta 25.
10000 Zagreb, Croatia
E-mail: ikovacev@agr.hr

Karla Kovačević Čorak
Croatian Institute of Public Health,
Division for Occupational Health,
Radoslava Cimermana 64a,
10020 Zagreb, Croatia
E-mail: karla.kovacevic@hzjz.hr

Petra Kovačević Totić
Clinical Hospital Centre "Sisters of mercy",
Clinic for rheumatology,
physical medicine and rehabilitation,
Vinogradska cesta 29,
10000 Zagreb, Croatia
E-mail: petrakova13@gmail.com

Filip Kovačić
University of Applied Sciences in
Security and Safety,
Veslačka 2a,
10000 Zagreb, Croatia

Damir Kralj
Karlovac University of Applied Sciences
Trg J. J. Strossmayera 9
47000 Karlovac, Croatia
E-mail: damir.kralj@vuka.hr

Toni Kralj
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: toni.kralj@vuka.hr

Diana Kralj
M. Krleže 19,
47000 Karlovac, Croatia
E-mail: dianakralj55@gmail.com

Alen Krivačić
Valinge Croatia d.o.o.,
Otok Oštarski 4K,
47300 Ogulin, Hrvatska
E-mail: info@valinge.hr

Dubravka Krivačić
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: dubravka.krivacic@vuka

Dejan Krstić
University of Niš,
Faculty of Occupational Safety,
Čarnojevića 10a, 18000 Niš, Serbia
E-mail: dejan.krstic@znrfak.ni.ac.rs

Elizabeta Krstić Vukelja
Dental Clinic Zagreb,
Perkovčeva 3, 10000 Zagreb, Croatia
E-mail: ekrstic@spz.hr

Marko Kršulja
Juraj Dobrila University of Pula,
Faculty of Engineering, Zagrebačka 30,
52100 Pula, CROATIA
E-mail: mkrsulja@unipu.hr

Martina Kušec Ruganec
Dom zdravlja Karlovac,
Ul. Dr. Vladka Mačeka 48,
47000 Karlovac, Croatia

Vlado Kušec
Veleučilište u Križevcima,
M. Demerca 1.,
48260 Križevci, Croatia
E-mail: vkusec@vguk.hr

Matija Landekić
Faculty of Forestry and Wood Technology,
University of Zagreb,
Svetošimunska cesta 23,
10000 Zagreb, Croatia
E-mail: mlandekic@sumfak.unizg.hr

Bojan Latić
Kemigal, Technical tests and analysis,
Juranovo brdo 3,
47250 Duga Resa, Croatia
E-mail: bojan.latic47250@gmail.com

Ivan Leniček
Department of Electrical Engineering Fundamentals and Measurements,
Faculty of Electrical Engineering and Computing,
University of Zagreb, Croatia
E-mail: ivan.lenicek@fer.hr

Marijana Leontić
University of Applied Sciences in Security and Safety, Veslačka 2a,
10000 Zagreb, Croatia
E-mail: marijana@vss.hr

Dragica Ličko
INA Plc., Avenija Većeslava Holjevca 10,
10000 Zagreb, Croatia

Gorana Lipnjak
Croatian Association for Healthy Work Place
Kornatska 1d, 10000 Zagreb, Croatia

Nenad Lorković
University of Applied Sciences,
Trg J. J. Strossmayera 9, Karlovac, Croatia
E-mail: nenad.lorkovic@vuka.hr

Marjan Lukežič
Municipality of Ljubljana,
Streliška cesta 14,
1000 Ljubljana, Slovenia
E-mail: marjan.lukezic@ljubljana.si

Mladena Lukić
Faculty of Occupational Safety,
Čarnojevića 10a, Niš, Serbia
E-mail: mladena.lukic@znrfak.ni.ac.rs

Slaven Lulić
Karlovac University of Applied Sciences,
Trg J. J, Strossmayera 9,
47000 Karlovac, Croatia
E-mail: slulic@vuka.hr

Krešimir Malarić
Department of Communication and Space Technologies,
Faculty of Electrical Engineering and Computing,
University of Zagreb, Croatia
E-mail: kresimir.malaric@fer.hr

Zoran Marjanović
Ministry of Defence Republic of Serbia

Dragan Markushev
Institute of Physics, Pregrevica 118,
11000 Beograd, Serbia
E-mail: dragan.markushev@ipb.ac.rs

Bojan Matijević
Karlovac University of Applied Sciences,
J.J.Strossmayer Square No. 9,
47000 Karlovac, Croatia
E-mail: bojan.matijevic@vuka.hr

Karmen Matković Melki
Aspira University of Applied Sciences,
Ulica Domovinskog rata 65,
21000 Split, Croatia
E-mail: karmen.matkovic@aspira.hr

Zvonimir Matusinović
University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: zvonimir.matusinovic@vuka.hr

Srđan Medić
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: smedic@vuka.hr

Zrinka Mesić
Karlovac University of Applied Sciences,
Trg J. J. Strosmayera 9,
47000 Karlovac, Croatia
E-mail: zrinka.mesic@vuka.hr

Antonio Metić
Karlovac University of Applied Sciences,
Trg J. J, Strossmayera 9,
47000 Karlovac, Croatia
E-mail: antonio.metic@gmail.com

Marija Mićović
Research associate, University of Criminal Investigation and Police Studies,
Cara Dusana 196, 11080 Zemun, Belgrade

Misel Mihalić
Međimurje University of Applied Sciences in Čakovec,
Bana Josipa Jelačića 22a,
40000 Čakovec, Croatia
E-mail: misel.mihalic@student.mev.hr

Anđelko Mihok
Karlovac University of Applied Sciences
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: andelko.mihok@student.vuka.hr

Ivan Mijailović
University of Niš, Faculty of Occuaptional Safety,
Čarnojevića 10a,
18000 Niš, Serbia
E-mail: ivan.mijailovic@znrfak.ni.ac.rs

Budimir Mijovic
University of Bihac,
77000 Bihac, Bosnia and Herzegovina

Marina Milaković
Croatian Institute of Public Health,
Division for Occupational Health,
Radoslava Cimermana 64a,
10020 Zagreb, Croatia
E-mail: marina.milakovic@hzjz.hr

Franjo Mirosavljević
Fina GS d.o.o., Radnička cesta 182,
10000 Zagreb, Croatia
E-mail: franjo.mirosavljevic@finags.hr

Eduard Missoni
Fakultet prometnih znanosti,
Vukelićeva 4,
10000 Zagreb, Croatia
0038598-249-492
E-mail: emissoni@fpz.unizg.hr

Cvetanka T. Mitrevska
International Slavic University St. Nikola,
Marsal Tito 77, Sveti Nikole,
North Macedonia

Tina Mudrovčić
Croatian Institute for Public Health, 10000 Zagreb, Croatia

Selma Mujanić
University of Bihać, Pape Ivana Pavla II 2/2, 77000 Bihać,
Bosnia and Herzegovina
E-mail: selmamujanic14@gmail.com

Nenad Mustapić
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: nenad.mustapic@vuka.hr

Josipa Nakić
Faculty of Kinesiology,
University of Zagreb,
Horvaćanski zavoj 15,
10000 Zagreb, Croatia
E-mail: josipa.nakic@kif.unizg.hr

Vesna Nikolić
University of Niš, Faculty of Occupational Safety
Čarnojevića 10A,
18000 Niš, Serbia
E-mail: vesna.nikolic@znrfak.ni.ac.rs

Matija Novosel
Tehničko veleučilište u Zagrebu,
Vrbik 8, Croatia
E-mail-mnovosel@tvz.hr

Domagoj Opačak
University of Slavonski Brod,
Trg I. B. Mažuranić 2,
35000 Slavonski Brod, Croatia
E-mail: domagoj.opacakk@gmail.com

Zvonimir Ornik
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: zvonimir.ornik@gmail.com

Dominik Oroz
Croatian Institute of Public Health,
Division for Occupational Health, Radoslava Cimermana 64a,
10020 Zagreb, Croatia
E-mail: dominik.oroz@hzjz.hr

Mirsada Oruč
Faculty of Engineering and
Natural Sciences,
University of Zenica,
Bosnia and Herzegovina

Željko Otmačić
Energo inspekt doo, J. Jelačića 47a,
10430 Samobor, Croatia

Marko Ožura
Karlovac University of Applied Sciences,
Trg J. J. Strosmayera 9,
47000 Karlovac, Croatia
E-mail: marko.ozura@vuka.hr

Darko Palačić
University of Applied Sciences in
Security and Safety,
Veslačka 2a,
10000 Zagreb, Croatia
E-mail: darko@vss.hr

Sanela Paskaš Dlugoš
HZJZ, R. Cimermana 64a,
10020 Zagreb, Croatia
E-mail: sanela.paskas-dlugos@hzjz.hr

Dušica J. Pešić
University of Niš, Faculty of
Occupational Safety in Niš,
Čarnojevića 10a,
18000 Niš, Serbia
E-mail: dusica.pesic@znrfak.ni.ac.rs

Igor Peternel
University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: igor.peternel@vuka.hr

Krunoslav Pintur
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: krunoslav.pintur@vuka.hr

Nina Popović
Karlovac University of Applied Sciences,
Trg J. J. Strosmayera 9,
47000 Karlovac, Croatia

Željka Potočnjak
Karlovac University of Applied Sciences,
Trg J. J. Strosmayera 9,
47000 Karlovac, Croatia

Marko Prahović
Karlovac University of Applied Sciences,
Trg J. J. Strosmayera 9,
47000 Karlovac, Croatia
E-mail: marko.prahovic@vuka.hr

Andreja Primužak
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: andreja.primuzak@vuka.hr

Lada Purgar
Karlovac University of Applied Sciences,
J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: ladapurgar@gmail.com

Tanja Pušić
Department of Textile
Chemistry and Ecology,
Faculty of Textile Technology,
University of Zagreb, Croatia
E-mail: tanja.pusic@ttf.unizg.hr

Iva Putanec
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47 000 Karlovac, Croatia

Ana Rački Marinković
University of Applied Sciences in
Security and Safety,
Veslačka 2A,
10000 Zagreb, Croatia
E-mail: ana.racki.marinkovic@vss.hr

Antun Radečić
Karlovac University of Applied Sciences,
Student at the Mechanical
Engineering Study,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: antunradecic49@gmail.com

Nebojša Raičević
University of Niš, Faculty of
Electronic Engineering,
A. Medvedeva 14,
18000 Niš, Serbia
E-mail: nebojsa.raicevic@elfak.ni.ac.rs

Anica Ranđelović
University of Niš, Faculty of
Occupational Safety,
Čarnojevića 10 a, 18106 Niš, Serbia

Uwe Reischl
Boise State University, Idaho, USA

Matija Rendulić
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: matija.rendulic112@gmail.com

Jasminko Saletović
INA - Industrija nafte, d.d.
10310 Ivanić-Grad, Croatia
E-mail: jasminko.saletovic@ina.hr

Vanesa Sarvaš
Karlovac University of Applied Sciences,
Trg J. J, Strossmayera 9,
47000 Karlovac, Croatia
E-mail: sarvasvanesa@gmail.com

Luís Serra
Polytechnic Institute of Beja, Portugal
E-mail: luisviegas.serra@hotmail.com

Milena Spasovska
Faculty of Psychology, International Slavic
University St. Marsal Tito,
Sveti Nikole, North Macedonia
E-mail: milena.spasovska@msu.edu.mk

Vladimir Stanković
Faculty of Occupational Safety,
University of Niš,
Čarnojevića 10a,
18000 Niš, Serbia
E-mail: vladimir.stankovic@znrfak.ni.ac.rs

Anita Stilin
University of Applied Sciences of Rijeka,
Vukovarska 58,
51000 Rijeka, Croatia
E-mail: anita.stilin@veleri.hr

Ivana Stipaničić,
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: ivana.sti.upravna@gmail.com

Martina Stvorić
Aspira University of Applied Sciences,
Ulica Domovinskog rata 65,
21000 Split, Croatia
E-mail: martina.stvoric@aspira.hr

Tomislav Šančić
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: tsancic@vuka.hr

Ana Šaravanja
University of Zagreb Faculty of
Textile Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia
E-mail: ana.saravanja@ttf.unizg.hr

Bosiljka Šaravanja
Department of Clothing Technology,
Faculty of Textile Technology,
University of Zagreb, Croatia
E-mail: bosiljka.saravanja@ttf.unizg.hr

Goran Šarić
Karlovac University of Applied Sciences
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: goran.saric@vuka.hr

Zlatko Šarić
Croatian Institute for Public Health, 10000
Zagreb, Croatia
E-mail: zlatko.saric@hzjz.hr

Maja Šikić
Karlovac University of Applied Sciences,
J. J. Strossmayera 9,
47000 Karlovac, Croatia

Alen Šimec
Tehničko veleučilište u Zagrebu,
Vrbik 8, Croatia
E-mail: alen@tvz.hr

Nikola Šimunić
Karlovac University of Applied Sciences,
Trg J.J.Strossmayera 9,
47000 Karlovac, Croatia
E-mail: nsimunic@vuka.hr

Domagoj Škarica
HEP Proizvodnja d.o.o. – EL-TO Zagreb,
Zagorska ulica 1,
10000 Zagreb, CROATIA
E-mail: domagoj.skarica@gmail.com

Goranka Škeva
Health center Zagreb County,
Lj. Gaja 37,
10430 Samobor, Croatia
E-mail: goranka.skeva@gmail.com

Pero Škorput
University of Zagreb,
Faculty of Transport and Traffic Sciences,
Vukelićeva 4,
10000 Zagreb, Croatia
E-mail: pero.skorput@fpz.unizg.hr

Dino Šojat
Faculty of transport and traffic services,
Vukelićeva 4,
10000 Zagreb, Croatia
E-mail: dsojat@fpz.unizg.hr

Silvija Špehar
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: silvijaspehar996@gmail.com

Bruno Štajner
ZITEL EURO CONTROL d.o.o.,
Bolnička cesta 94, 10000 Zagreb, Croatia
E-mail: bruno@zitel.hr

Marko Štajner
ZITEL EURO CONTROL d.o.o.,
Bolnička cesta 94, 10000 Zagreb, Croatia
E-mail: marko@zitel.hr

Ivan Štedul
Karlovac University of Applied Sciences,
I. Meštrovića 10,
47000 Karlovac, Croatia
E-mail: ivan.stedul@vuka.hr

Snježana Štefok
Ministry of Labour, Pension System,
Family and Social Policy,
Ulica grada Vukovara 78,
10000 Zagreb, Croatia
E-mail: snjezana.stefok@mrosp.hr

Kristina Štimac
ZITEL EURO CONTROL d.o.o.,
Bolnička cesta 94,
10000 Zagreb, Croatia
E-mail: kristina.stimac@zitel.hr

Hasan Talić
University of Bihać, Pape
Ivana Pavla II 2/2,
77000 Bihać, Bosnia and Herzegovina
E-mail: hasan.talic@unbi.ba

Anita Tarbuk
University of Zagreb Faculty of
Textile Technology,
Prilaz baruna Filipovića 28a,
10000 Zagreb, Croatia
E-mail: anita.tarbuk@ttf.unizg.hr

Lidija Tepeš Golubić
Tehničko velučilište u Zagrebu,
Vrbik 8, Croatia
E-mail: lidija.tepes@tzv.hr

Aleksandar Terzić
Master of Political Science

Marina Tevčić
University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000Karlovac, Croatia
E-mail: marina.tevcic@vuka.hr

Ana Tomašić
Karlovac Technical School,
Ljudevita Jonkea 2a,
47000 Karlovac, Croatia
E-mail: ana.tomasic1@skole.hr

Ljerka Tomljenović
University of Applied Sciences of Rijeka,
Vukovarska 58, 51000 Rijeka, CROATIA
E-mail: ljerka.tomljenovic@veleri.hr

Maja Trečić
Veleučilište u Karlovcu,
Trg J.J. Strossmayera 9,
47000 Karlovac, Hrvatska

Nikola Turina
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia

Marinko Đ. Učur
scientific advisor in a permanent position
Rijeka

Maja Ulemek
General hospital Karlovac,
Andrije Štampara 3, 47000 Karlovac, Croatia
E-mail: majaulemek0@gmail.com

Ivana Varičak
Karlovac University of Applied Sciences
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: ivana.varicak@vuka.hr

Leon Vedenik
Ministry of the interior of the
Republic of Slovenia, Police, Police Directorate
Murska Sobota, Arhitekta Novaka 5, 9000
Murska Sobota, Slovenia
E-mail: leon.vedenik@policija.si

Anamarija Vonić Lukinec
Health center Zagreb County,
Lj. Gaja 37, 10430 Samobor, Croatia

Ivan Vrabec
Karlovac University of Applied Sciences
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: ivan.vrabec@student.vuka.hr

Lora Vucelić
Istrabenz plini d.o.o,
Pristanište podbok 3,
51221 Bakar, Croatia
E-mail: lruzic1809@gmail.com

Zoran Vučinić
Zavod za hitnu medicinu
karlovačke županije,
dr.Vladka Mačeka 48,
47000 Karlovac, Croatia
E-mail: zoranvucinic5@g,mail.com

Marinela Vulić
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: marinela.vulic@vuak.hr

Elizabeta Zandona
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: ezandona@vuka.hr

Sandra Zavadlav
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47 000 Karlovac, Croatia
E-mail: sandra.zavadlav@vuka.hr

Darko N. Zigar
University of Niš, Faculty of
Occupational Safety in Niš,
Čarnojevića 10a,
18000 Niš, Serbia
E-mail: darko.zigar@znrfak.ni.ac.rs

Suzana Zikovska
International Slavic University St. Nikola,
Marsal Tito 77,
Sveti Nikole, North Macedonia
E-mail: lidija.joleskabureska@msu.edu.mk

Branko Zlomislić
University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia

Manuela Žakula
Karlovac University of Applied Sciences,
Trg J. J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: manuela.zakula@vuka.hr

Ana Marija Žalac
Karlovac University of Applied Sciences,
J.J.Strossmayer Square No. 9,
47000 Karlovac, Croatia
E-mail: anamarija.zalac@vuka.hr

Eric Žgela
Karlovac University of Applied Sciences,
Trg J.J. Strossmayera 9,
47000 Karlovac, Croatia
E-mail: eric.zgela@student.vuka.hr

Ivana Žitko
Rimac Technology d.o.o., Ljubljanska 7,
10431 Sveta Nedelja, Croatia
E-mail: ivana.zitko@rimac-technology.com

Filip Žugčić
Karlovac University of Applied Sciences,
Trg J. J, Strossmayera 9,
47000 Karlovac, Croatia
E-mail: fzugcic@vuka.hr

SPONSORS

KARLOVAČKA ŽUPANIJA

In medias res

STUDENTSKI
CENTAR
KARLOVAC

PROFESIONALNI VATROGASCI

KARLOVAC

Web ZNR

ZIRS

SIGURNOST D.O.O.

D-COLOR

grafički dizajn & produkcija

OCCUPATIONAL SAFETY AND HEALTH

OCCUPATIONAL SAFETY AND HEALTH