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**The Effects of Explosion and Explosive Materials on the Human Body and the
Opportunities for Prevention**

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Opportunities for Prevention**

Theses of PhD dissertation

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DESCRIPTION OF THE SCIENTIFIC PROBLEM

The role of the explosives and blasting operations in shaping the history of mankind and in its developing is unquestionable. On the one hand these effects are positive as long as they served, serve the transportation, the industrial development, in total they serve the improvement of our everyday lives.

At the same time the pages of our history has been contaminated by bloody wars, a lot of sufferings, ten and hundreds of millions of extinguished lives, and the explosives and bombing actions also have prominent roles in it, whether they are legal, blasting operations applied by policy and defense organizations or criminal ones, which are committed for religious or ideological reasons or the purpose of gain.

The work environment is 1 to 3 times more dangerous than our everyday surroundings. Such health hazards may come from itself at work or from the presence of etiological factors on site, which cannot occur among the other members of the society.

However the health hazards in working sites can affect the developing, the procession, the recrudescence of a number of diseases. The harmful effects of the labour conditions may be responsible for 5-20% of all the diseases beyond the occupational or occupation related illnesses. The more than 100.000 types of chemicals, 50 types of physical, the more than 200 types of ergonomical and unknown psychosocial etiological factors, and the health damages caused by the suboptimal recourse are in the background of this.

The potentially explosive activity within different working environments, the exposition site and the blasting process belong to a highly dangerous and health damaging category both in military and industrial fields.

In the contemporary modern professional armed forces the value of the qualified soldiers have significantly increased, and the professional and contract staff appear as employees. It is a justified social expectation that same high standards must be raised in connection with the military working environment and the work - as with the industrial jobs.

During the blasting activity the human body can be affected by a number of etiological factors, so the fundamental goal and one of the pillar of the sustaining development of the OSH (occupational safety and health) and labour hygiene is the decreasing of the risks of different accidents and harmful effects on the health.

Recently terrorism has become a real source of danger, terrorist bombings are not kites any more. After joining the NATO, during her international responsibilities Hungary has become the target of the terrorists, who mostly want to achieve their goals by terrorist bombings.

The continuous development of the possibilities of the detection and destruction, the preparation of new types of devices and the protection of the combat personnel are one of the most important areas of the fightings against the improvised explosive devices. The world's armies and arms manufacturers are in competition with the most advanced methods used by the terrorists.

It is also a major task to confront the legacy of the past wars. Even today damaged, unexploded explosive ordnances have been found in large quantities from under playgrounds, from the roofing of the houses, at construction sites and in the fields.

Every year bomb disposal operators of the Hungarian Armed Forces deactivate and annihilate several hundreds of thousands devices to protect the Hungarian population.

Preventing of the explosive injuries is given priority by all military and law enforcement authorities. Enormous progress has been made in the methods of procedure, and the same happened to the collective and the personal protective devices.

I have been serving in the Medical Centre of the HDF 1st Explosive Ordnance Disposal and Warship Regiment for seven years. Since 2007, I have been working as an occupational medicine specialist and as a labour hygienist since 2012.

In 2007, I started to deal with explosive materials, as with the explosion and the harmful effects of the explosion during the session, with the characteristics and possibilities of the prevention of the explosive injuries.

I began my scientific research work on November 1st, 2007, and finished on September 30th, 2013.

In my dissertation I would like to introduce the relationship between the industrial and military explosion techniques and the labour hygiene, those carrying out the explosions, as well as the risk factors for those who suffered them, and also the possibilities, which aim to reduce these risk factors.

This problem has not been examined in this context in Hungarian medical, military and explosion technology scientific literature. Similar topics have already appeared in the literature by the translations of foreign language articles.

The publications and the PhD dissertation in connection with explosive injuries written by Dr Levente Varhelyi are viewed from surgical approach, while Dr Livia Bekesi deals with the military labour hygiene in general - not with a special professional field, so I hope that the results of my research will be of gap-filling importance.

I tried to give the Hungarian explanation of the medical terms, formulate them in Hungarian in most places in my dissertation, or comment on them in the footnote, interpret them, because hopefully the communication of my results will be used not only by sanitary experts but also by the society of demolition experts with great benefit.

RESEARCH OBJECTIVES

My research objectives are:

- To examine and summarize the adverse health effects of the secondary or high explosive materials used in large quantities - on the basis of national and foreign scientific literature sources.
- To determine the observed labour hygiene rules while working with explosives, which may prevent occupational diseases and poisonings.
- To make recommendations regarding the applicable personal protective equipment (PPE) in respect of the activities carried out with explosives.
- To summarize the characteristics of the explosion injuries, the defensive capabilities of the protective clothing used to prevent injuries, and to define their conditions, labour hygiene rules in connection with their application.
- To formulate proposals for avoiding hearing damage due to blast effect and acute acoustic trauma caused by the explosion.
- To define the degree the crew performing demolition activities is exposed to toxic gases produced by explosions.
- To make proposals, recommendations in order to avoid health impairment caused by explosive gases.
- To draw up a practical guide for the risk assessments regarding to the explosives and demolitions, for choosing the personal protective devices, and for regulating and completion of the aptitude tests, and for helping the occupational safety and labour hygiene specialists.
- To develop those labour hygienic regulations that I suggest to be included in the curriculum for the demolition trainings, courses, and they may be incorporated into the Explosive Code planned to be published later.

In my dissertation, I do not deal with the initiating explosives used in very small quantities, nor with the pyrotechnical products, nor with the alternative explosives used in mainly home made explosive ordnances.

I have analyzed the topic in the field of explosive injuries in terms of the defence capability and application of the protective device, because it is my professional field. In his PhD dissertation, Dr Levente Varhelyi has already dealt with the theme according to his field of expertise in terms of the surgical care, and he presented a number of cases when the victims were cared during his home and missionary service.

I analyzed the latest military protective equipment, the type EOD-9 bomb-suit currently in circulation, which serve to prevent explosive injuries, because it is used in the Bomb Squad of the Hungarian Defense Forces during their activities against improvised explosive devices.

In my dissertation, furthermore I do not deal with the harmful materials from detonated objects and from buildings, dusts, aerosols, or the potential CBRN agents – only with the toxic gases from the explosive materials.

THE RESEARCH HYPOTHESES

I started my research to define the hypotheses and objectives of the scientific dissertation by the experiences working as team physician for one of the corps of the Hungarian Defense Forces, which uses most explosives.

- The labour hygiene aspects of the activities with explosion and explosive materials are not given adequate emphasis in the national industrial and military explosive technique neither during the education and training nor during the implementation of the activities.

- The General Blasting Safety Regulations and the Mű/213 Demolition Instructions of the Hungarian Defense Forces, which contain the industrial blasting technique's safety standards, do not include the protection of the soldiers' health in respect of labour hygiene; they comprise only safety engineering regulations, or very generally worded instructions, for example for the ventilation time.

- During the training/education and during the activity with explosive materials, the labour hygiene aspects are not taken into account because of the lack of regulation. These aspects are not included in the instructions because they are not adequately worked out; literature data also tend to be found rather in the international professional literature.

- Protective devices are not specifically defined for activities with different explosives and demolition tasks. It falls to the competent health and safety professionals and occupational health specialists to do this task, who are not sufficiently informed on how to select because of lacking reference literature and guides.

- When using special protective clothing to prevent blasting injuries, they have not examined the burden and stress due to the equipment itself, and the labour hygiene regulations observed during the use have not been worked out yet.

- The health hazards caused by explosives, gas and rumbling related harm can be prevented by compliance with labour hygienic regulations at work, and by using properly chosen protective equipment.

- The aptitude requirements for those who handle and apply explosives in large quantities in the units of the Hungarian Defense Forces do not include the examination of their impact, and there are no statutory requirements in this respect.

RESEARCH METHODS

I have studied both the domestic and foreign professional literature in order to achieve the set goals, topics very similar to Othmár Mueller's Separate Collection of Technical

Explosion. When researching and working out the theme, processing the literature I used general research methods like analysis, synthesis, induction and deduction.

I have consulted with the occupational health specialists of the Hungarian Institute of Occupational Health and with the professional staff of the Work Hygiene Laboratory of the Military Public Health and Epidemiological Institute of the Medical Centre of the Hungarian Defence Forces. Part of my work hygiene measurements are the result of their efforts, because they possess a laboratory accredited by National Accreditation Staff and great value, certified and calibrated measuring instruments. I would highlight and recognize Eng. Capt. Gabor Guth noise- and vibration engineer's professional help.

Significant portion of the labour hygiene measurements were carried out during explosions used with the specialized duties of the HDF 1st Explosive Ordnance Disposal and Warship Regiment, and during explosive practices of the National University of Public Service, and during mining and explosive welding.

I analyzed the majority of the measurements in caves and mines in collaboration with Lorand Kugyela explosion-leader, the colleague of the Explosives Qualifying Laboratory of TÜV Rheinland InterCert Ltd., and together we have written several publications about them. On the spot, I could study the manufacturing process of the explosives at the Mexikóvölgy, site of Mikerobb (Miskolc Komplex Building Demolition and Explosion Technical) Ltd., and the mining explosions in a basalt quarry near Dunabogdány. Here I would like to highlight and appreciate Gabriella Kuris mining engineer's professional help.

I took part in the project of the Protection of Buildings against Demolitions in the TÁMOP-4.2.1.B-11/2/KMR-2011-0001 Critical Infrastructure defence research 4th subprogramme - jointly tendered and won by Óbuda University and University of Public Service. Doing so my tasks were to analyze the explosive injuries and to examine the sound blast damage caused by the explosion, and the toxic gases released during the explosion.

Experimental series of explosions were carried out together with the experts of TÜV Reinhardt Ltd., during which me and my working team measured the airborne concentration of the exploding gases and the impulse noise.

Medical records of the employees were obtained through the primary health care, and by using a questionnaire method during the screening tests, at which the use of data for statistical purposes was authorized by the stakeholders' signatures.

I participated in a number of domestic and foreign conferences held mainly for explosion technical experts, where I made presentations about the topic I studied.

In the middle of 2013, our joint programme started with the colleagues of the Institution of Machine Structure Engineering and Security Technology of Óbuda University's Donát Bánki Machinist and Security Engineering Faculty, for examining the demolition expert's protective garment ergonomically, and studying its burden and stress.

DESCRIPTION OF THE RESEARCH IN CHAPTERS

My dissertation is formulated into three chapters according to the stated research objectives.

In the first chapter, I present the home- and law defensive, industrial and criminalistic/malicious usage of the demolishing techniques, and their basic concepts of labour hygiene. I analyze the connection points of the demolishing techniques and the labour hygiene, and I reveal the problematic areas.

In the second chapter, I present the toxicological characteristics of the secondary explosives. I analyze the medical records of a group of workers who use explosives in larger quantities. I present and make recommendations regarding to the usage of material for preventing the harmful effects to the health causing explosives, regarding to the applicable hygienic rules, and the individual protective devices applicable in the different work processes.

In the third chapter, I introduce the harmful health effects of the physical and chemical processes triggered by explosion, the mechanisms causing the injuries; knowing these I analyze the defense capability of the currently most advanced protective equipment, the EOD-9 heavy demolition expert's protective garment and the employee's load and stress while using it. I also define the labour hygiene rules to be held during use.

In the second part of the chapter, I analyze the characteristics of the impulse noise that causes acute acoustic trauma and sound blast damage to the hearing during demolition tasks, and the injuries related to this. I formulate suggestions to avoid this hazard.

In the third part of the chapter, I analyze the composition of the exploding gases in case of different demolition jobs and applied explosives, and I define the methods of preventing the poisoning caused by the explosive gases.

SUMMARY CONCLUSIONS

Let me start with the words of my consultant, Dr Gyula Kóródi:

„A doctor cultivating military service can add to the things included in his or her oath, the more and more effective protection of the human lives by the innovative methods of his or her professional field.”

The most effective 'treatment' mainly of the occupational diseases is prevention. It is required by today's legislative environment require, and the developed industrial facilities - using appropriate protective devices and keeping some basic labour hygiene regulations - make it possible that occupational poisoning should not happen while working with explosives.

There is risk of occupational hazard when production, packaging, shipping and using of explosives, but it can be avoided by keeping the labour hygiene rules elaborated by myself and using individual protective devices. The same is true in the case of the acute acoustic trauma and sound blast damage, and in the case of intoxications caused by gases.

Unfortunately the methods elaborated for avoiding explosive injuries, the Personal Protective Equipments (PPE), the EOD-9 heavy demolition expert's protective suit offer no absolute protection, but reduce the seriousness and extension of the injuries, and provide a chance to survive. Their application is heavy load and stress for the demolition experts who use them. This burden can be reduced by keeping those measures that I have proposed. The testing of the ergonomical loading of the explosive-garment is still ongoing.

The civilian law currently in force, the General Demolitions Regulations (ÁRBSZ-in Hungarian abrv.) and the Mű/213. Demolitions Instructions deal with the protection of the employees from the point of view of safety technology; they refer to the presence of explosive gases, but they do not contain precise instructions even in this context. They only set out the safety distances.

In connection with aptitude tests the civilian recommendations and the military laws (it disposes over the bomb disposal operators and mine-hunters in detail) deal with rather the requirements of health aptitude (sight, hearing, hands integrity) during the implementation of the explosion activities. They do not take into account the possibilities of the health hazards caused by explosives. There are no specified biological exposure indicators for these materials.

I have proved my hypothesis that the labour hygiene aspects of activities with explosions and explosive materials are not given proper attention in the national industrial and military demolitions techniques, neither during the education and training nor during the implementation. The currently operative rules in force contain only very generally phrased references to the health protection of employees, or one situation is taken out occasionally.

Labour hygiene aspects are taken into consideration during training, education and implementation in the case of the competent labour safety and health experts acquire information even from foreign professional literature, from sources difficult to access. I hope that my dissertation will provide them great help.

NEW SCIENTIFIC RESULTS

I have reached my scientific goals by my research. I have proved by applied research methods that my research hypotheses were justified. Summarizing the results of my completed work, I evaluate the followings as new achievements:

1. I was first to elaborate and evaluate the toxicological problem areas comparing with my own experiences in this country.
2. I have worked out the whole system of the labour hygiene regulations while working with explosives, by which the occupational diseases can be avoided more efficiently.
3. I have defined the exposition caused by the explosive gases affected the person carrying out the explosion during the different blasting activities, I measured the impulse noise level and I have worked out recommendations for the tasks applicable to health protection.
4. I have summarized the characteristics of the explosive injuries and I have analyzed the defense capability of the currently most efficient military protective equipment, the type EOD-9 bomb-suit.
5. I have worked out those occupational health methods by which the employee's load and stress caused by EOD-9 bomb-suit can be reduced, and its the defense capabilities can be optimized.
6. I have worked out a Practical Guide, which is going to give some guidelines to the labour safety and sanitary experts in dividing employees - who work with explosion technique - into risk groups, and based on these, disposing aptitude tests and selecting protective equipment. I will make the risk assessments clear and maximize the employees' safety.

RECOMMENDATIONS

My dissertation can be used by labour hygiene professionals (occupational physicians and labour hygienists), and the labour safety professionals in their everyday work for the activities in connection with explosive technique, manufacturing and using explosive materials, and for the risk assessments of the tasks, and for selecting the personal protective equipment.

In the national explosion technique, the studied area does not get enough attention in terms of training civilian and military experts working with explosives, who at the same time are exposed to the harmful effects of explosions and explosives every day. I hope my dissertation is also going to be beneficial in their work, and when training the new demolition experts – the next 'blaster' generation.

I sincerely trust that the health protection measures that I have worked out may soon be put into proper legislative and doctrinal environment.'Mű 224/18 Regulations for demolitions of doors and windows' published by the Hungarian Defense Forces in 2012 has already contains the effects of the explosive materials and explosion on the human body and the possibilities of prevention.

Budapest, 18th November 2013

Dr Maria Hernad