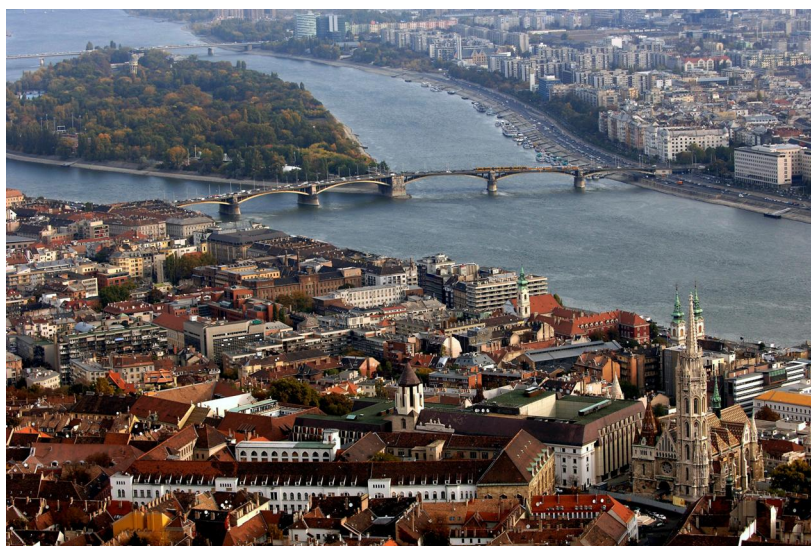




Use of Probabilistic Safety Assessments (PSA) for Evaluation of Impact of Ageing Effects on the Safety of Nuclear Power Plants

**Proceedings of EC Enlargement and Integration Workshop,
15-16 November 2007, Budapest, Hungary.**

A. Rodionov, A. Bareith



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1. Summary and Conclusions

1.1. Goal of the Workshop

To present, exchange and discuss the research results, best practice, methods and approaches available for application of reliability and PSA techniques on NPP ageing evaluation and management.

1.2. General Context

IAEA PRIS data concerning ageing profile of nuclear generation shows that actually (on the date of 3/08/2007) 115 units are between 30 and 40 years in operation and 213 are between 20 and 30 years old, which in total represent about 3/4 of 438 reactors operated worldwide.

More and more utilities, nowadays, move to the long-term operation policy. In US, for example, at July 2006, approximately one-half of the licensed plants either have received, or are under review for license renewal. What means that in the next decade the ageing management and life extension issues will become one of the key points of nuclear safety.

The PSA as a safety evaluation tool could be more integrated into these programs to help with identification and prioritization of ageing issues and optimization of ageing management activities.

For applying PSA to characterize potential risks associated with ageing effects, PSA should be as realistic as practical and appropriate support data should be available for the review.

- Could PSA be applied for ageing assessments?
- How realistically PSA models reflect important ageing issues?
- If any modifications or revisions of PSA assumptions are needed to apply PSA approach for risk-informed decision making in case of ageing evaluation?
- What data are available and how representative they are with regards to the important ageing?

These and other related issues were presented and discussed during the workshop.

1.3. Workshop Programme

The two days program included the following modules:

- PSA as a tool in NPP Ageing Management (AM) and Life Extension (LEX) activities, current practices and approaches
- Selection of the systems, structures and components (SSC) to be considered in Ageing PSA
- Reliability and data analysis
- Incorporation of Age-dependent reliability parameters and data into PSA model. Interpretation of quantification results

1.4. General Conclusions

The workshop demonstrates the level of interest and progress with Ageing PSA development in each organization. It could be stated that there is a variety of topics under development as well as a level of details in presented results.

Two ongoing projects were presented. At the present stage, the projects mainly focused on the issues treated in task 3 and 4 of APSA. This will provide the examples of practical application of approaches presented or under development within mentioned tasks.

Many participants would like to see more practice oriented results and examples, in particular, the links with maintenance practice and reliability data analysis.

The following conclusions present the main issues discussed during each session.

1.4.1. Introductory Part

The workshop started with greetings and round table presentation. The VEIKI presented the overview of nuclear energy in Hungary and JRC IE provided the information about Ageing PSA Network background and current activities.

1.4.2. Ageing PSA in a context of risk and reliability aspects of ageing management

This session started from a presentation of Ageing Management program for Paks NPP. It was underlined that this program was mainly focused on passive components and do not include any PSA application. Possibility of introduction of PSA results into the program are now under discussion within the VEIKI.

The Canadian Nuclear Safety Commission informed participants about the progress of R&D project to identify the areas of possible PSA application for the ageing management activities. The project is started this year and up to moment the first phase of the project is in progress. The approach and main difficulties were presented and discussed.

Third presentation in this section relates to the Armenian project on incorporation of ageing into PSA level 1 for Armenian NPP. This project is started recently and is in a beginning stage.

1.4.3. Selection of the SSCs to be Considered in Ageing PSA

Two papers were presented in this section and they reflect the activities related to the Task 3 of Ageing PSA Network. The paper presented by Mrs. M. Nitoi from NRI/Romania interlinks with the approach applied by CNSC for component and system selection.

1.4.4. Reliability and Data Analysis

This section contained seven presentations that covered

- generic issues and difficulties concerning the ageing consideration into PSA and IAEA activities on data collection (J.Yllera / IAEA),
- overview of the state of the art with components reliability data collection (A.Rodionov / JRC IE)
- and several studies on active and passive components reliability have done by Ageing PSA Network

A draft of the guideline on reliability parameters estimation developed in the frame of Task 4 was presented by D. Kelly.

The most interesting conclusions from this section are:

- most of the difficulties and questionable issues related to consideration of ageing effects into PSA listed by J.Yllera are under consideration by Ageing PSA Network working program. On some of them the case studies and benchmark exercises are in progress or planned for realization, others will be clarified by expert panels or bibliographical studies;
- the overview of the state of the art of reliability data collection shows that in most of the countries the assumption about constant failure rate is taken without validation. To perform such validation additional amount of data are required. Possible approaches and methods for validation are proposed in the draft of guideline on reliability parameters estimation. The potential difficulties related to the data interpretation (model checking, assumption on renewal process, etc.) were identified and will be alarmed in the guideline.
- to perform age dependent reliability assessments current PSA reliability data are not enough and need to be completed by additional data categories. Collection and processing additional data is time and resource consuming process. To reduce the cost of data collection, this process has to be improved on multipurpose bases;
- from the presented case studies on time dependent reliability analysis of active components it could be concluded that in case of identified ageing trend the process of degradation would be relatively slow and consequently failure rate increasing would be no so dramatic in comparison with constant failure rate values actually applied in PSA model. In those cases the improvement of maintenance could fix the problem quickly and it will not needed for PSA model modification;
- for complex active components with several failure modes the time dependent reliability analysis has also some theoretical limitations. The recommendation of Dr. Klugel / KKG is to perform a trend assessment using specific data with 10 years periodicity and not to spent resources for predictive risk analysis;
- another practical corollary of Khinchine's theorem is the following: if a time dependent trend in failure rate is identified it is possible that it relates to the single (but) dominant ageing mechanism or/and sub-component.

1.4.5. Incorporation of Age-Depended Reliability Parameters and Data into PSA Models

The papers presented in this section demonstrate possible ways to incorporate ageing effects (time-dependent reliability models) into PSA. The examples concerns different PSA codes and different initial assumptions.

1.5. Workshop Statistics

Number of presentations: 16

Number of participants: 20

Participants' geographical spread: 14 countries (EU, Switzerland, Korea, Russia, USA, Canada):

Armenia	1	Romania	2
Austria (IAEA)	1	Russian Federation	2
Bulgaria	1	Slovak Republic	1
Canada	1	Slovenia	1
Hungary	5	South Korea	1
Lithuania	1	Switzerland	1
Netherlands (EC JRC)	1	USA	1

2. Workshop Programme

Day 1

1. Introductions and welcome greetings

9:00-9:40

1.1. E. Holló / VEIKI, HU. Nuclear energy in Hungary and introduction of VEIKI.

1.2. A. Rodionov / JRC IE, NL. Presentation of Ageing PSA Network activities.

2. Ageing PSA in a context of risk and reliability aspects of ageing management

9:40-10:40

2.1. A. Biro / VEIKI, HU. Ageing Management at NPP Paks.

2.2. A. Trifanov / CNSC, CA. Status of the CNSC APSA Research Project.

11:00-11:50

2.3. Sh. Poghosyan / ANRSC, AM. Ageing aspects incorporation into PSA level 1 model for Armenian NPP Unit 2.

2.4. M. Patrik / NRI, CZ. Analysis of main PSA tasks with regards to Aging PSA and its applications. Skipped.

3. Selection of the SSCs to be considered in Ageing PSA

11:50-12:15

3.1. M. Nitoi / NRI, RO. Approaches for selection of components sensitive to ageing.

12:15-12:30 Discussion

14:00-14:25

3.2. A. Bareith / VEIKI, HU. Combined Use of Information from Ageing Management and Paks Plant Specific PSA Models to Support Task 3 in APSA Network.

4. Reliability and data analysis

14:25-15:15

4.1. J. Yllera / IAEA, AU. IAEA activities on PSA and reliability data acquisition.

4.2. A. Rodionov / JRC IE, NL. Overview of reliability data collection with regards to ageing reliability analysis applications.

15:40-16:40

4.3. A. Antonov / INPE, RU. Elaboration of reliability methods for ageing assessment of NPP components.

4.4. S.Y. Choi / KAERI, KO. Some Activities for Data Analysis and Reliability Model at KAERI.

16:40-17:00 Discussion

Day 2

4. Reliability and data analysis (cont.)

9:00-10:20

4.5. J.-U. Klugel / KKG, SW. Investigation of time- dependent trends in plant specific data for active components Can A.Y. Khinchine be rejected?

4.6. D. Kelly / INL, USA. Development of Guideline for Component Reliability Data Collection and Parameter Estimation for Use in Aging PSA.

4.7. A. Getman / VNIIAES, RU. Methods for definition of probability of pressure vessels and pipelines destruction.

5. Incorporation of Age-depended reliability parameters and data into PSA model

10:40-11:30

4.2. G. Petkov / TUS, BG. Ageing sensitivity analyses by dynamic reliability methods (GOFLOW and ATRD).

4.3. M. Cepin / JSI, SL. Evaluation of ageing in probabilistic safety assessment.

11:30-12:30

Discussions

Workshop conclusions

14:00-15:00

Meeting of APSA Network : discussion of activities and case studies, future plans for case studies.

3. List of Participants

Following is a list of workshop participants including their affiliation.

Name	Organisation	Address	Country	E-mail
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4. Presentations

4.1. Introductions and Welcome Greetings

- 4.1.1. E. Hollo / VEIKI, HU. [Introduction to Nuclear Situation in Hungary](#)
- 4.1.2. A. Rodionov / JRC IE, NL. [EC JRC Network on Use of PSA for Evaluation of Aging Effects to the Safety of Energy Facilities](#)

4.2. Ageing PSA in a Context of Risk and Reliability Aspects of Aging Management

- 4.2.1. A. Biro / VEIKI, HU. [Aging Management at the VVVERr-440/213 Units of Paks NPP](#)
- 4.2.2. A. Trifanov / CNSC, CA. [Status of Research Project "Incorporating Ageing Effects into PSA"](#)
- 4.2.3. Sh. Poghosyan / ANRSC, AM. [Ageing Aspects Incorporation into PSA Level 1 Model for Armenian NPP Unit 2](#)
- 4.2.4. M. Patrik / NRI, CZ. [Analysis of Main PSA Tasks with Regards to Aging PSA and its Applications](#)

4.3. Selection of the SSCs to be Considered in Ageing PSA

- 4.3.1. M. Nitoi / NRI, Romania. [Approaches for Selection of Components Sensitive to Ageing](#)
- 4.3.2. A. Bareith / VEIKI, HU. [Combined Use of Information from Ageing Management and Paks Plant Specific PSA Models to Support Task 3 in APSA Network](#)

4.4. Reliability and Data Analysis

- 4.4.1. J. Yllera / IAEA, AU. [IAEA Activities on PSA and Reliability Data](#)
- 4.4.2. A. Rodionov / JRC IE, NL. [Overview of Reliability Data Collection with Regards to Ageing Reliability Analysis Applications](#)
- 4.4.3. A. Antonov, V. Chepurko, A. Polyakov, / INPE, RU, A. Rodionov / JRC IE, NL. [Elaboration of Reliability Methods for Ageing Assessment of NPP Components](#)
- 4.4.4. S.Y. Choi, S-J. Han, J.E. Yang / KAERI, KO. [A Study on Data Analysis and Reliability Model by Considering Aging](#)
- 4.4.5. J.-U. Klugel / KKG, SW. [Investigation of Time-Dependent Trends in Plant Specific Data for Active Components – Can A.Y. Khinchine be Rejected?](#)
- 4.4.6. D. Kelly / INL, USA. [Repair as New or Same as Old: Practical Issues in Choosing the Appropriate Stochastic Process to Model Failure](#)
- 4.4.7. A. Getman / VNIIAES, RU. [Methods for Definition of Probability of Pressure Vessels and Pipelines Destruction](#)

4.5. Incorporation of Age-Depended Reliability Parameters and Data into PSA Models

- 4.5.1. G. Petkov, M. Pekov / TUS, BG. [Ageing Effects Sensitivity Analysis by Dynamic System Reliability Methods \(GO-FLOW and ATRD\)](#)
- 4.5.2. M. Cepin / JSI, SL. [Application of Methods and Discussion of the Results about the Ageing in Probabilistic Safety Assessment](#)

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Abstract

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PSA as a safety evaluation tool could be more integrated into these programs to help with identification and prioritization of ageing issues and optimization of ageing management activities.

For applying PSA to characterize potential risks associated with ageing effects, PSA should be as realistic as practical and appropriate support data should be available for the review.

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