AUTHOR'S DESCRIPTION OF DOCTORAL (PhD) DISSERTATION

LUDOVIKA UNIVERSITY OF PUBLIC SERVICE
FACULTY OF MILITARY SCIENCE AND OFFICER TRAINING
DOCTORAL SCHOOL OF MILITARY ENGINEERING

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Extending Explosion Safety Studies to Enhance Operational and Work Safety

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DEFINING THE SCIENTIFIC PROBLEM

Science and technology are constantly changing in the technical world. Throughout history several technological innovations have been discovered, making our everyday lives easier. However, these innovations can also pose risks, such as explosions, endangering human lives and material goods. Therefore, it is crucial to define the right conditions for safe work. As electricity gave us lot of support and benefit in our history, its usage has also expanded widely. However, this expansion has brought new risks, such as explosions that is why research on prevention also started. Initially, identifying potentially explosive environments and safe separation of the source of ignition in case of electrical and non-electrical equipment usage was a priority. To improve safety, checked electrical devices that comply with strict safety regulations were introduced. Over time, safety regulations have been effective in reducing accidents caused by electrical ignition sources and this is due to successful regulations. This does not necessarily mean that accidents do not occur. As like other disasters explosions often due to human error. Today, many applications require explosion-proof products. In the professional field during the continuous research activity electrical measurement technique was performed, which can be set up at hazardous areas.

Different standards let manufacturers to determine if they have developed explosion-proof systems or devices. In Hungary the explosion protection is controlled by complex regulations involving multiple authorities, following the 3/2003. (III. 11.) FMM–ESZCSM joint decree, considering legal foundations and workplace safety. Official work carries significant responsibility, so the related research activity has to be continuous. To ensure safety and efficiency certain requirements and standards are required to obey by the relevant authorities. However, these requirements are effective, with the duties investigation further suggestions can be made to improve safety.

Most standards related to this field refer to normal conditions. However, it is essential to verify and extend the concept of "normal conditions" based on practical experiences. Normal condition is a planned normal operation, which includes reasonably foreseeable abnormal operations when designing protective systems. Research on abnormal conditions is less widespread compared to research on normal conditions, that is why this requires further analysis to establish minimum requirements for abnormal conditions.

Safety and supervision of hazardous industrial activities are very important. Compliance and enforcing various regulations and laws is essential. Understanding the properties of hazardous

materials is also crucial, which is provided in safety data sheets. With their help, we can understand the health effects of hazardous substances and the safe use, storage, and disposal of products. This method can be used effectively, however in my opinion extreme conditions can occur in a hazardous plant causing the hazardous substance to behave differently than usual. I have selected a material which I would like to analyze.

In the field of disaster protection, it is obvious that saving lives is always the primary concern, that is why giving safety is a prominent role in various operations. The basic condition for safe work is that employees, especially in the industry, are familiar with the sources of danger in their environment and their effects. For this reason, I would like to make sure that employees in various hazardous industrial plants have adequate work, fire, and accident prevention knowledge, and whether the existing regulations offer further opportunities for development. I plan to implement this through my own questionnaire data collection, where my primary goal is an attitude study among the workers of hazardous plants. In my opinion the topic I am researching is actual and could gain even greater importance in the future due to the continuous development of the industry.

FORMULATION OF RESEARCH HYPOTHESES

Following the presentation of the scientific problems related to my topic, I have formulated the following research hypotheses:

1. **I assume that further development of specific domestic regulations relating to explosion protection can improve the safety of hazardous plants in Hungary.**
2. **I presume that under extreme conditions certain hazardous materials can lead to an explosion more quickly than the values found in the instruction manuals.**
3. **I assume that current fire and occupational safety regulations and standards contain further possibilities for regulation options, which could improve the current level of safety by clarifying the regulatory environment and defining boundaries.**

RESEARCH TARGET

For the sake of protecting human life and material assets, as well as establishing a safe working environment I define the following research objectives:

1. In order to create an even safer working environment than before, I aim to reveal the weak points of some domestic laws and guidelines in order to formulate a framework for more effective explosion protection.
2. My goal is to map whether hazardous substances used in certain domestic hazardous plants can show a chemical phenomenon under extreme conditions different from normal operating conditions, which has a significant impact on safety and justifies the need to revise and expand the physical/chemical data content of the safety data sheet. .
3. My goal is to make sure that the employees of the various hazardous industrial plants have adequate knowledge of work, fire and accident prevention, and to determine what further development opportunities are contained in the labor protection regulations aimed at this.

RESEARCH METHODS

To achieve the upper outlined research objectives, I used the following main research methods:

- I examined and analyzed in detail the scientific results of relevant domestic and international academic literature concerning the topic.
- I conducted personal consultations with recognized domestic and international experts in the field, summarizing their views and using them in my dissertation.
- I created and analyzed my own diagrams and graphs concerning the results relevant to my research.
- I also used my own experiences in examining the technical issues related to hazardous plants.
- I created a scenario with conditions close to reality, which I used to analyze the consequences of a potential accident (case study creation).

- While investigating the combustion properties of dichloromethane (DCM), I conducted laboratory tests in three different laboratories in the country.
- I conducted an attitude survey among employees working in hazardous plants using a questionnaire data collection method. I examined the results of my questionnaire using a null hypothesis and variance analysis and I also used the so-called Pearson correlation.

CONDUCTED RESEARCH SHORT DESCRIPTION BY EACH CHAPTER

Chapter 1: In the first chapter I make a general overview of explosion protection through an analysis of relevant domestic and international technical literature. I examine the theoretical background of combustion and the related physical and chemical processes. Description of the basic principles of protection is also given. Specific examples of international and domestic disasters related to explosions occurred in the past and lessons from it were presented in my research. I go into the details of the conditions required for working in an explosion-prone space including presenting zone classification criteria. Following this I describe the risk assessment process using a multi-step analysis as well as the minimal requirements for work conditions. I describe in detail the importance and necessity of authority presence in explosion protection and the contradictions within Hungarian law. I show the role and importance of Fire Protection Technical Guidelines (hereafter TvMI), and further improvement opportunities in the field of explosion protection. With the help of an assumed example mathematical calculations, I determine the setup or establishment conditions for a simulated disaster. In this chapter as a first goal I define Hungarian guide-lines and laws extension possibilities. At the end of the chapter I summarize in short my conclusions, key findings and results.

Chapter 2: In the second chapter I do a widespread combustibility check of dichloromethane. Within this framework I discuss the most important characteristics of working with hazardous materials. After this the results of previous measurements and laboratory experiments related to hazardous materials are presented, followed by a study of the chemical phenomena occurring at the flashpoint of dichloromethane. This is done through by my own three-step laboratory experiment. I publicize that hazardous materials can pose additional health risks under extreme conditions, besides those listed in safety data sheets and manuals. I also tell the risks in what conditions can occur. In this chapter completed my second aim with investigating the Hungarian

hazardous plants using hazardous materials in extreme conditions, checking the chemical phenomenon shown in hazardous plants compare to the scientific literature. At the end of the chapter I summarize in short my conclusions, key findings and results.

Chapter 3: In the third chapter I examine work conditions in an explosion-prone environment with attention to further improvement opportunities. Through questionnaire data collection the possibilities for improving fire and accident prevention lectures investigated. First the methodological background of the questionnaire research is presented in general along with the results of previous surveys in the field of disaster protection. Based on my questionnaire data collection I evaluate the results of demographic, self-assessment of workers and workplace fire and accident prevention attitude surveys. These are analyzed with a null hypothesis and variance analysis and also Pearson correlation is used. Within this framework I recommended for further improvements in fire and accident prevention lectures. In this chapter completed my third aim with made certain that the employees knowledge regarding fire and safety protection is adequate. I investigated the reserves from which safety can be increased and improved in short-term. At the end of the chapter I summarize my conclusions, key findings and results.

At the end of my thesis summarized conclusions of my research are shown as well as my new scientific results. I also put my dissertation recommendations and the practical applicability of my research results.

NEW SCIENTIFIC RESULTS

1. As a result of the overview examination of explosion protection, I realized that in the case of establishment conditions, it is necessary to expand the Fire Protection Technical Guidline on Explosion Protection with the possibility of applying HAZOP/SIL procedures, the support of this processes, the accuracy of risk measurement could be improved and, at the same time, the assumed risk can be reduced.

2. During laboratory experiments and a complex examination the flammability of dichloromethane, I found that there are potencial dangerous substances that, in addition to the dangers indicated on their safety data sheets, can explode under and during extreme conditions. Several series of experiments, I showed that in the case of dichloromethane, below the self-ignition temperature of 605°C highlighted on its safety data sheet, an explosion could be occurs at 310°C in the presence of a hot surface and an ignition source. By this recognition, it should be necessary to extend the safety data sheet with the value of 310°C.

3. As a result of the analisys of working in an explosive working environment, I determined the actual knowledge level of the employees of the checked hazardous plants as a representative manner, based on the previous highlights I prepared formulated proposals regarding the development of the currently and actual applied fire-, accident- and occupational safety trainings. I proved that it is necessary to train and teach the topic with more details and depths by the terms of explosion protection, which contributes to even a safer work environment in the domestic hazardous plants.

RECOMMENDATIONS

I recommend my dissertation to:

Organizations and professionals who work on a daily basis in explosion-hazardous areas, or with technical equipment used in explosion protection.

Legislators who are responsible to create and modify laws related to explosion protection.

Disaster management experts who are responsible for preventive fire protection in the field of explosion-hazardous activities.

Civilian and professional students who plan to write their thesis or degree work on the explosion protection subject. My PhD dissertation could help their studies.

All national and international teachers, researchers and PhD candidates who plan to write academic works in this subject.

Experts within the National Fire Safety Directorate, as well as the Fire Safety Department within the institution of BM OKF.

All higher education institutions that take part in engineering education.

Professionals who work on a daily or even weekly basis in various laboratories, primarily working in fire protection laboratory.

PRACTICAL USAGE OF RESEARCH RESULTS

The role of explosion protection in fire prevention considering active fire safety measures and plant safety provides opportunities for legislative changes based on my research results. My reasearch title is "Research and Development of tools used in explosion protection." After clarifying and analyzing normal conditions, non-normal conditions could be part of future legislative changes. The results of my research could also expand the actual TvMI.

Currently preventive, rescue, and fire protection engineering training do not cover explosion protection sufficiently. The subject matter themes anayses, which I conducted provides opportunity to create new subject matter themes or update existing ones.

My measurements results conducted in laboratories can be used by natural or legal persons, who work with DCM or substances with similar properties at their workplaces or sites.

The results of my laboratory experiments can greatly contribute to the duplication of heat-sensing elements operating in multiple zones in the case of an existing polymer and its matrix-forming solvent. They also assist in developing alerts in separate zone sections with different temperature trends, as well as the measurement of the displacement of the heat elements with the establishment of an independent system.

My research results can be used and applied for the domestic-level integration of HAZOP/SIL and LOPA, further expanding the regulatory environment's guidelines.

AUTHOR'S LIST OF PUBLICATIONS FOR THE STUDY

Lektorált folyóiratban megjelent cikkek

1. Király Lajos - Restás Ágoston - Cimer Zsolt: Robbanásvédelem szabályozási javaslata Magyarországon. *Védelem Tudomány*, III. 3. (2018), 50-64.o.
2. Király Lajos - Restás Ágoston: Industrial safety in explosive work environment view for Hungary. *Ecoterra: Journal of Environmental Research and Protection*, XIV. 4. (2017), 15-22.o.
3. Király Lajos: Robbanásveszélyes zóna besorolásának szabályai – esettanulmány. *Védelem Tudomány,* II. 1. (2017), 102-116.o.
4. Király Lajos: Robbanásveszélyes terekben történő munkavégzés feltételrendszere. *Védelem Tudomány,* I. 1. (2016), 82-96.o.
5. Király Lajos - Vájó Norbert: Rendezvények biztonsági kérdései. *Hadmérnök*, X. 1. (2015), 11-23.o.

Presentation published in conference publications

1. Hoffmann Imre - Cimer Zsolt - Király Lajos: A csapadék vízgazdálkodás iparbiztonsági aspektusai. In: Bíró, Tibor (szerk.): Országos Települési Csapadékvíz-gazdálkodási Konferencia tanulmányai. Dialóg Campus Kiadó. Budapest, Magyarország: 2019. 15 p. 311-325.o.
2. Király Lajos: Robbanásvédelmi rendszerbiztonság. In: Vass Gyula - Mógor Judit; Kovács Gábor - Dobor József - Horváth, Hermina (szerk.): Katasztrófavédelem Tudományos Konferencia 2018. Veszélyes tevékenységek biztonsága. BM OKF. Budapest, Magyarország: 2018. 347 p. p. 329.
3. Király Lajos - Restás, Ágoston: Some Issue Relating to the Industrial Safety Focusing on Explosive Work Environment. In: Konferencia, Szervezőbizottsága (szerk.) 11th International Conference on "Environmental Legislation, Safety Engineering and Disaster Management" Elsedima: Building Disaster Resilience in a Changing Word (Book of abstracts). Kolozsvár, Románia: Babes-Bolyai University, Faculty of Environmental Science and Engineering 2016. 199 p. pp. 104-104.
4. Király Lajos - Restás, Ágoston: Robbanásbiztonság – tűzbiztonság. In: Restás Ágoston - Urbán Anett (szerk.): Tűzoltó Szakmai Nap 2016. Budapest, Magyarország: BM OKF (2016) 186 p. pp. 144-146.
5. Király Lajos - Restás Ágoston: Robbanásvédelem a tűzmegelőzésben. In: Restás Ágoston - Urbán Anett (szerk.): Katasztrófavédelem 2015. Budapest, Magyarország: BM Országos Katasztrófavédelmi Főigazgatóság. 2015. 192 p. 174-177.o.

THE DOCTORAL CANDIDATE'S PROFESSIONAL SCIENTIFIC BIOGRAPHY

Lajos Király was born on April 22, 1985 in Tatbánya. He started his secondary school studies at László Bárdos High School in Tatabánya, then he first obtained a bachelor's degree in environmental engineering at István Széchenyi University, then in 2011 he obtained a bachelor's degree in mechatronics engineering at Óbuda University, and he obtained his master's degree in environmental technology at Pannónia University in 2012. He started his PhD studies in 2018 at the National University of Public Service, Faculty of Military Science and Defense Officer Training, Doctoral School of Military Technology. He currently works in

the Nyergesújfalu factory of Toray Industries and LG Chemical in the position of Facility and EHS manager.

THE CANDIDATE PROFESSIONAL CAREER ROUTE

He started his work at Zoltek Vegyipari Zrt. as a technical draftsman and continued his duties as an employee of the environmental protection organization. In 2009, he performed his duties as an environmental protection manager and in 2013 as an Occupational Safety and Environmental Protection manager in the integrated organization. In addition to his duties at work, he also took on the role of founder of a specialist group at the Engineering Chamber, later continuing as a specialist group leader. He has given several presentations in the field of explosion safety technology in the framework of ATEX forums and Fire Protection Professional Days. In addition, he participated in the editing of conference publications 5 times, in the evaluation of theses and in 2 topic management, and he was a jury member of the school's Student Circle Conference 1 time.

THE CANDIDATE SCIENTIFIC COMPETITION

In addition to the general examinations of the doctoral school, the Candidate also completed activities related to other studies. In 2019 and 2020, he participated in the development of the Fire Protection Technical Guidelines for Explosion Protection. as a speaker, he participated several times in explosion protection forums and professional days. Currently, he leads the working group of explosion safety technology, whose main focus is to resolve bottlenecks between explosion protection and work safety and make them unequivocal. In the current phase of the work, the first step is to join the accredited education system, the further continuation of which will be the further strengthening of legal coherence. In parallel with his studies, the candidate completed the NEBOSH (National Examination Board in Occupational Safety and Health- L1-3) training courses recognized and accredited by the United Kingdom at the international level.

Budapest, 2023.september 19.

KIRÁLY, Lajos