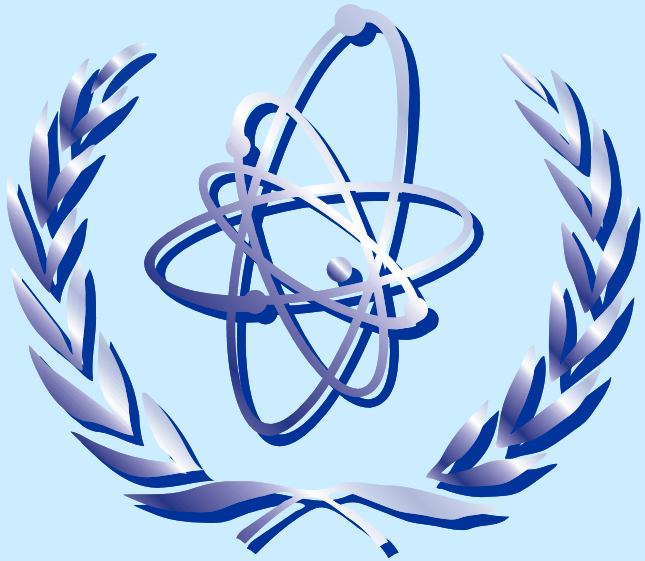
PSA applications



Use of PSA to support design and design modifications

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Use of PSA to support design and design modifications

Two major areas of this application:

- Use of PSA to support NPP design
  - New design - new challenges - risk "optimized" design
- Use of PSA to support NPP upgrade and backfitting activities and plant modifications
  - The very first natural PSA application.
  - One of the most important applications for PSAs of operating nuclear power plants is to identify potential safety improvements and to support the selection, design, installation, and licensing of plant upgrades.

Use of PSA to support NPP design

Uses, benefits and advantages

- Identification and resolution of plant vulnerabilities
- Identification of important intersystem dependencies and potential CCFs
- Examination of risk benefits from different design options
- Identification of accident scenarios and operator actions with a high sensitivity to human error
- Balance between preventive and mitigative measures
- Optimisation of systems and components for safety and availability
- Qualitative knowledge and understanding of the contribution of components and systems to accident sequences.

Use of PSA to support NPP design

Technical and methodological aspects

PSA requirements

- The scope of analysis should include at least a limited-scope Level 2 PSA.
- The PSA should determine the frequency of different plant damage states that may occur and it should identify all important physical and functional dependencies that affect containment or confinement systems.
- The PSA should include initiating events, failure modes, event sequences and dependencies that may be introduced by new design features.
- Event Sequence Diagrams may be used to develop the accident sequences.

Use of PSA to support NPP design

Precautions and limitations

- Deterministic methods continue to be very effective to ensure safe plant designs. (success oriented approach - and what is PSA?)
- PSA methods have limited capability to estimate the reliability and risk contributions from software based systems for instrumentation and control, plant protection, and operator interfaces, that advanced designs rely on.
- The PSA for a new plant design may contain substantial uncertainties.

Use of PSA to support NPP modifications

Uses, benefits and advantages

- One of the major goals of PSA is to assess the level of safety of existing plants and to identify potential **design weaknesses** which may result in proposed plant improvements .
- If CDF is dominated by a limited number of accident sequences, effective backfits may be proposed to prevent or to mitigate these scenarios.
- Backfits may also be suggested if PSA results show that a plant does not meet recommended or established national or international probabilistic safety criteria.
- A plant specific PSA is an extremely valuable tool to examine each proposed measure, to assess benefits and weaknesses, and to provide inputs to **cost-benefit analyses**.

Use of PSA to support NPP modifications

Technical and methodological aspects

PSA requirements

- The minimum modelling requirements for this application include a detailed plant specific Level 1 PSA.
- The containment vulnerabilities are also important for this application.
- To the extent possible, the PSA should use plant specific data.

=> All the requirements for a “Living PSA” are to be considered.

Use of PSA to support NPP modifications

Technical and methodological aspects (Cont.)

- The evaluation process for a design change requires the evaluation of the impact of the change in each of the following areas of the PSA
  - Initiating events
  - Safety function/success criteria definition
  - System modeling
  - Data analysis
  - Human reliability analysis

Use of PSA to support NPP modifications

Precautions and limitations

- PSA can only be used to identify which safety improvements are most effective to reduce overall plant risk within the limitations of the PSA models and scope of analysis.
- Modified procedures and training are often suggested as alternatives to plant hardware modifications.
- Decisions about proposed plant improvement options should be based on a thorough review of the PSA event sequences and examination of different measures of importance.

Use of PSA to support NPP modifications
Precautions and limitations (Cont.)

- Options should not be based on limited examination of a single issue unless that issue completely dominates the total plant risk profile.
- Recommended improvement options should consider the inherent uncertainties in the PSA methods, models, and results.
- Selection of practical backfits to achieve full compliance with national or international probabilistic safety criteria may be rather difficult for some plants if the PSA does not identify any dominant contributors to risk.

Examples

- **Use of PSA to support NPP design**
  - PSA is nowadays used to supplement deterministic criteria and analyses in the design process for new reactor concepts in the United States (e.g. AP-600 , ABWR), for the joint French-German project EPR], for the European EP1000,
  - The final PSA may be submitted to the regulatory body as part of the supporting documentation for the plant design and licensing criteria
  - In The Netherlands the development of a Level 3 PSA is required as part of the siting procedures. Should the construction of a new nuclear power plant be contemplated, first, a generic PSA would support the early stages of the siting and licensing. Finally, a full scope Level 3 PSA would be necessary to demonstrate that the combination of site and plant design fulfils the Dutch probabilistic safety criteria for The Netherlands

Examples (Cont.)

- Use of PSA to support NPP upgrade and backfitting activities and plant modifications
  - Some plants in Spain have used PSA as an input to the study of compliance with the Appendix R of 10CFR50 and the consequential plant upgrading related to fire safety.
  - The PSA reference studies in Germany have triggered upgrading and backfitting activities to improve NPP safety design. Level 1+ PSAs are being performed for all nuclear power plants in operation in the framework of the periodic safety review (PSR). Regulatory Guides have been developed to support this application.

Examples (Cont.)

- Prioritization of Safety Enhancement Measures (SEM) in Paks
- The first PSA study for unit 3 has already contained suggestions for activities in order to decrease the CDF value, i.e. to increase the safety condition of the unit and the whole plant. The main findings of the project were importance of:
  - replacing of the AEFW System into the confinement because of high probability of loss of feedwater by damage of both the FWS and the AEFWS pipelines due to common cause failures in the machine hall;
  - implementation of primary circuit feed-and-bleed.
  - Some of the planned measures were cancelled (e.g. the 13th diesel generator).

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