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EXAMINATION OF RADIATION PROTECTION REQUIREMENTS FOR NUCLEAR FACILITIES

NUKLEÁRIS LÉTESÍTMÉNYEK SUGÁRVÉDELMI KÖVETELMÉNYEINEK VIZSGÁLATA

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Abstract

On 1 January 2016, the Govt. decree 487/2015. (XII.30.) came into force to change the regulatory system regarding radiation protection and to adapt the Directive 2013/59 /EURATOM in Hungary.
In consequence of the decree a work was initiated to study the situation if further regulations are necessary in relation to nuclear facilities. We have come to the conclusion that, although the radiation protection regulation handle certain issues separately for special facilities, including nuclear facilities, but not with sufficient detail. In some radiation protection issues, specific requirements have to be drafted and incorporated into the Govt. decree 118/2011. (VII.11.) regulating nuclear facilities.
The main source of the detailed requirements was the IAEA safety standards for nuclear facilities.
In this article we present the results of the above work: why the modernization is necessary, what kind of nuclear facilities are available in Hungary and which IAEA recommendations should be adapted.

***Keywords**: radiation protection, legislation, modernization*

Absztrakt

2016 január 1-től hatályba lépett a 487/2015. (XII.30.) Korm. rendelet, amelyre egyrészről a hatósági hatáskörök változása, másrészről a 2013/59/EURATOM irányelv megfeleltetése miatt volt szükség.
Megvizsgáltuk, hogy a NAÜ ajánlásai között milyen speciális, nukleáris létesítményekre vonatkozó ajánlások szerepelnek, melyeket célszerű lenne beépíteni a hazai szabályozásba.
Arra az eredményre jutottunk, hogy ugyan a sugárvédelmi rendelet foglalkozik bizonyos kérdésekben külön a kiemelt létesítményekkel, közöttük a nukleáris létesítményekkel, de nem kellő részletességgel. Számos sugárvédelmi kérdésben speciális követelményeket kell megfogalmazni, melyek helye inkább a nukleáris létesítményekre vonatkozó külön rendelet, a 118/2011. (VII.11.) Korm. rendelet lehetne.
Jelen cikkben bemutatjuk, hogy miért van szükség a korszerűsítésre, milyen nukleáris létesítményei vannak Magyarországnak, illetve mely NAÜ ajánlásokat volt célszerű feldolgozni.

***Kulcsszavak:** sugárvédelem, jogszabály, korszerűsítés*

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INTRODUCTION

According to the modification of the Act CXVI of 1996 on Atomic Energy [1] and its executive decrees, the Hungarian Atomic Energy Authority (HAEA) became the main licensing and supervisory authority also in the field of radiation protection from January 1, 2016. In order to modernize the regulatory regime (Ministerial Decree 16/2000 (VI. 8.) EüM. of the Minister of Health on the Implementation of Certain Provisions of the Act CXVI of 1996 on Atomic Energy [2]) a new government decree, the Govt. decree 487/2015. (XII. 30.) on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system [3] was drafted and introduced.

The most important innovation of this new regulation as compared to the previous one is that it introduced a one-step, centralized licensing: at the national level the HAEA became the licensing authority and as a result of this simplification, there is now a common license for both application and operation, reducing the number of license types. When the regulation was drafted, the Council Directive 2013/59/Euratom on laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation [4] was also taken into account because it must be adapted into the Hungarian legislation by 6 February 2018.

We examined in our previous article the structure of the legislation on nuclear facilities and presented the new official system. [5]

The next step in the development of domestic radiation protection is the systematization, modernization and expansion of facility-specific radiation protection requirements for the operation of nuclear facilities and radioactive waste storage facilities. This finding is supported by the fact that the International Atomic Energy Agency (IAEA) also addresses nuclear facilities separately in the safety standards, by separating them apart and even treating radioactive waste storage facility separately.

In the current domestic legislation, in terms of a systematic and detailed nature of radiation protection approach there are gaps in the requirements compared to the recommendations of the IAEA:

On the one hand, the specific requirements for nuclear facilities do not differ to such a decree either in the new radiation protection decree or in the decree containing the safety regulations for nuclear facilities (Govt. Decree 118/2011 (VII. 11.) on the nuclear safety requirements of nuclear facilities and on related regulatory activities [6]) nor in the decree on radioactive waste storage facilities (Govt. Decree 155/2014. (VI. 30.) on the safety requirements for facilities ensuring interim storage or final disposal of radioactive wastes and the corresponding authority activities [7]), on the other hand, the aforementioned legislation may add additional special radiation protection requirements in response to the IAEA recommendations.

The IAEA safety standards are recommendations, they are not mandatory, but the Nuclear Safety Convention expects that the national legal systems of the Member States to be consistent with the IAEA safety standards. The recommendations of IAEA, however, are of decisive importance, so the Member States, including Hungary, are seeking to refer to them, so it is an obvious step to review and use them to modernize domestic legislation. [8]

The review is also timely and necessary, because the five yearly revision of the nuclear safety regulation including the Govt. decree 118/2011. [6, 3.§ (7)] is to be completed in 2017.

Modernizing the design requirements is also necessary, not just for the new nuclear power units, but also because the design requirements are taken into account for the modification and safety upgrade of nuclear facilities. In addition, a periodic safety review must be carried out every ten years for the nuclear facilities, and consistency with design requirements should be examined.

Based on these, we reviewed the recommendations of the IAEA for nuclear facilities and compared them with the domestic regulations. In this article, we present the results of this activity. During our work, we have always kept in mind that our proposals do not result in a legal environment that would prevent the operation of nuclear facilities. In addition, we have also observed that over-regulation is contraproductive, and it moves safety culture in the wrong direction. Moreover, the authority has the possibility to issue guides that may contain more detailed requirements although with much less power.

When drafting our proposals, we have strived to keep the general radiation protection requirements in the Govt. decree 487/2015. (XII. 30.), and to incorporate the specific requirements into the legislation for nuclear facilities (Govt. decree 118/2011. (VII. 11.)). This would create a more transparent legal system.

The publication of the results was approved by the Deputy Director General of the HAEA. [9]

INTERNATIONAL RECOMMENDATIONS, DIRECTIVES

We started the modernization of the radiation protection requirements with IAEA safety standards. The recent changes of the IAEA standards necessitated a review of the radiation protection requirements for nuclear facilities. [9]

Gábor Kecskés et al. presented the structure of IAEA documents in their book entitled Nuclear Law in the First Decades of the 21st Century. [8] IAEA documents have been deployed in a three-level hierarchy. The Fundamental Safety Principles are at the top level, the next level of the hierarchy is represented by the Safety Requirements whiles the third level by the Safety Guides. The technical issues, practical experience and the foundation of the standards are summarized in lower-level publications. The IAEA proposes to integrate the 3 levels into different levels of regulation. This is illustrated in Figure 1.

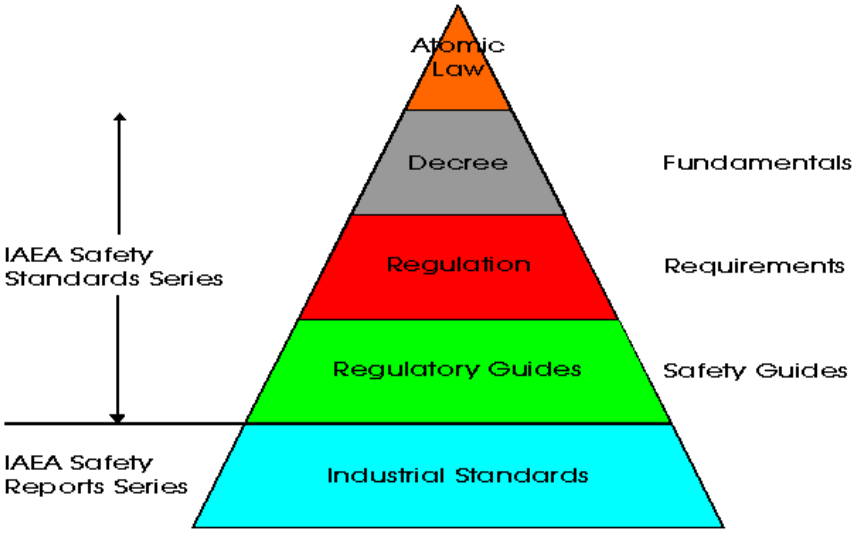

Figure 1: Relationship of IAEA safety standards with national legislation [10]

In 1995, the Board of Governors of the IAEA decided that all regulatory documents should be reviewed and integrated into a single system. As a result of the work, the structure of the document system was established in 2003. The Safety Requirements have been classified into two groups under the Fundamental Safety Principles. One of the groups covered various topics, including radioactive waste management, decommissioning and remediation of contaminated sites, in the other group included requirements related to facilities, including the requirements for radioactive waste management and disposal facilities.

In 2006, the IAEA published the entire area in a single volume of Fundamental Safety Principles. In November 2006, the IAEA's Safety Standards Committee proposed that the organization review the structure of the Safety Standards and place it on new bases to ensure consistency with the new volume of Fundamental Safety Principles and to limit the number of safety requirements and guidelines.

The essence of the proposal is to summarize the general safety requirements in a single seven-part volume to be finished until 2013, and it should be supplemented six more volumes containing safety requirements, which depend on the characteristics of the activities and facilities. They had to be developed by 2015. Safety Guides are connected to the Safety Requirements. Figure 2 illustrates the structure of the IAEA Safety Standards Series.

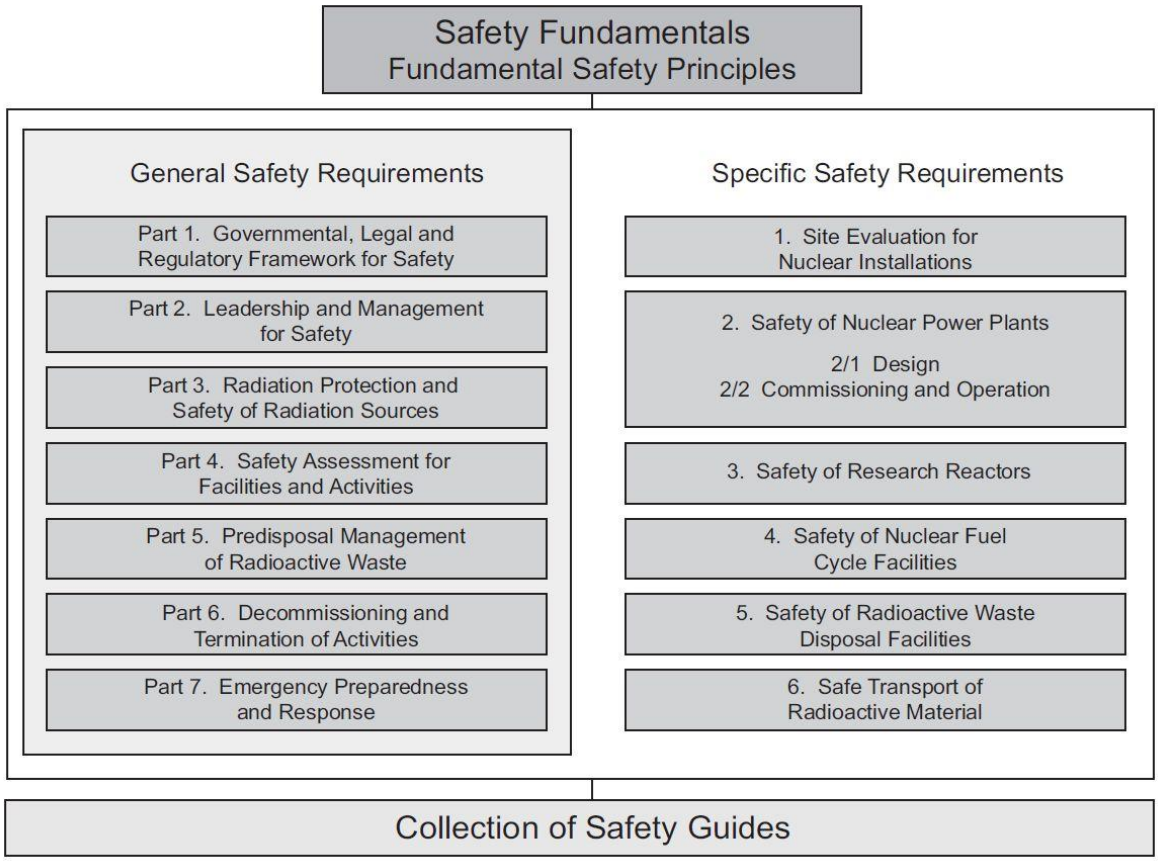

Figure 2: The long term structure of the IAEA Safety Standards Series [10]

The Safety Standards of IAEA can only formulate recommendations, not binding the Member States, but from any Member State which demands technical assistance, it is expected that the legal system should be consistent with the recommendations. The significance of the IAEA's safety requirements and guides are decisive so the Member States should consider them as references.

IAEA documents have been reviewed and the guides and requirements (general and safety) that may be relevant to the radiation protection regulation for nuclear facilities have been examined in detail.

The following documents were found relevant, which contain requirements that are missing from our radiation protection regulations:

- GSR Part 3: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [10]
- SSR-2/1 Safety of Nuclear Power Plants: Design [11]
- SSR-2/2 Safety of Nuclear Power Plants: Commissioning and Operation [12]

- NS-R-4: Safety of Research Reactors [13]
- NS-R-5 Safety of Nuclear Fuel Cycle Facilities [14]
- WS-G-2.3 Regulatory Control of Radioactive Discharges to the Environment [15]
- RS-G-1.1 Occupational Radiation Protection [16]
- NS-G-1.13 Radiation Protection Aspects of Design for Nuclear Power Plants [17]
- NS-G-2.7 Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants [18]
- IAEA-Tecdoc-248 Decontamination of operational nuclear power plants [19]

GSR Part 3: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [10]

In consideration of the new recommendations (ICRP 103) [20], the bases of radiation protection have been supervised and a new general safety requirement document has been created, titled Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards.

The document determines three different irradiation situations, such as planned, emergency, and existing exposure situations. The document consists of separate chapters: general requirements for protection and safety and separate chapters for the different exposure situations.

Most part of the document is covered by Govt. decree 487/2015., but there are some points that would be worth integrating into domestic legislation.

SSR-2/1 Rev. 1 Safety of Nuclear Power Plants: Design [11]

It is also a requirement document containing specific requirements for the design of nuclear power plants. In the document radiation protection requirements can be found in several sections. It has five chapters: applying the safety principles and concepts, management of safety in design, principal technical requirements, general plant design and design of specific plant systems.

SSR-2/2 Rev. 1 Safety of Nuclear Power Plants: Commissioning and Operation [12]

This is also a requirement document. The document contains general requirements, which are relevant for nuclear power plant under commissioning and operation. It contains requirements for the radiation protection programme and the management of radioactive waste.

NS-R-4: Safety of Research Reactors [13]

It is a requirement document. It is divided into seven chapters, which are the safety objectives, concepts and principles, regulatory supervision, management and verification of safety, site evaluation, design, operation and decommissioning.

NS-R-5 (Rev. 1) Safety of Nuclear Fuel Cycle Facilities [14]

The document has the same structure as the previous one and it is a requirement document. It is divided into nine chapters, which are the safety objective, concepts and safety principles, legal framework and regulatory supervision, the management system and verification of safety, siting of the facility, design of the facility, construction of the facility, commissioning of the facility, operation of the facility and finally decommissioning of the facility.

WS-G-2.3 Regulatory Control of Radioactive Discharges to the Environment [15]

This document is one of the guide level documents. It deals with the supervision and regulation of radioactive discharges from the introduction of a new practice to the releases already made.

RS-G-1.1 Occupational Radiation Protection [16]

It is also one of the guide level documents, which deals with radiation safety, including dose limitation, optimization of radiation protection for practices, radiation protection programme, intervention in emergencies and health surveillance.

In many cases, it deals with these topics in general, so the recommendations of the document, are described in more detail in other recommendations.

NS-G-1.13 Radiation Protection Aspects of Design for Nuclear Power Plants [17]

This safety guide deals the following: safety objectives, dose limitation and optimization; radiation protection aspects in design; protection of site personnel in operational states and during decommissioning; protection of the public during plant operation and decommissioning; guidelines for estimating radiation dose rates during plant operation and decommissioning; monitoring for radiation protection during plant operation and decommissioning; process radiation monitoring; auxiliary facilities; protection of site personnel and the public under accident conditions. This guide is supplemented by five attachments and a glossary.

NS-G-2.7 Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants [18]

The document is guide-level and deals with nuclear safety. It is one of the most important documents for nuclear facilities in Hungary under operation. It deals with the following topics: radiation protection programme; radioactive waste management programme, including discharges; training; and records.

IAEA-Tecdoc-248 Decontamination of operational nuclear power plants [19]

An important issue of radiation protection is decontamination. we reviewed the IAEA safety standards to find some recommendations connected with decontamination.

We have not find a document in the safety series that would deal with decontamination in sufficient detail, so we have tried to look for other recommendations. A technical committee meeting was held in Mol in 1979 where a study was made for decontamination of operational nuclear power plants. we used this study issued in the frame of a TECDOC for the proposals.

Basically, between the different IAEA Safety Standards there is a great overlap, so we have made a regulatory proposal in which differences have been taken into account and elaborated on our proposals.

In addition, the Council Directive 2013/59/EURATOM [4]was also considered.

HUNGARIAN RADIATION PROTECTION REQUIREMENTS AND REGULATIONS

In their article Sebestyén at all have presented the current structure of the Hungarian legal system, and they identified that the regulation of radiation protection appears in several laws for nuclear facilities. The Act on Atomic Energy [1] regulates the most general issues of peaceful use of atomic energy. These general issues are detailed by government and

ministerial decrees. Such governmental regulations are the aforementioned Govt. decree 118/2011 (VII. 11.) and its annexes, the Nuclear Safety Codes (hereinafter: NSC) and Govt. decree 487/2015 (XII.30), which contains radiation protection requirements. [5]

The regulatory recommendations on how to execute the regulatory requirements are set out in the regulatory guides, if they are observed the related regulatory procedures are simpler and can be shorter in time. The guidelines are more flexible because they can amended and re-issued by the Director General of the HAEA as necessary (for example for the request of the licensees).

The definition of a nuclear facility is contained in the atomic act. [1]

nuclear facility:

a) enrichment facility, nuclear fuel fabrication facility, nuclear power plant, reprocessing plant, nuclear fuel examination laboratory, research reactor, training reactor, nuclear critical and other system applied for neutron multiplication, facility used for storage of fresh nuclear fuel or interim storage of spent nuclear fuel,

b) facilities located at the same site as the nuclear facilities listed in Para. a) and directly connected thereto, and used for the storage of radioactive wastes, if they are considered as separate facilities;

EXISTING NUCLEAR INSTALLATIONS IN HUNGARY [20: P. 18-24]

Paks Nuclear Power Plant

Figure 3: A view of Paks Nuclear Power Plant [22]

MVM Paks Nuclear Power Plant Ltd operates 4 pressurized-water nuclear units of the type VVER-440/V-213; both the moderator and the coolant of the reactors are light water. (On the basis of its safety philosophy, the power plant belongs to the group of second-generation VVER-440 nuclear power plants.) The reactor has 6 cooling loops, each one is connected to a steam generator. Each power plant unit is supplied with a so-called localizing tower (operating on the bubble condensing principle) connected to airtight compartments for handling any incidents caused by pipe ruptures. In these towers, trays filled with water containing boric acid are layered one above the other, completed with air traps. This system of hermetic compartments and localizing towers makes up the containment for the reactors.

Each unit is installed with 3 active safety systems, and in case of incidents their electrical supply might be ensured by diesel generators. These systems are supplemented by passive systems. Two saturated (wet) steam turbines operate in each unit. The original nominal thermal power of each unit was 1375 MW, and the nominal electric power outputs of each unit were 440 MW. As a result of the power uprating programme realized between 2006 and 2009, the thermal power of each unit has increased to 1485 MW and the electric power to 500 MW.

The designers of the power plant chose the so-called twin-unit version. The turbine hall is common for the four units and the reactor halls each shared by 2 units enable common use of high value maintenance equipment. At the same time, the main components and safety systems of the units are independent of each other. The only exception is the safety cooling water system, where the pressure line at the water intake facility from the pumps to the pressure-equalizing tank is shared by two units.

Taking advantage of a common site and adjacent location of units, the supply systems were designed to be shared by the whole power plant.

Spent Fuel Interim Storage Facility

Figure 4: A view of the Spent Fuel Interim Storage Facility [23]

In order to store the spent fuel assemblies removed from reactors of Paks Nuclear Power Plant for an interim period of 50 years, a modular type dry storage facility operates on a site adjacent to the site of the plant.

The holder of the operating license of the Interim Spent Fuel Storage Facility (hereinafter referred to as ISFSF) is the Public Limited Company for Radioactive Waste Management.

The modules that are capable of storing fuel assemblies can be extended in a modular system. The positioning of modules in a row allows the use of a common reception building and loading equipment. Spent fuel assemblies are stored individually in vertical tubes in the storage building. In order to prevent corrosion during long-term storage, the storage tubes are filled with nitrogen gas and are placed in vaults surrounded by concrete walls. The removal of residual heat generated by irradiated fuel takes place by natural flow of air through the vaults and the connected stack system. This cooling process is self-regulating. The cooling air does not come into direct contact with the fuel assemblies as they are in a hermetically sealed environment.

Budapest Research Reactor

Figure 5: A view of the hall of the Budapest Research Reactor [24]

The Budapest Research Reactor operated by the Energy Research Centre of the Hungarian Academy of Sciences (formerly known as the KFKI Atomic Energy Research Institute) was built in 1959 and its full reconstruction was carried out between 1986 and 1993. After its reconstruction, the periodic safety review of the Budapest Research Reactor was first completed in 2003 and then in 2013. Based on the results of nuclear safety reviews, the HAEA issued a license for further operation and for performing activities described in the Final Safety Analysis Report. The operating license is valid until December 15, 2023.

The reactor is a tank-type reactor, the tank is made of aluminium alloy and both coolant and moderator are light water. The nominal thermal power is 10 MW.

Training Reactor

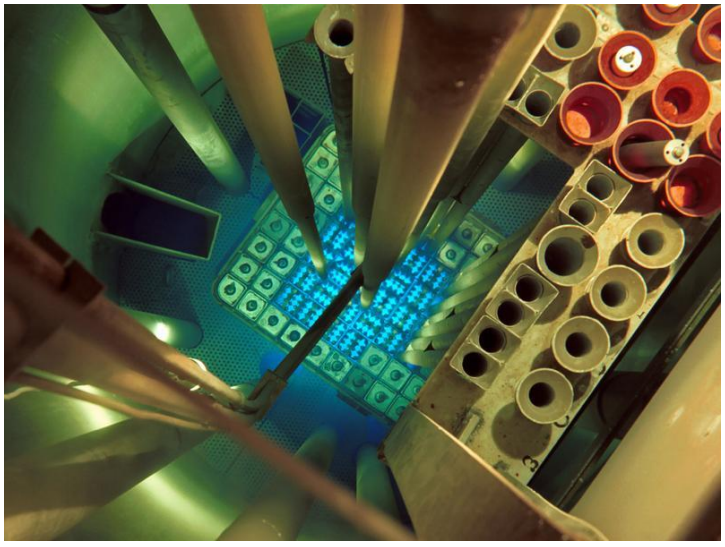

Figure 6: A view of Training Reactor [25]

The reactor operated by the Institute of Nuclear Techniques at the Budapest University of Technology and Economics was built in 1971 for training and research purposes. The current operating license of the Training Reactor is valid until June 30, 2017.

The reactor is a pool-type reactor, the coolant and moderator are light water. The fuel assamblies are a type of EK-10, and their have 10% enrichment.

BACKGROUND - FURTHER RESEARCH WORKS

During the work we conducted a literature research and did not find any Hungarian publication that would have been aimed at development of radiation protection regulations, but we have found some documents aimed at improving the domestic regulatory system.

József Rónaky and his co-authors have developed the uniform regulatory system in the framework of a doctoral dissertation. It came to the conclusion at first that the Hungarian nuclear regulatory authority can only meet the challenges of the 21st century in a unified organization and control. It is suggested that a single authority should regulate all issues of peaceful use of atomic energy. For this, it is necessary for an authority to have nuclear safety, security, radiation protection, physical protection and legal competences. The HAEA had the appropriate professionals, so it was suitable and therefore proposed for carrying out the tasks identified.[26]

József Solymosi and his companion described the content of the book of "The Safety of Nuclear Reactors" and it has one of the important chapters, which deals with the legal framework for reactor safety. They highlighted those important findings that I have also tried to emphasize in this article, namely that the relevant legislation should lean heavily on different international standards and other internationally accepted norms. The most important of these are the IAEA safety standards and the mandatory laws and recommendations of the European Union. The realization of safety is ensured by the international organizations and the international conventions system. [27][28]

In the field of radiation protection, perhaps one of the most significant works is the book on Radiation Protection. Every chapter of the book is written by an acknowledged expert on the subject. For the practical understanding of our proposals, this book can give great helping in the following chapters: [29]

- Basics of dosimetry
- Radiation protection regulation
- Protection against external exposure
- Mechanism and calculation of internal exposure
- Safe transport of radioactive materials
- Radioactive waste
- Methods for controlling radiation hazardous workplaces
- Personal Dosimetry
- Nuclear Environmental Monitoring
- Metrological Requirements of Radiation Protection Instruments
- Exposure of the population
- Nuclear emergency preparedness
- Radiation protection control system of the Paks Nuclear Power Plant
- Definitions

RECOMMENDATIONS TO DEVELOP RADIATION PROTECTION REGULATIONS

Due to the completeness and clarity of the requirements, we have taken over requirements from the Govt. decree 487/2015. The purpose was that the general radiation protection requirements are contained in Govt. Decree 487/2015, while special requirements for nuclear facilities and radioactive waste storage facilities are included in the Govt. Decree 118/2011 and the Govt. Decree 155/2014. This will help to create a more transparent legislation. [9]

During the work, several topics have been found in which modernization is needed. These are listed below:

- Radiation protection programme
- Management system
  - occupational health service
  - radiation protection service
  - Categorization of work areas
  - Planning of radiation protection training
- Optimization of radiation hazardous work
  - General requirements
  - Time-protection
  - Dose constraint
  - Shielding
  - Personal protection equipment
  - Planning of dose
  - Minimisation of radioactive materials and sources
- Radiation work permitting
- Work with high risk of radiation
- Workplace monitoring and monitoring system
  - Workplace control systems
  - Personal dosimetry control
  - Determination of internal exposure
- Control of discharges
  - General requirements
  - Requirements for radiation protection measuring instruments
  - Control of liquid discharges
  - Control of gaseous discharges
- Decontamination
- Requirements for radioactive waste management
  - Gaseous radioactive waste
  - Liquid radioactive waste
  - Solid radioactive waste

During our work, we have put forward suggestions on how to develop the radiation protection requirements that we have made to amend the Govt. decree 118/2011. When formulating individual provisions we have provided particular technical requirements and justification on how and why they correspond to the formal legal environment and how they can be implemented into the nuclear safety legislation.

In our previous article, we described by topics what proposals we have developed and what kind of points we have drawn from the IAEA safety standards. [9]

CONCLUSIONS

This article presents the structure of IAEA recommendations connecting to radiation protection and the procedure how to adapt the selected standards into the Hungarian legislation. Not lll of the proposals were applicable or reasonable to apply for every nuclear facility. The whole proposal is recommended for nuclear power plants and should be reviewed for other nuclear facilities to see which ones are recommended.

We have proposed during our work a large amount of modification. We have proposed some of them directly in the Govt. decree 118/2011, while others are to be published in guidelines.

We sorted our proposals from the nine IAEA documents into nine main topics. Our work has been designed to be used as a separate attachment to the Govt. decree 118/2011 as a radiation protection volume of it.

It can be integrated into the current NSC structure by separating the design and the operation requirements, to fit into the appropriate volume, and a number of suggestions can be included in both places.

We proposed the modernization and improvement of the Hungarian radiation protection regulations for nuclear facilities with using IAEA documents. The possibility of continuing the work is seen in the collecting and utilization of international good practices. [9]

REFERENCES

[1] *Act CXVI of 1996 on Atomic Energy*

[2] *Ministerial Decree 16/2000 (VI. 8.) of the Minister of Health on the Implementation of Certain Provisions of the Act CXVI of 1996 on Atomic Energy*

[3] *Govt. decree 487/2015. (XII. 30.) on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system*

[4] *COUNCIL DIRECTIVE 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom*

[5] HORVÁTH K., KÁTAI-URBÁN L., SEBESTYÉN ZS.: A nukleáris biztonság és védettség hazai kutatási-fejlesztési eredményei. *Hadmérnök*, XI. 4. (2016), 69-90

[6] *Govt. Decree 118/2011. (VII. 11.) on the nuclear safety requirements of nuclear facilities and on related regulatory activities*

[7] *Govt. Decree 155/2014. (VI.30.) on the safety requirements for facilities ensuring interim storage or final disposal of radioactive wastes and the corresponding authority activities*

[8] KECSKÉS G., LAMM V., SILYE J., SULYOK G., *Nukleáris jog a 21. század első évtizedeiben*. Budapest: Wolters Kluwer, 2013, ISBN: 978-963-295-339-7

[9] SEBESTYÉN ZS., LACZKÓ B., ÖTVÖS N., PETŐFI G., TOMKA P.. *Nukleáris létesítményekre vonatkozó sugárvédelmi követelmények korszerűsítése.* Sugárvédelem, X. 1. (2017) 1-43. http://www.sugarvedelem.hu/sugarvedelem/docs/V10i1/Seb_V10i1.pdf

[10] European Commission, Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, International Labour Organization, OECD Nuclear Energy Agency, Pan American Health Organization, United Nations Environment Programme, World Health Organization, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[11] International Atomic Energy Agency, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1 (Rev. 1), IAEA, Vienna (2016).

[12] International Atomic Energy Agency, Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2 (Rev. 1), IAEA, Vienna (2016).

[13] International Atomic Energy Agency, Safety of Research Reactors, IAEA Safety Standards Series No. NS-R-4, IAEA, Vienna (2005).

[14] International Atomic Energy Agency, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. NS-R-5 (Rev. 1), IAEA, Vienna (2014).

[15] International Atomic Energy Agency, Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3, IAEA, Vienna (2000).

[16] International Atomic Energy Agency, International Labour Office, Occupational Radiation Protection, IAEA Safety Standards Series No. RS-G-1.1, IAEA, Vienna (1999).

[17] International Atomic Energy Agency, Radiation Protection Aspects of Design for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.13, IAEA, Vienna (2005).

[18] International Atomic Energy Agency, Radiation Protection and Radioactive Waste Management in the Operation of Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.7, IAEA, Vienna (2002).

[19] International Atomic Energy Agency, Decontamination of operational nuclear power plants, Report of a technical committee meeting on the procedures for decontamination of operating nuclear power plants and handling of decontamination wastes organized by the International Atomic Energy Agency and held in Mol, Belgium 23-27 april 1979, IAEA, Vienna (1981).

[20] International Commission On Radiological Protection, The 2007 Recommendations of the International Commission on Radiological Protection, Publication 103, Elsevier (2007).

[21] Magyarország: *National report, seventh report, Prepared in the Framework of the Convention on Nuclear Safety*. Budapest: Magyarország, 2016

http://www.oah.hu/web/v3/HAEAportal.nsf/8A5717870555C46BC12580D1002C3FA0/$FILE/Seventh_National_Report_Hungary_final.pdf (downloaded: 19.11.2016.)

[22] Az MVM Paksi Atomerőmű Zrt. honlapja:

http://www.atomeromu.hu/hu/Lapok/default.aspx/ (downloaded: 19.11.2016.)

[23] A Radioaktív Hulladékokat Kezelő Közhasznú Nonprofit Korlátolt Felelősségű Társaság honlapja: www.rhk.hu/letesitmenyeink/ (downloaded: 19.11.2016.)

[24] A Magyar Tudományos Akadémia Energiatudományi Kutatóközpontjának honlapja: http://www.energia.mta.hu/hu (downloaded: 19.11.2016.)

[25] A Budapesti Műszaki és Gazdaságtudományi Egyetem Nukleáris Technikai Intézetének honlapja: http://www.reak.bme.hu/kutatas/oktatoreaktor.html (A letöltés ideje: 2017. február 19.)

[26] RÓNAKY J., SOLYMOSI J.: *Elemzés a hazai sugárvédelmi, biztosítéki, nukleáris biztonsági, és nukleáris veszélyhelyzeti felkészülési jogkörök egyesítéséről.* Hadmérnök, II. 1. (2007) 86-123.

[27] SOLYMOSI J., SOLYMOSI M.: *Gondolatok „Az atomreaktorok biztonsága" című könyvről*. Hadmérnök, IX. 1. (2014) 124-129.

[28] ADORJÁN F., LUX I.: *A reaktorbiztonság jogi keretei* In Elter J., Gadó J., Holló E., Lux I. (Szerkesztők) *Atomreaktorok biztonsága I., II. kötet.* Budapest: Somos Környezetvédelmi Kft., ELTE Eötvös Kiadó, 2013. ISBN 978-312-180-1, és ISBN 978-312-182-5

[29] DEME S., FEHÉR I. (Szerkesztők): *Sugárvédelem*. Budapest: ELTE Eötvös Kiadó Kft., 2010. ISBN 978-963-284-080-2