EC JRC Network on Use of PSA for Evaluation of Aging Effects to the Safety of Energy Facilities.

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Abstract

This paper summarizes acivities of research studies and followed discussions on the use of PSA for evaluation of SSC aging effect to the overall plant safety carried out in the frame of EC JRC Network activities on Incorporating Ageing Effects into Probabilistic Safety Assessment (Aging PSA) [1].

1. Introduction.

The basic interest in using PSA to evaluate ageing stems from the requirement to meet safety goals over the whole lifecycle of the nuclear installation (including its extended lifetime). In probabilistic terms, INSAG-12 [2] specifies the safety goal as follow :

"The target for existing nuclear power plants consistent with the technical safety objective is a frequency of occurrence of severe core damage that is below about 10^{-4} events per plant operating year. Severe accident management and mitigation measures could reduce by a factor of at least ten the probability of large off-site releases requiring short term off-site response."

So, for the units which approach to the end of initial design lifetime and especially for those which planned to extend the lifetime, it has to be demonstrated that the plant safety level, at least, will be remain in accordance with this target till the end of operation.

Another motive for ageing PSA development is a worldwide tendency to apply risk-informed regulation, in which the PSA approach and results play a key role (see figure 1) [3].

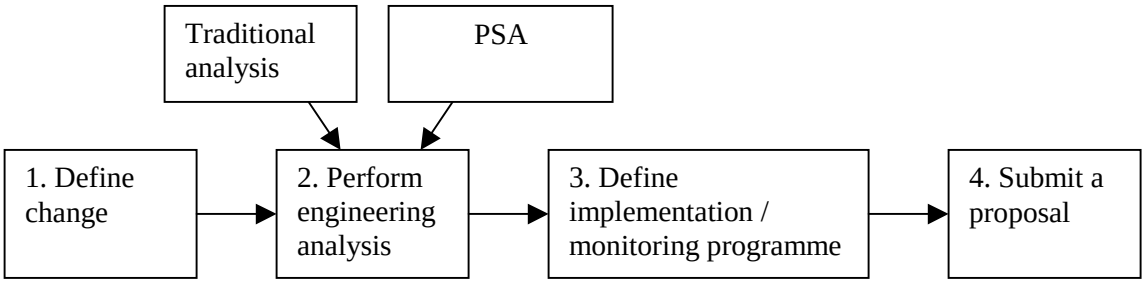

Figure 1: Principal elements of risk-informed, plant-specific decision-making

Presently, ageing evaluation-related activities have been or are being carried out as part of the following programmes:

- Periodic safety review,
- Ageing management,
- Maintenance optimisation,
- Lifetime extension.

There are number of national and international standards and guidelines available [4], but all of them in general are based on the deterministic approach and describe very limited PSA application.

Only few elements concerning the possible application of PSA for aging evaluation were found in IAEA TECDOC 1511 [4].

Could PSA be applied to ageing assessments? How realistically do PSA models reflect important ageing issues? Are any modifications or revisions of PSA assumptions needed to apply a PSA approach to risk-informed decisionmaking with regard to ageing evaluation? What data are available and how representative are they with regard to important ageing issues?

All these and others related questions prompted the setting up of the EC JRC Ageing PSA Network.

2. Presentation of EC JRC Ageing PSA network.

The initial motivation behind the Network on the Use of Probabilistic Safety Assessment (PSA) for the Evaluation of Ageing Effects on the Safety of Energy Facilities (Ageing PSA) was the fact that current standard PSA tools do not adequately address important ageing issues, which could have a significant impact on the conclusions drawn from PSA studies and applications where plants are operated at an advanced age or long term.

For instance:

- reliability models for components are based on the "component constant failure rate" assumption, which may not be valid in the long term;

- the reliability data used in the PSAs may not even adequately represent the current status of the plants, because the data was mostly collected during PSA development; it might reflect the situation at the beginning of operation, but equipment reliability could deteriorate with time;

- existing PSAs traditionally overlook some components (e.g. cables, structures, etc.) as having a very low probability of failure, but they may have increasing weight due to ageing effects.

The problem with applying the PSA approach to evaluating ageing effects is that experience in this area is limited worldwide; there are no commonly accepted methods, all the studies are performed by relatively isolated organisations, and publications on the subject are scarce.

The knowledge resulting from the Ageing PSA Network should help PSA developers and users:

- to incorporate the effects of equipment ageing into current PSA tools and models to perform engineering analysis,
- where PSA cannot be applied (where there are no or inadequate probabilistic ageing models or a lack of data, etc.), to specify and prioritise reliability monitoring actions/approaches to ensure that any decrease in the reliability of SSC is identified and corrected in time,
- to promote the use of PSA for ageing management and risk-informed applications for nuclear power plants.

The Ageing PSA Network is under development as part of JRC FP-7 institutional Project No 52101 "Analysis and Management of Nuclear Accidents" (AMA) [1].

So far, 14 organisations have joined:

- NRSC, Armenia,
- TU of Sofia, Bulgaria,
- NRI Rez, Czech Republic,
- JRC IE, European Commission,
- IRSN, France,
- VEIKI, Hungary,
- ENEA, Italy,
- KAERI, South Korea,
- LEI, Lithuania,
- JSI, Slovenia,
- KKG, Swiss,
- INR, Romania,
- CNE-prod, Romania,
- IATE, Russian Federation.

The main tasks to be covered by Network activities are as follows:

- Task 1. Organisation and coordination of network activities.
- Task 2. Analysis of main PSA tasks with regard to Ageing PSA.
- Task 3. Selection of the SSC to be considered in Ageing PSA.
- Task 4. Reliability and data analysis for active components.
- Task 5. Reliability and data analysis for active components II. Common Cause Failures.
- Task 6. Reliability and data analysis for passive components.
- Task 7. Incorporation of age-dependent reliability parameters and data into PSA model. Interpretation of quantification results.

- Task 8. Ageing PSA development and applications.

Presently, Tasks 1-4 and 7 are under development.

The Network operates via joint case studies and benchmarking exercises, expert meetings and workshops. More information about Network activities can be found on the following web site: http://www.energyrisks.jrc.nl/APSA/ .

3. Recent activities and futher plans.

A Network Steering Committee was hold in Fabruary 2007 in Amsterdam [6]. The objective of the meeting wos to discuss the technical and organizational issues related to the Network activities at 2007.

For efficient elaboration of Network tasks the following organisational structure was proposed and approved (see Figure 2).

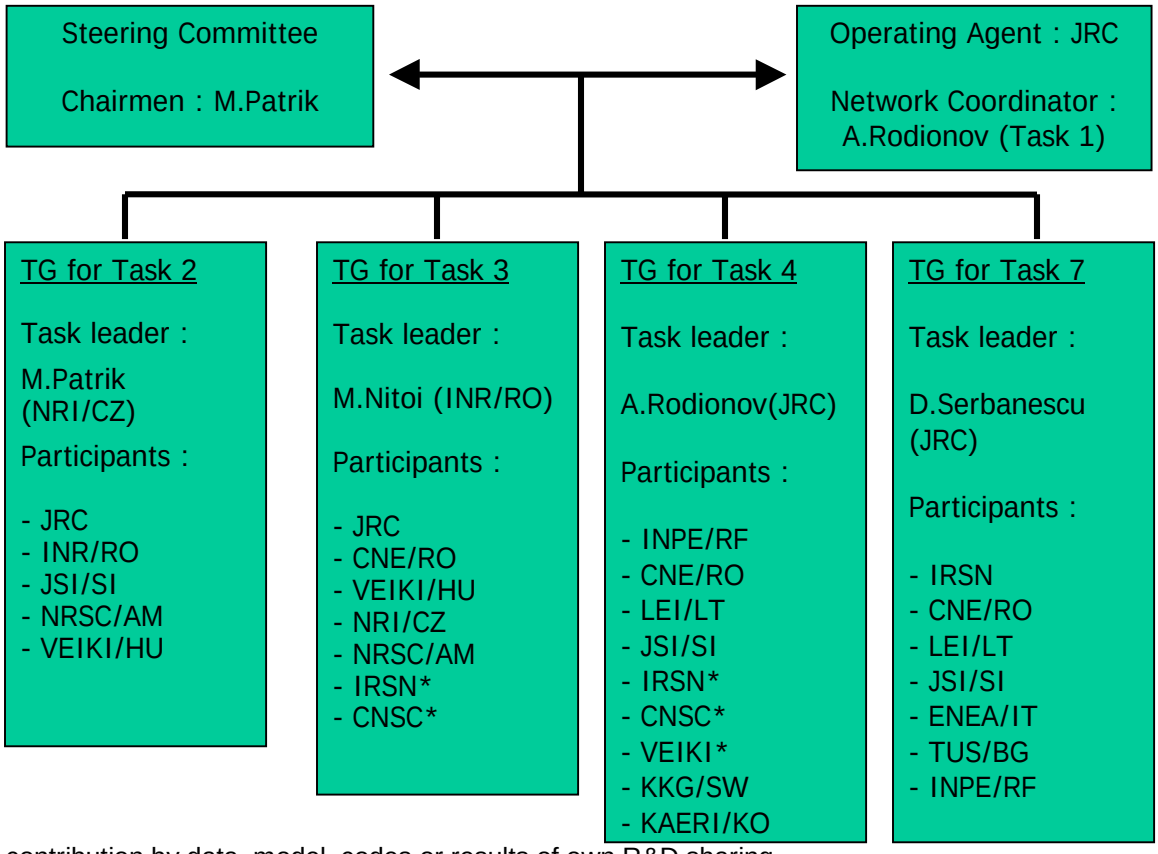

Figure 2: Ageing PSA Network organisational structure.

The short summary of each task activities is presented below.

Task 1. Coordination of network activities.

The expected results of this task are :

- Define status of network and conditions for participation.
- Coordination of network activities and dissemination of results.
- Operate network web site.
- Organization of Ageing PSA Workshop.

The deliverables from the Task 1 are listed below :

- Network Terms of Refferences (done).
- Steering Committee meeting minutes (done).
- Workshop Proceedings (to be done).
- 2 presentations in a 2nd IAEA symposium on NPP Life Management, 15-19 October 2007, Shanghai, China (done).
- Web site update (in progress).

In addition, the Steering Committee decided to prepare and to submit to EC DG RTD the Expression of Interests for a small cooperative research project on the topic "Use of PSA for Evaluation of Ageing and Maintenance Effects". The proposal was submitted and evaluated by DG RTD. It is expected that the topic will be included in planned calls for proposal under the other related issues specified by NULIFE Network.

Task 2. Analysis of main PSA tasks with regards to Aging PSA

It is expected that the results of this task will help

- to define the links between standard PSA tasks and Aging PSA development,
- to identify new potentially important issues,
- to prioritize and structure the project R&D.

The deliverable planned for 2007 is a draft report and review. The status of the progress will be presented by M.Patrik.

Task 3. Selection of the SSC to be considered in Ageing PSA

The expected result is a demonstration a qualitative approach to identify the NPP SSC sensitive for aging and important from risk and safety point of view.

The deliverables for 2007 are the Case Study report and review. The statuse of this task activities will be presented by M.Nitoi.

Task 4. Reliability and data analysis for active components

The expected results is a demonstration the methods to elaborate the reliability parameters for Aging PSA model and classify the data needed. The results will help

- to improve reliability and maintenance data collection system,
- to choose the appropriate reliability model for the parameters estimation,
- to address ageing and maintenance effects in component failure models,
- to evaluate the model uncertainties.

The deliverables expected in 2007 are the Case Study report and draft of the guideline on reliability data collection and processing. The results of the activities will be presented by A.Rodionov, D.Kelly, A.Antonov and J.Klugel.

Task 7. Incorporation of Age-depended reliability parameters and data into PSA model. Interpretation of quantification results.

It is expected to demonstrate a technique how to introduce aging effect to the existed PSA model and to show the possible impact of ageing on PSA results.

It is planned to have one deliverable on the task in 2007 : the report which presents the approach and examples of practical applications. Due to internal reorganisations in JRC this task isnt advanced enough this year.

Planned activities.

The following topics are planned for further development:

- areas of possible PSA application in ageing management and risk-informed approaches (within the Task 2),
- reliability data collection and parameter estimation guideline finalisation (Task 4),
- consideration of common cause failures (Task 5),
- passive component age-dependent reliability models (Task 6),
- the incorporation of ageing effects into the PSA model (continuation of Task 7).

4. Conclusions.

As discussed above, the PSA could be used as a tool for ageing analysis. It enables a particular SSC ageing assessment to be linked to the overall plant safety effect via risk evaluation.

In this context, the purpose of EC JRC Ageing PSA activities is to make available to PSA engineers practical approaches, methods and advice on how evaluate the importance of ageing issues by means of PSA modelling.

The main tasks identified and approved by Network participants are in progress and planned for realisation for next years.

The results of the activities and case studies performed will be presented and discussed during the workshop.

References

1. EUR 22645 EN. A. Rodionov, Ch. Kirchsteiger. Terms of References for APSA European Network on Use of Probabilistic Safety Assessment (PSA) for Evaluation of Ageing Effects to the Safety of Energy Facilities. DG JRC Institute for Energy, Petten, Netherlands, 2007.

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4. T. Inagaki. IAEA activities on safe long term operation and PSA. EUR 22514 EN. "Proceedings of EC Enlargement and Integration Workshop on Use of Probabilistic Safety Assessments (PSA) for Evaluation of Impact of Aging Effects on the Safety of Nuclear Power Plants. 2-5 October 2006, Bucharest (Romania)". DG JRC Institute for Energy, Petten, Netherlands, 2007.

5. TECDOC 1511. PSA Quality for Applications. IAEA, Vienna, 1999.

6. D(07)5504 from 5 of March 2007. Meeting Minutes "EC JRC Aging PSA Network Steering Committee meeting. 20 February 2007, Amsterdam, Netherlands."