MINISTRY OF EDUCATION
UNIVERSITY OF PETROSANI
DOCTORAL SCHOOL
DOCTORAL FIELD: MINES, OIL AND GAS

DOCTORAL THESIS

- SUMMARY –

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Petroșani
2024

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INNOVATIVE TRAINING METHODOLOGIES FOR INTERVENTION AND RESCUE PERSONNEL IN THE MINING AND OIL AND GAS INDUSTRY

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Key words

For a good understanding of the following exposition, it is necessary to list some notions specific to the field addressed: mining rescuer, intervention and rescue personnel, training, interventions, incident major, mobile training facility, virtual reality, physiological parameters, psychological training.

The motivation of the doctoral thesis

The research regarding the achievement of the thesis started from the role of the intervention and rescue activity at the level of economic agents in terms of the state of safety and health at work at the level of each individual unit. The fact that I have been active in the mining industry for 24 years, being also a mine rescuer for 16 years, and for 6 years I have been active in the Rescue Risks Laboratory within NIRD INSEMEX Petroșani, the concern for this activity is and will remain a major one, taking into account of its importance in saving human lives, as well as in the operation of economic units with a major risk of incidents.

The increasingly frequent major incidents at the level of economic agents or civil society make those involved in intervention and rescue activities increasingly better prepared both physically and psychologically, in order to increase the efficiency of interventions and implicitly the state of security and occupational health of workers.

The work aims to improve the way of practical training of intervention and rescue personnel by using modern training equipment and creating training scenarios through this equipment to put the rescuer in a situation as close as possible to the real intervention.

Pursued objectives

For the elaboration of this paper, I pursued several essential objectives:

- Highlighting the role of the intervention and rescue activity in our country and mainly for the mining and oil and gas industry;

- The role of practical training of mining rescuers and from the oil and gas industry in the rescue activity;

- The efficiency of monitoring psychophysiological factors in the activity of practical training of rescuers, with the role of selection in order to form the rescue teams that intervene in the case of major incidents;

- The way rescuers react in difficult situations of major incidents by monitoring the stress factor and resilience in making essential decisions for the success of the intervention;

- What role do they have and what improvements are made in the process of practical training of rescuers through the use of modern means of training and how do they lead to the increase of the intervention capacity, respectively of the state of safety and health at work at the level of the economic agent.

Structure of the doctoral thesis

Structurally, the work includes an introductory chapter with a characteristic theme and 4 content chapters, to which is added a chapter of Final Conclusions and personal contributions, totaling 153 pages, of which 126 pages represent the actual thesis, 7 pages represent the Bibliography which it has a number of 102 bibliographic notes and 20 pages of specialized appendices that facilitate a better understanding of the thesis and its objectives.

The first chapter, entitled ”**Legislation in the field of industrial intervention and rescue. Current methods of training intervention and rescue personnel used in the mining and oil and gas industry**”, present the legislation in the field of mining rescue through the provisions of the Law of Mines correlated with the Law of Safety and Health at Work, as well as the Normative that regulates the activity of intervention and rescue in within units with a risk of toxic / explosive / flammable gas emissions. Also, in this chapter are presented the current methods of training rescuers in the mining and oil and gas industry, methods used in the monthly practical training sessions at the headquarters of economic agents.

The training of mining rescuers must cover as broad a topic as possible and their duration over the course of a month must be more than 3 hours of theory and 3 hours of practice as much as the legislation in force provides as a minimum, taking into account the specifics of the mining activity and the fact that no other state intervention structure has intervention procedures for underground rescue.

To exemplify the current training method at the level of mining rescue stations, it was analyzed the training method of miners from the coal extractive industry (Lupeni Mining Unit within CEVJ) and those from the salt extraction and processing industry (Praid Mining Unit from SALROM S.A.).

The practical training of intervention and rescue personnel from the oil and gas industry is carried out in their own facilities during monthly theoretical and practical trainings, and for example, in this chapter I have dealt with the practical training of rescuers from the oil and gas extractive branch (Asset Oltenia within OMV Petrom) and those in the refining branch (Petromidia Năvodari Refinery within Rompetrol).

The training carried out within the economic employers presented in this chapter concludes that they are the basis of the practical training of mining and surface rescuers and no other training method can replace these training methods but they constitute a complementary part of the development of the training method of rescuers, for an effective intervention and for a good selection of intervention and rescue personnel in order to select the members of the teams that will intervene in the event of a major incident.

The second chapter, entitled ”**The role of psychology in the practical training of intervention and rescue personnel in the mining and oil and gas industry**”, deals with how to psychologically test rescuers before and after training, the integration of psychology in the training of intervention and rescue personnel, monitoring the stress factor.

The psychological assessment of rescuers is a fundamental element in ensuring the effectiveness and safety of rescue operations. In order to face the challenges and carry out their missions effectively, rescuers need not only technical and physical skills, but also good mental health. General mental health refers to emotional, psychological and social well-being and is distinct from mental or psychological disorders.

As part of the activity they carry out, most of the time, the rescuers are exposed to stress factors, both physical and mental, of high intensity. To be able to face them, and thus be effective in the face of professional challenges, but also to maintain their emotional health, rescuers must be very well prepared, both physically and psychologically. Thus, the correlation between their physical and mental training becomes a necessity.

An advantage is the use of virtual reality (equipment presented in chapter 3 of the thesis and used in the training of intervention and rescue personnel) in the psychological training of rescuers because it offers the possibility of immediate feedback and allows us to evaluate the progress in real time. Rescuers can receive information about how they reacted to stressful situations, techniques used to manage their emotions, and ways to improve these skills. In an

attempt to help first responders better understand their reactions to stress and develop more effective coping strategies, this type of feedback is essential.

The use in rescuer testing of an innovative Mind MI test tool (equipment within Rescue Hazards Laboratory), to assess the compatibility level of a team of rescuers within an economic agent, leads to a quick assessment of rescuer before or after training. The device monitors skin biopotentials, electrodermal potential and electrodermal response through a hand scanner equipped with electrodes, collecting all the necessary data in about 5 minutes.

The third chapter entitled ”**Presentation of modern equipment for the practical training of intervention and rescue personnel in toxic/explosive/flammable environments**” describes the modern equipment for training intervention and rescue personnel in the endowment of the Rescue Hazards Laboratory, respectively the mobile training ground for rescuers and the system of practical training through virtual reality.

All the equipment that makes up the mobile training facility, both those in the fitness compartment and those in the confined spaces compartment, are presented with the characteristics of each and their role within the range as follows:

I. Compartment for fitness equipment and control equipment comprising the following:

- Endless stairs with computer interface;
- Bike ergometer with computer interface;
- Treadmill;
- Impact device with computer interface;
- Stepper with computer interface;
- Control equipment;
- Telemetry system;
- Air conditioning installation;
- Electric generator;
- Cabinet for breathing protection equipment.

II. Compartment for confined spaces containing the following:

- Route of confined spaces;
- Fog product machine;
- Ventilation system;
- Heat area 4 kW;
- Installation of light and sound effects;
- Thermal imaging cameras (2 pieces).

- Infrared cameras (2 pieces).

It is presented in the chapter how to use the mobile polygon through the software program installed in the control desk. For the training system through VR, the component parts and scenarios transposed by software programs are presented, as follows:

- scenario 1 - fitting and checking a breathing protection device based on compressed air, a mandatory operation for every rescuer before participating in an intervention and rescue action;

- scenario 2 - traveling through the training ground in confined spaces, a polygon that reproduces an industrial area on a smaller scale with simulated areas of confined spaces, pipes, cable ducts, climbing and descending from tanks, various obstacles in the form of blockers, etc.

The fourth chapter entitled ”**Modern methods of training intervention and rescue personnel in the mining and oil and gas industry**” presents training scenarios in the mobile training facility with the monitoring of the physical and physiological parameters of the rescuers.

A first training scenario I considered taking the time factor as a constant for working on each machine in the fitness compartment and letting the rescuer choose the parameters of each machine separately in order to monitor them as a function of time and to be able to evaluate the performance of each rescuer by type of device, respectively in the compartment of confined spaces the time to complete the route.

Scenario 2 within the mobile training facility takes into account the time factor as a parameter to be monitored by establishing for each of the fitness equipment the parameters that the rescuers must achieve, following that when the parameter imposed on one device is achieved, it will move to the next one and in this way until all 5 machines in the fitness compartment are completed, after which it will move to the confined spaces compartment.

In the confined space compartment, the rescuers will complete the route twice (oil rescuers) or three times (mining rescuers), in different temperature, visibility and noise conditions. At the end of the training, the rescuers will be evaluated according to the time achieved for the entire training and the way of using the breathing protection device (the amount of air and oxygen consumed) during the training session.

Case studies were presented in the chapter for the two training scenarios, using the mobile training facility, for rescue personnel from the mining industry and from the oil and gas industry, respectively, as follows:

- mining rescuers from the coal mining industry, Lupeni Mining Unit - CEVJ;

- mining rescuers from the extractive and salt processing industry, Praid Mining Unit - SALROM S.A.;

- rescuers from the oil extraction industry, Asset Oltenia - OMV Petrom;

- rescuers from the refining industry, Petromidia Năvodari Refinery - Rompetrol.

During the first scenario, rescuers were monitored for the following physiological parameters: respiratory rate, heart rate, and blood oxygen saturation.

The chapter also presents training scenarios through virtual reality with case studies for the two categories of rescuers, respectively those from the mining and oil and gas industries, with the stages included in the scenario in accordance with the procedures in force for each scenario in part.

The fifth chapter entitled ”**Conclusions and personal contributions**” presents the research results materialized through conclusions and personal contribution.

Conclusions

The modern equipment for the training of intervention and rescue personnel from the endowment of the Rescue Hazards Laboratory, represented by the mobile training facility for rescuers and virtual reality equipment, lead to the development of the training base for rescuers from all branches of activity where this intervention and rescue activity is organized.

The practical training with the help of these modern equipment leads to the increase of the intervention capacity of the rescue personnel in case of accidents, events or major incidents and implicitly to the increase of the state of security and health at work at the level of each economic agent where the practical training of the rescuers is implemented through such means.

By carrying out the training scenarios, it is possible to monitor the physical preparation of the rescuers, a primary factor in a rescue operation, as well as the way in which rescuers in conditions of intense physical effort use the breathing protection devices provided, by dosing oxygen or compressed air from the bottle, in this way having an image of the time interval when they can intervene in critical situations.

The possibility of permanent monitoring of the physiological parameters that the rescuer achieves during training in the mobile training range (heart rate, respiratory rate, blood oxygen saturation, blood pressure, etc.) leads to a monitoring of the health of the rescuers, to their capacity for intense physical effort, as well as to how they manage the extreme situations they are exposed to during training.

The mobility of modern training equipment, namely the mobile training facility of rescuers and the training system with the help of virtual reality, means that they can be used during the training / retraining sessions of the rescue personnel both at NIRD INSEMEX Petroșani headquarters and at the headquarters of economic agents , which means that the staff will no longer be deployed for a certain period of time, being able to participate including in the basic activity within the economic agent.

Personal contributions

The main theoretical contributions with significant technical-scientific impact, derived from the doctoral thesis, are:

Drawing up the specifications for the acquisition of the mobile rescuer training facility and the rescuer training system using virtual reality, with all the necessary requirements in terms of the equipment and software programs that underlie them, as well as the follow-up in the realization phase of them on each phase and stage separately.

Establishing the scenarios implemented through virtual reality and establishing all the stages in order to integrate them into the software program made by the company that made the system.

Designing mobile rescuer training facility training scenarios for both mining and oil and gas rescuers and establishing the physical and physiological parameters monitored within the scenarios.

Ensuring psychological testing within the Rescue Hazards Laboratory, before and after training in order to establish how to manage stress, a determining factor in the success of an intervention in case of major incidents, as well as in the process of selecting rescuers to form rescue teams.

Guiding all heads of rescue stations in drawing up monthly theoretical and practical training programs that must be carried out at the level of rescue stations, so that their subject matter covers the entire area of training of rescuers to deal with real interventions in case of major incidents in the units where they carry out their activity, guidance given during the annual audit carried out by the members of the Rescue Authorization Group at the level of each rescue station.

Drawing up the practical and theoretical training programs at the rescue station at the NIRD INSEMEX Petroșani, as head of the rescue station, and participating with teams from the

station in the inspection and control from the point of view of mine gases and ventilation, for mining works reopened in the base exploration licenses for rare and scattered ores.

Guiding the activity of mining rescue stations, especially those within the Valea Jiului Energy Complex during the interventions they have (frequently in the case of endogenous fires) considering that I have been active for 24 years within the mines of Valea Jiului and have been for 16 years as a rescuer in the rescue stations of these mining units, participating in many interventions in conditions of maximum difficulty.

In the case of audit actions from rescue stations in the mining and oil and gas industry, analysis of the theoretical and practical training of rescuers in these rescue stations and guidance for future training.

The experimental and applied contributions, documented in the thesis, which have a significant value from a technical-scientific point of view are:

The endowment with modern equipment for practical training of the Rescue Hazards Laboratory within NIRD INSEMEX Petroșani was done on the basis of the Core Program 2019 – 2022: Development of the infrastructure for practical training of intervention and rescue personnel in toxic / explosive / flammable environments by creating a mobile training facility, of which I was responsible, won in the research project competition held at the level of the Ministry of Research and Innovation.

Documentary visits regarding the modern training equipment both in terms of the mobile training facility and the training system through virtual reality, in order to identify the best performing characteristics of the component equipment in order to design the two training environments.

Coordination of practical training in the mobile training facility for all categories of personnel analyzed as case studies in this paper, analysis of the physical and physiological parameters determining the training process, their transposition into graphics and criteria for selecting members of the rescue teams.

Coordination of practical exercises in the training / retraining phase of the rescue personnel, exercises carried out in the own facilities of the economic agents in the mining and oil and gas industry, with monitoring of the use of breathing protection devices and the behavior of the rescuers in conditions of intense effort.

From the point of view of disseminating the results during the doctoral research, I published as first author and co-author a number of 17 articles related to the practical training of intervention and rescue personnel through the mobile training facility and the virtual reality system.

Future research directions

Having created the database from the IT system of the mobile training facility, numerous studies can be done on various criteria (age, profession, field of activity, seniority in the rescue activity, etc.) and according to the parameters created and entered into the database within the trainings carried out during the training scenarios.

By using the virtual reality training system, extreme situations can be created in which rescuers have to intervene and studies can be carried out regarding their reaction, decision-making resilience, their emotional reactions and many other details. of a psychological nature, a primary factor in the success of an intervention.

Eng. Cristian Nicolescu