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ANALISYS OF AIRBORNED RADIOACTIVE MATERIAL RELESED TO THE ENVIRONMENT

Brochure of PhD dissertation by the author

(THEZIS)

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I. ABSTRACT OF THE RESEARCH TASK,OBJECTIVES AND METHODS

ABSTRACT

During the operation of nuclear installations radioactive material can get out to the environment. My objective was to investigate the consequences of airborne release of radioactive material in case of normal operation, in postulated and in severe accident. In this dissertation the results for Educational Reactor (ER), Budapest Research Reactor (BRR) and Paks NPP (PNPP) are presented using own elaborated models and international codes adapted for Hungarian conditions.

In case of normal operation I participated in elaborating the national regulation of release of radioactive material, than I investigated how the ER, BRR and PNPP meets the requirements. In case of postulated accidents of BRR, PNPP the environmental consequences are compared with dose criteria, in case of severe accidents of PNPP with probabilistic criteria (with the individual and social risk). In case of severe accidents (with high radioactive release) of PNPP the effectiveness of countermeasures are presented.

The results can be utilized for the sake of safe operation of national nuclear installation, during national and international emergency exercises and ensures equality comparison of radiation safety of nuclear reactors in our area.

OBJECTIVES

In the frame of this study the object I proposed to myself to investigate the quantity, dispersion and exposure of radioactive material released to the environment and finally to verify the completion of national and international criteria for normal operation, postulated and severe accidents.

My analyses were focussed on:

Employment of criteria for normal operation of nuclear installations (ER, BRR, and Isotope Institute GmbH) and verifying its completion.

Developing of spreading model and presentation of its applicability in (BRR's). postulated accidents.

Deterministic analyses. Adapting and application of consequence calculation model (PC COSYMA) for postulated accidents of BRR and PNPP. Comparison of the estimated exposure with the dose criteria.

Probabilistic analyses. Estimating the health, economical consequences of severe accident with high release of radioactive material, and the effectiveness of countermeasure. Comparison of probabilistic results for PNPP with international (the individual and social risk) criteria.

METHODS

The methods applied for solution of the problem consist of several steps :

- survey of literature
- data collection
- international collaboration
- model developing
- experiments
- analysis
- evaluation
- presentation and acceptation of results in scientific quarters

II. SHORT DESCRIPTOIN OF INVESTIGATION PERFORMED AND CONLUSIONS DRAWED FROM

My dissertation - with detailed description the performed task is - consist of 8 chapter. After the introduction (*Chapter one*) the *Second Chapter* is dealing with the regulation of radioactive material released from high priority (nuclear) installations to the environment. In the frame of this task firstly the principles of regulation of airborne release of radioactive material were determined. The next step was to determine the release limits and criteria for 3 nuclear installations (ER, BRR and Isotope GmbH) using the dose constrain. It find out that in case of planned (and realized) the release limits are satisfied and the release criteria is also widely fulfilled.

The *Chapter 3* is dealing with model discretion used in deterministic analyses. This chapter deeply discuss the dispersion and dose calculation model used in

forthcoming chapters for estimating the health, economical consequences considering the countermeasures. As this model (PC COSYMA) fits to international requirements , so its application ensures comparison of safety in “euro conform way”.

The *Chapter 4* is dealing with analyses of environmental consequences of release of radioactive material of postulated accidents 2 nuclear installations (BRR and PNPP). The quantity (the source term) of released radioactive material at BRR is determined using the model described in Annex1. Having known the source term the results of deterministic analysis are performed for 2 nuclear installations. It is found that both for BRR and PNPP the exposure of critical group stay far below under the dose criteria.

The *Chapter 5* discusses the analyses of the severe accidents for 2 enhanced nuclear installations. Here firstly the doses around the reactor building and the initial dispersion parameters are determined for the BRR. Using this latter parameters the exposure of the population and boarder of urgent protective zone (UPZ) were estimated. It is found that this zone is not overhang the boarder of the campus.

In this chapter takes place the probabilistic analyses of severe accidents of PNPP. Using the available release categories the health and economical consequences are presented in probabilistic way. This chapter discusses the consequences of fail of countermeasures. It is found that in case of the implementation of countermeasure in time the individual and social risk criteria are satisfied.

The *Chapter 6* is an overview of the last previous chapters, the *Chapter 7* contains suggestions, recommendations for normal operations, postulated and severe accidents.

The Chapter 8 summarising the new scientific results (Thesis)

III. SUGGESTIONS

Normal operation

At nuclear installations the derivation should be performed in such a way that in case of satisfying the release limits and release criteria, the yearly exposure of the population must be below the dose constrain. Harmonising the legal system of European Union the dose contribution of unit release should be derived using international codes with best estimates parameters.

Postulated accident

The consequence calculation should be performed for the critical group of the population (the critical group for BRR : the population of resort area at 1 km from the reactor; the critical group for PNPP : the population of the adults of Csampa village. In the calculation all exposure routes (which evokes early protective measure) should be taken into account. The postulated accident of a nuclear installation must be performed that no protective measure need to be implemented.

Severe accident

The analyses for BRR should be performed in deterministic, for PNPP in probabilistic way. The deterministic analysis should be performed for most probabilistic meteorological parameters. From this results the boarder of urgent protective zone can be derived. The probabilistic analyses should be performed using one year meteorology data file and stratified meteorological sampling. Conditional probabilities - multiplying with the probability of the source term - the individual and social risk can be derived witch should be oriented to the averaged risk in the industry.

Scientific results
(Thesis)

In the frame of scientific work I analyzed the airborne radioactive material released from national nuclear installations, I studied its environmental consequences in case of normal operation, in postulated and severe accidental situations.

My scientific results are:

I. I employed the basic principles regulating the release of nuclear installations in normal operation, minimising the risk of radiation exposure of population. I solved far opened task: I presented the calculation methodology for nuclear and non nuclear installations and I calculated the release limits for enhanced installations.

II. Using the principles of regulations of release I calculated the nuclidspecific release limits of enhanced installations (Educational Reactor, Research Reactor and Isotope Institute GmbH). I controlled the fulfilment of dose constrained for the critical group.

III. Using my model I estimated the activities released from the damaged fuel elements during the postulated accidents at different ventilation state of the Research Reactor. From the activities released – in several meteorological conditions - I estimated the dose rate around the reactor building. Using adapted international models I estimated the exposure of critical group.

IV. I analysed the environmental consequences of postulated accidents at Paks NPP using the PC COSYMA program package adapted on Hungarian circumstances. I performed deterministic analysis for estimating the exposure of critical group and the results were compared by the criteria.

V. Using the my activity spreading model I estimated the consequences of the severe accident (i.e. the total core melting) around the Research Reactor and in the environment. The initial dispersion parameters and dose conversion factors were calculated by the wind tunnel experiment. In case of accidental situations the source term can be estimated from the dose rate at the detector points. In this severe accidental situations I estimated the exposure of critical group and I decided the boarder of the urgent protecting zone (UPZ).

VI. I performed the PSA Level –3 of Paks NPP. With stratified sampling – using Hungarian meteorological data file - I estimated the radiological, health and economical consequences of release categories using the source term results of PSA-Level 2. I estimated the social and individual risk of the population and I compared with the international criteria.

AUTHOR'S PUBLICATIONS

(RELATING THE DISSERTATION)

1. **L. Sági**: Hungarian Regulation. Technical Committee Meeting to review National Experience on the Regulatory Control of Discharges to the Environment. IAEA Vienna, 14-18. 05.2001.

2. **Sági László**: Tanulmány a Kibocsátási határértékek meghatározására a BME Oktatóreaktor tevékenységére vonatkozólag. Budapest 2002 február.

3. **Sági László**: Tanulmány a Kibocsátási határértékek meghatározására az Izotóp Intézet Kft. tevékenységére vonatkozólag. Budapest 2001. november .

4. **Sági László**: Tanulmány a Kibocsátási határértékek meghatározására Budapesti Kutatóreaktor tevékenységére vonatkozólag. Budapest 2001 november.

5. **L. Sági**: Determining the source term for emission of radioactive material from the faces of a building, International Conference on Monitoring, Assessments and Uncertainties for Nuclear and Radiological Emergency Response. Rio de Janeiro November 21-25, 2005.

6. **L. Sági**, I. Goricsán, S. Deme, E. Láng and Zs. Szepesi: Determining the source term for emission of hazardous material from the faces of a building, AARMS, Vol. 5, No. 4. (2007).

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8. Gy. Ézsöl, L. Perneczky, **L. Sági**, R. Taubner and P. Vértes: Analysis of the LOCA scenario with a 90 mm diameter cold leg break of spray line in loop No. 6. AGNES Project 1992.

9. Gy. Ézsöl, L. Perneczky, **L. Sági**, R. Taubner and P. Vértes: Analysis of the LOCA scenario with a 73 mm diameter cold leg break of make-up water line in loop No. 5. AGNES Project 1992.
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11. **Sági L.**, Szabó Z., Bérci K., Mórocz I., Ozorai J., and Ördög M.: Radioaktív kibocsátás alrendszerekből és komponensekből. AEKI Kutatási Jelentés Budapest 1993. szeptember.

12. Gy. Ézsöl, L. Perneczky, **L. Sági**, R. Taubner and P. Vértes: Analysis of the LOCA scenario with a 233 mm diameter cold leg break in the HPIS pipeline of loop No. 4. AGNES project Task No. B07.1. 1993.

13. Gy. Ézsöl, L. Perneczky, **L. Sági**, R. Taubner and P. Vértes: Analysis of the LOCA scenario with 100 per cent cold leg break of the 492 mm diameter pipe of loop No. 4. AGNES project Task No. 1993.

14. **Sági László**, Vértes Péter: Aktivitásterjedés és környezeti következmények számítása AEKI-DBAC-2005-736/33/M3.

15. **Sági László** and Vértes Péter: A Paksi Atomerőmű biztonságának értékelése nagy radioaktív kibocsátások szempontjából D4-5-6. A kibocsátások következményeinek elemzése Budapest 2005.

16. **L. Sági**: Source term determination and consequence calculation analysis at research reactors IAEA Workshop 2003. September.

17. **L. Sági** and L. Koblinger: Consequence Analyses of Hypothetical Nuclear Accident by the COSYMA Code (PSA - Level 3). 21st Workshop on Radiation Protection, 22-24, May 1996, Balatonkenese.

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24. Fehér István, Gadó János, Macsuga Géza, **Sági László**, Szabó Zoltán, és Vigassy József: A KFKI Kutatóreaktorban kis valószínűséggel bekövetkező balesetek elemzése Budapest 1992. augusztus.

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26. **Sági László** : Alrendszer meghibásodások következményei. AEKI jelentés Budapest 2003.

27. **L. Sági**, I. Balásházy, N. Fülöp, and A. Kerekes: Providing Site Specific Data around Paks NPP Budapest 1993.

CURRICULUM VITAE

I was born in 1958 in Hungary.

(1977-1978) After high school studies and diploma I got enrolled to the **Chemical Industry University of Veszprem (Hungary), Chemical Engineer Faculty**.

(1979-1982) Following the successful termination of my first term , the second term of University studies was continued at the **Eötvös Loránd University of Sciences, Budapest, Faculty of Natural Sciences**, where I was being trained for chemistry/physics lecturer's and research activity.

(1983-1985).After having taken the University degree I applied for **scholarship of the Hungarian Academy of Sciences.** In the course of this scholarship I had the possibility to take part in a project of a space spectrometer designed for detecting the charged heavy particles onboard of satellites. The results of this work were summarised in a dissertation which resulted in **university doctor's degree** I got in June 1985.

(1986). After the Chernobyl accident I took part in analysing the consequences of the accident. I measured the iodine activity in the thyroid and the alpha activity of hot particles.

(1987-1989). In next years the at the **Atomic Energy Research Institute** I was responsible for the personal dosimetry and environmental monitoring (mainly in the field of alpha and gamma spectrometry) around the nuclear facilities of the Central Research Institute for Physics e.g. research reactor, accelerators etc. In this period I joined into a **IAEA TC project HUN/4/006 "Reactor Modernization".**

(1990). I had the possibility to get special training in the frame of a **fellowship of the IAEA in Germany at the GFS Institute**, in Munich where I studied the effect of sum coincidence effect in gamma spectrometry.

(1991-1995). In the next years I joined into the **AGNES (Advanced Gneral and New Evaluation of Safety) project** to analyse the environmental consequences of LOCA at Paks NPP (Hungary). In the frame of this project I was responsible to evaluate the radiation and health consequences of the hypothetical severe accidents as well.

(1996).This year I joined into the **MARIA** (Methods for Assessing the Radiological Impact of Accidents) EU project by filling the data file of PCCOSYMA with the Hungarian specific data (meteorological, population and agricultural production data). Paralelly I take part in adopting the PSA codes (**MACCS and PCOSYMA**) preparing them for the PSA-level 3.The results of my activity were summarised in several report and presented at international conferences (PSA' 95, Soul, Korea), IRPA 96 (Vienna, Austria).

(2000) As a head of technical group for regulating the radioactive release I took part in preparation the decree of Environmental Ministry (15/2001).

(1996-2001) As the Head of Environmental Protection Service I am responsible to control the radioactive contamination of air, water in KFKI Campus.

(2001) This year I joined into several project :

- preparing the Emergency Plan for Paks NPP
- preparing the deterministic analyses for Paks NPP

(2001-2006) Probabilistic safety analysis (PSA Level 3) for Paks NPP

(2007) Member of international group review of IBSS

Other activities:

(1993-1996) Chairman of radiation protection seminars at Atomic Energy Research Institute

(1996-2001) Secretary of Scientific Committee of Atomic Energy Research Institute

Membership :

Eötvös Lóránd Society, (and International Radiation Protection Association)
Hungarian Nuclear Society (secretary from 2001-2003)