REVIEW OF THE DOCTORAL (PhD) DISSERTATION

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

László Manga

Research and development of procedures and methods for assessing the environmental radiation situation following severe nuclear accidents

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DEFINING OF THE SCIENTIFIC PROBLEM

In case of a potentially severe nuclear accident, it is a basic requirement to have a suitable Emergency Response Plan, with an essential part of it, which is to be constantly aware of the radiation conditions. These two factors basically determine what effects we can expect regarding the environment.

In order to clearly see these connections, it is necessary to study the nuclear power plant's nuclear environmental monitoring systems, work programs and the data that can be extracted from them. Furthermore, it is necessary to examine how these data can be integrated into nuclear emergency response, as well as which devices and systems should and can be improved in order to mitigate the impact on the environment as effectively as possible and thereby protect human lives and health.

In connection with this, the emission and environmental monitoring systems must be revised, especially the transmitters, but also the sampling, assuming a severe nuclear accident. Beside the identification of the system elements to be developed, special attention must be paid to ensure that it meets the Fukushima experience, like providing important data for radiation protection even under extreme conditions (earthquake, station blackout).

In light of this, the Emergency Response Plan must be revised, with a focus on radiation protection-related tasks and, within that, the radiation situation assessment. This includes software that calculates the spread, vehicle mounted reconnaissance with radiation detection capabilities, and drones. Drones, in relation to the Paks nuclear power plant, carries completely new possibilities in such events.

Finally, using the aforementioned, I see the need to develop a complex decision support software. Using the data of existing and future monitoring and modeling software and other available databases, the software can provide great support to the decision-maker in making the final, most optimal decision. In this way, the load on the environment can be reduced to the lowest possible level and thereby protect people.

RESEARCH HYPOTESES

1. I assume that further improvements can be made on the nuclear environmental transmitter systems used at nuclear power plants. In case of a severe nuclear accident, these developments provide key data for decision-makers to make the optimal decision, thereby helping to minimize environmental impacts. I would like to present these developments through the example of the Paks nuclear power plant.

2. I assume that the nuclear environmental monitoring system can be supplemented with subsystems that can be used not only in normal operation and emergency, but also in case of accident and severe nuclear accident. Their application is very beneficial in point of view of human resources, economics and radiation exposure and, where appropriate, has preventive measures. Certain elements of it can also be extended to other areas of the nuclear industry.

3. I assume that a decision support system can be developed that will support decision makers in a faster and more efficient way in the event of a severe nuclear accident. Apart from the nuclear power plant environment, this system could also be applied to other national bodies that may be affected in such a situation.

RESEARCH OBJECTIVES

1. My objective is to examine, analyze and evaluate the national legislative environment, which is in line with international regulations, and to contribute to the implementation of proposals for the development of certain elements of the nuclear emission and environmental monitoring system, taking into account the lessons learned from the severe nuclear accidents that have occurred in the past.

2. My goal is to extend the environmental monitoring system with subsystems that can be used well in case of severe nuclear accidents, and can help in reducing the environmental effects in a preventive way. I would like to use international and domestic good practices to examine and evaluate the international and national legal recommendations related to emergency preparedness and the device systems published in research so far. Certain elements of these subsystems can also be advantageously used in other situations and areas of the nuclear facility.

3. My goal is to propose a development for a decision support software capable of receiving all the data of the power plant that may be important during accident management, including a severe nuclear accident. Furthermore to deliver the prioritized relevant information to the decision makers. An additional option may be to extend or integrate this towards the relevant national bodies.

RESEARCH METHODS

In addition to the basic methods such as synthesis, analysis, deduction and induction, I used the following procedures to study my research topic and its individual subfields and to achieve my objectives.

1. Study of international and national literature. In particular, severe accidents at nuclear power plants that have occurred in the past, safety analyses, radiation measurement devices, detection methods, transmitting and sampling systems, decision support software, emergency management action plans. The literature review includes specialist books, specialist articles, professional lectures, what was heard at scientific conferences, diploma theses, dissertations, patents and reports.

2. Study and comparison of international, European Union and natinal legal regulations. Within the national legislation, I gave preference to those in the statutory or lower-level legislative environment, as the requirements are more specifically defined in this.

3. Studying the recommendations of international professional organizations and examining their natinal adaptation in individual legal regulations, guidelines, regulations, specifications, standards, licensing procedures, agreements, action plans, drafts.

4. Study of international and natinal conventions, their traceability in national laws and regulations.

5. I studied various modeling-based, decision support and diffusion calculation software.

6. I studied official records, reports, evaluations, safety regulations and newsletters related to the topic.

7. I conducted a professional consultation with nationally and internationally recognized specialists who deal with the researched topic.

8. I have presented partial results of my research at national and international professional and scientific conferences, further training courses, and in secondary and higher education institutions.

9. I participated in study trips and conferences in countries that have a significant professional and scientific background in my researched topic.

10. As an expert and speaker, I participated in the nuclear industry's dominant company producing nuclear power plants in several areas of Russia, where I could consult with influential people in the profession.

11. Through IAEA meetings, I received feedback on the applied recommendations, guides, guidelines and operating experiences.

12. Using my more than twenty years of experience in various areas of the nuclear facility, such as radiation protection (dosimetry, nuclear environmental monitoring) and accident prevention.

BRIEF DESCRIPTION OF THE STUDY CARRIED OUT BY CHAPTER

In the **first chapter**, I examined and completed the systems and work programs related to nuclear environmental monitoring. I identified the system elements that need to be developed considering a severe nuclear accident and extreme conditions (earthquake, total power failure). I formulated specific proposals in the light of the previous ones, a good part of which has already been implemented with my personal contribution.

In the **second chapter** of the dissertation, I revised the Emergency Plan of the power plant, paying special attention to the tasks related to radiation protection. After that, I made proposals in the field of radiation situation assessment, focusing on the severe nuclear accident. Within the radiation situation assessment, I separately discussed my developments for the software that calculates the spread, regarding the radiation protection measuring vehicle and drones that have not yet been used in relation to the Paks nuclear power plant, because I think that in such a situation, the radiation situation assessment and radiation detection have a special role.

Finally, based on previous developments, in the **third chapter** I proposed the creation of a complex decision support software, which is based on the integration of existing and future monitoring, modeling and database management software. Thus, with the appropriate filters and algorithms, the decision-maker can make his decision much easier, with which we can ultimately reduce the burden on the environment to a minimum, thus protecting people's health and lives. The software also contains other possibilities, in the area of communication, thereby speeding up the flow of information and data to the relevant bodies.

SUMMARIZEd conclusions

I. Analysis and evaluation of nuclear environmental monitoring

1. The system and work program of emission and environmental monitoring comply with both international and national regulations. The Paks nuclear power plant operates a well-structured, two-level radiation protection control system for its operating environments, which consists on the one hand of the telemetry system providing online data, and on the other hand of offline laboratory evaluation.

2. Analyzing the transmitter systems measuring gaseous and liquid emissions of the emission control system, I identified the system elements that could be vital in the event of a severe nuclear accident, corresponding to the extreme cases of the targeted safety review, and then I also studied the controls based on sampling.

3. I performed the analyzes on the measuring network of the environmental monitoring system and identified the system elements that play a key role in the event of a severe nuclear accident. In this case as well, keeping in mind that they fulfill their function even in extreme conditions, I also studied the controls based on environmental sampling.

4. Based on my research, I have come to the conclusion that there are vital measurements in both the field of emission and environmental monitoring that need to be developed in connection with redundancy and diversity and need to be reinforced in order to comply with the earthquake and total power failure established in the targeted safety review. In addition to these, I made further development proposals in terms of greater availability and even more efficient data provision, where I deemed it necessary, I established measurements based on new measurement techniques, taking into account sampling as well.

II. Development of radiation situation assessment tool systems for nuclear accident response

1. In accordance with international and domestic regulations, I explained and reviewed the basic requirements of the National Nuclear Emergency Response Plan, which the relevant part of the Comprehensive Emergency Plan of the Paks nuclear power plant fully comply with. Within this, I examined the tasks related to radiation protection, including the radiation situation assessment and its tool system. Within this, I examined the development directions item by item and put them into groups and developed proposals for the individual sub-areas.

2. One of these areas was the review of the diffusion calculation software, where I deeply examined the operating principle of the programs, the algorithm and the extractable data, and I developed specific development proposals for the integration of complex diffusion calculation software according to the standards of the time, supplemented by the inside of the building and the immediate environment of the buildings with extensive forecasting, all this in such a way that we can do it with the most accurate source member possible, with the help of the available input data. Throughout the development proposals, I kept in mind the possibility of a severe nuclear accident. Then, as a further development opportunity, I gave the further usability of the software in order to facilitate decision-making in other fields.

3. After that, I analyzed the capabilities of the existing radiation protection measuring vehicle and formulated a concrete concept for the requirements of the radiation protection measuring vehicle, where I gave my proposal for the car's superstructure, design, instrumentation, collective protection, sampling, equipment, communication, protective equipment and other characteristics. In the case of my proposals for the development of the measuring vehicle, I always kept in mind that the vehicle could be used well even in the event of a severe accident.

4. In the following, I examined the applicability of drones, primarily through their reconnaissance ability to conduct radiologiacal situational assessment, which is certainly unique domestic, but can also be said to be a novelty at the international level. In relation to drones, I have examined separately, according to the types, how to make the best use of their properties, their areas of use and their provision of instrumentation. I touched on the other areas of use, both in connection with radiation situation assessment in terms of sampling, and in other areas of the nuclear facility as well. I consider it a great advantage, primarily the replacement of manpower, its speed and economy.

III. Conceptual development of complex decision support software

1. Finally, I propose the conceptual development of a complex decision-support software, which would greatly facilitate the work of decision-makers and, if possible, facilitate the flow of information to the national contributing bodies in emergency response. The basis of the software is to integrate the already available data and other databases and software available by the power plant and to filter the results they give or calculate according to the properly prioritized algorithm. The software can be advantageously used not only in the field of radiation situation assessment, but also in other fields and not only in accident, but also in normal operation and emergency situations.

NEW SCIENTIFIC FINDINGS

1. Based on the international and national regulation of nuclear emergency response regarding emission and environmental monitoring systems, as well as a comprehensive examination of relevant literature, I identified the key technical equipment used in the field of severe nuclear accident prevention and the subsystems and critical elements that ensure their efficient operation. Based on my investigations, I developed proposals for the possible development of the instrument systems and their subsystems, which are essential for the provision of primary radiation data in the field of nuclear power plants, for the assessment of the effects of severe nuclear accidents on the environment, as well as for the boundary conditions and their most important technical requirements for the reliable application of operational decision support software. Analytical, evaluation and systematic research work can contribute to a more effective reduction of the possible environmental effects of severe nuclear accidents.

2. In order to ensure a high level of immediate, effective and comprehensive assessment of the radiation situation of nuclear power plants, the determination of the subsystems that can be connected to the nuclear environmental situation monitoring, the analysis of their operating order, the evaluation of their resilience, and the mutual influence of the subsystems of the prevention of severe nuclear accidents - the international and national based on the analysis and evaluation through good operator practice, I made a concrete proposal for the procedural and technical aspects of the application possibilities of operator-specific unmanned aerial vehicles to prevent emergency and severe nuclear accidents, and I also revealed the technical possibilities and basic conditions for their normal operation in nuclear hazardous activities.

3. Based on my research work related to the analysis of the nuclear environmental situation, I determined the technical concept of an operator-specific radiation situation assessment decision support software that can be used in a nuclear power plant, which can facilitate the professional and technical foundation of quick and optimal severe nuclear accident response operator measures.

RECOMMENDATIONS

1. I recommend using my study related to the development and development possibilities of emission and environmental monitoring systems for the development of nuclear environmental monitoring systems for nuclear power plants, whether existing or future natinal or foreign power plants. These developments are closely related to the radiation protection measurements of severe nuclear accident systems and thus to the provisions of the emergency plan. I also recommend it to radiation protection specialists who want to widen their knowledge in this field, as well as for the development of technical foundational documents that can be related to the topic.

2. I recommend my research on the subsystems related to the environmental monitoring system primarily to those who want to complement the existing environmental monitoring systems with hazard prediction software and mobilizable radiation detection capabilities, which makes the provision of radiation protection data related to severe nuclear accidents even more effective. Furthermore, I recommend it for the provision of radiation protection data for the normal operation, emergency or accident situations of the nuclear power plant, for the assessment of the radiation exposure of the environment and the population, or for the determination of other traditional accidents, emergency situations, and dangerous substances in order to predict their spread.

3. I recommend my research related to the decision support software to all users who have installed or mobile measuring systems with transmitter capability, the results of which can be displayed and processed by the software according to the desired algorithms. Furthermore, I recommend it - at least at the level of displaying the data - to the organizations that have the given facility under their supervision and can find out about the conditions inside and outside the facility based on the data sent.

The practical applicability of research results

1. Through the Paks nuclear power plant, it can be well utilized for the implementation of the development proposals made for the emission and environmental monitoring system that have not yet been implemented, as well as for its integration into the environmental monitoring system of the future Paks II, and in my opinion, it can also be well utilized to supplement the environmental monitoring system of foreign power plants. Furthermore, the knowledge can be used in the case of science and research reactors, as well as institutions with radioactive emissions. Research and development can also be used to expand the knowledge of workers or students in the field of radiation protection.

2. Subsystems connected to the environmental monitoring system, such as mobile labs, diffusion calculation software and drones, can be used well during nuclear accidents, but can also be used in connection with other types of accidents and emergency situations, such as chemical and biological detection hazard predivtion, in connection with the detection and liquidation of those attempting sabotage, as well as the detection of fires or other natural disasters. Experiences gathered during their use can be integrated into education, research and development and thus beneficially used in other areas of industrial safety.

3. The decision support software can be of great service in nuclear power plants in general, but particularly in the Paks nuclear power plant and the future Paks II nuclear power plant, by facilitating the work of decision makers, who, given the abundance of data, could use the software to get a clear picture in order to make the fastest, most efficient and optimal decision possible . The software would provide an opportunity for the contributing bodies of national nuclear emergncy management to facilitate the flow of information about the situation. With the appropriate parameterization of the software, industrial security could also help in the management of other dangerous situations in the fields of disaster prevention and even the national defense.

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PROFESSIONAL-SCIENTIFIC BIOGRAPHY OF THE DOCTORAL CANDIDATE

Name: László Manga

Place and time of birth: Mohács, 17. September, 1978.

Studies:

In 2002, he graduated from the University of Veszprém as a certified environmental engineer, majoring in radiochemistry and radioecology. While still at university, he obtained an ISO 14001 senior auditor qualification in the field of Environmental Management System and a radiation protection qualification with an Extended Radiation Protection degree.

Professional career:

He has been working at the Paks Nuclear Power Plant since 2002.

In the period between 2002–2019, within the field of radiation protection, dosimetry gained experience in the field of radioactive waste and nuclear environmental monitoring as a radiation protection engineer, team leader and laboratory manager.

Within the power plant, he participated in many other trainings and courses, where he acquired knowledge of ADR, quality management, corporate management, information security and nuclear power plant technology.

The Environmental Monitoring Laboratory he managed for almost 15 years had an accredited status and a "C" color isotope laboratory classification. As part of this, he was a regular participant in international and domestic competitions, where he performed with exceptionally good results.

In the course of his career, for more than ten years, as a teacher and examiner, he assisted the training of nuclear technicians at the Energetics Vocational High School in Paks and assisted with the preparation and assignment of assignments for national scientific student competitions.

He actively participated in summer internships for university, college, and high school students and provided assistance in diploma theses and theses as a supervisor, consultant, or reviewer. Author and/or contributor of several external and internal course materials and notes.

He participated in the theoretical and practical education of Extended and Comprehensive radiation protection knowledge and in hosting international organizations (IAÜ, WANO, OSART, EURATOM). For 3 years, he was asked as an expert and lecturer by the market-leading Russian nuclear power plant manufacturer Rossatom in connection with the Leningrad-Rostov- and Novovoronezh power plants.

Since 2019, he has been working in the Emergency Preparedness Section, where his task is, among other things, to prepare various exercises. Keeping the associated procedures, regulators, tools, materials up-to-date and maintaining contact with the authorities.

Language skills:

He has an intermediate level language exam in English and German.

Qualification:

ISO 14001 management auditor.

Advanced and comprehensive radiation protection qualification.

Scientific activity:

Since 2010, he has been a regular member of the Tolna County Chamber of Engineers, and since 2016 he has held a position in the board of directors and experts of the Environmental Protection Group, as well as in the supervisory board. In 2019, the engineering chamber recognized his work with the Antal Bohli Youth Award.

Since 2002, he has been a regular member of the Eötvös Lóránt Fizikai Társulat, Radiation Protection Department, and a regular speaker, for which he won the Radiation Protection Level Award several times.

Member of the Pécs Academic Committee of the Hungarian Academy of Sciences (Radiochemistry Working Committee).

Budapest, 5. September, 2023.

László Manga