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External Events PSA - Requirements Applicable to New Nuclear Installations Projects

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1. Introduction

Hazards must be pre-assessed and periodically reassessed throughout a nuclear facility lifetime so that its design and operation assure that radiological risk will be maintained within an ALARA (as low as reasonably achievable) range. Thus, a safety analysis covering facility site, design and operation must be conducted, in which deterministic and probabilistic methods may be used. Based on this analysis, it is possible to verify compliance with design criteria applicable to safety related structures, systems and components, as well as to improve operational procedures, emergency procedures and guidelines for accident management. [1]

Probabilistic Safety Assessment (PSA) stands for a comprehensive and structured approach to identify hazards and evaluate possible accident scenarios arising from initiating events and constitutes an entire conceptual and mathematical tool for risk management at different phases of facility lifetime. [1]

After the Fukushima Daiichi accident, increased attention has been given to external hazards regarding accident initiating events, and the following implications for PSA may be mentioned:

- Search for a systematic approach to determine most relevant hazards (single and combined) for a particular site;
- Refinement of methods to assess potential magnitude and probability of occurrence of external hazards;
- Clarification of the impact on safety related structures, systems and components with respect to low probability and/or high impact external hazards. [2] [3]

2. Discussion

PSA scope and level of detail must be adequate for the expected use and applications of this study, taking into consideration installation lifetime phases, which are siting, design, construction, operation, life extension and decommissioning. In particular, PSA level of detail may vary as (i) facility design and operation are modelled, (ii) facility-specific experience is incorporated into models and input data; and (iii) knowledge on expected response under design criteria is gained. Thus, a PSA used as support study during facility design phase is not expected to have the same level of detail as a PSA developed for a facility with several years of operational experience. [4]

In this context, it is necessary to divide installation life into clear phases. According to CNEN NE 1.04 [5], which regulates the licensing of nuclear installations in Brazil, this process necessarily involves the request by an applicant, and the issuance by CNEN, of the following acts: a) site approval; b) construction license; c) authorization for use of nuclear material; d) authorization for initial operation; and e) authorization for permanent operation. Besides these authorizations, renewal of operation licenses, known as life extension licenses, may be requested.

The main objective of this paper is to define requirements and capabilities that are prerequisites for the implementation of a structured external events PSA throughout installation lifetime. Moreover, the importance of having a clear path to achieve a full scope PSA will be shown, considering modelling requirements, data requirements and calculation capabilities. In Table I, requirements associated with the implementation of an external events PSA in each phase of installation lifetime are presented. It is important to note that siting evaluation phase comprises an initial collection of data regarding external hazards in future installation vicinity prior to the development of the PSA. [6]

Table I - Requirements and capabilities applicable to External Events PSA

External Events PSA	PSA Modelling Requirements	Data Requirements	Calculation Capabilities
Siting	-	1) Site Characteristics regarding seismology, geology, hydrology, and meteorology. 2) Data on industrial and military activities.	1) Preliminary analysis of frequency of occurrence and magnitude of external hazards in a specific site.
Design	– Conceptual/Early Design Level 1 Full Power Internal Events PSA	1) Design information at the engineering level of detail; 2) Design criteria of Structures, Systems and Components for design basis external hazards; 3) Identification of single and combined potential external hazards.	1) Qualitative screening for single external hazards.
Construction	– Level 1 Full Power Internal Events PSA; – Level 1 Full Power Internal Fire PSA; – Level 1 Full Power Internal Flood PSA; – Level 1 Low Power and Shutdown Internal Events PSA.	1) Assessment of frequency of occurrence of all possible initiating events; 2) Vulnerability analysis of SSCs regarding external hazards; 3) Incorporation of expected operator actions in PSA model.	1) Quantitative screening for single and combined external hazards; 2) Preliminary quantification of Conditional Core Damage Frequency (CCDP)/ Conditional Large Early Release Frequency (CLERF) for selected hazards.

Operation / Life Extension	– Level 1 PSA; – Development of Level 2 and Level 3 PSA; – If required, PSA for others radiation sources – spent fuel pool.	1) Data update / upgrade using information on SSCs operation/maintenance and operator actions according to a Living PSA program; 2) Tracking of the evolution of external hazards – increase of population/industrial activity, climate change etc.	1) Determination of accident sequences, system minimal cut sets and quantification of Core Damage Frequency (CDF), including uncertainty analysis – Level 1 Full Power External Events PSA; 2) Quantification of LERF (Large Early Release Frequency (LERF) and risk metrics associated with offsite consequences - Development of Level 2 and Level 3 External Events PSA.
Decommissioning	– If required, PSA for others radiation sources – spent fuel pool	1) Modifications during decommissioning process of spent fuel system and inventory considering low power and shutdown PSA models.	1) Determination of accident sequences, system minimal cut sets and quantification of Fuel Damage Frequency (FDF).

Requirements proposed in Table I consist of a graded approach for the progressive implementation of an External Events PSA during installation lifetime considering regulatory requirements and project maturity.

3. Conclusions

Considering practical difficulties to comply with the requirements proposed in this paper and the necessary resources to develop a PSA study, it is common that designers/operators postpone the development of External Events PSA and include quantification of risk associated with external hazards in the PSA to be developed during the installation operation phase. However, since regulatory requirements in the early stages of installation lifetime focus on PSA for internal events, calculation of a risk metric (CDF/LERF) associated with external hazards only in installation operation phase may result in an undue increment in the total risk metric for the installation.

Since a PSA is a study developed based on a comprehensive and complex logic, using a large amount of data, it is fundamental that regulatory authorities establish clear requirements and operating organizations managers foresee all different combinations of requirements that fulfill the objectives of an External Events PSA technically adequate.

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