

Probabilistic Event Selection, Safety Classification and Reliability Criteria

This issue, along with the issues of source term and containment discussed in Attachments 5 and 6, respectively, are closely related and should be considered together since the recommendation on each successive issue builds upon the recommendations in the previous issues.

ISSUE 4: To what extent can a probabilistic approach be used to establish the licensing basis for:

- selection of events to be considered in the design and for emergency planning?
- safety classification of systems, structures, and components?
- replacement of the single-failure criterion?

BACKGROUND:

In SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and Process Inherent Ultimately Safe [PIUS]) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements," April 8, 1993, the staff described the approaches proposed by non-light-water reactor (LWR) designers for the selection of events to be considered in the design and for safety classification. Except as noted below, these approaches are similar to what was proposed for the pebble bed modular reactor (PBMR) during its pre-application review.

As a result of reviewing the proposed approaches the staff, in SECY-93-092, proposed to develop a single approach for accident evaluation to be applied to all advanced reactor designs and the Canadian Deuterium Uranium (CANDU 3) design during the pre-application review. The approach proposed in SECY-93-092 had the following characteristics:

- Events and sequences would be selected deterministically and would be supplemented with insights from probabilistic risk assessments (PRAs) of the specific designs.
- Categories of events would be established according to expected frequency of occurrence. One category of events that would be examined is accident sequences of a lower likelihood than traditional LWR design basis accidents. These accident sequences would be analyzed without applying the conservatisms used for design basis accidents. Events within a category equivalent to the current design basis accident category would require conservative analyses, as is presently done for LWRs.
- Consequence acceptance limits for core damage and onsite or offsite releases would be established for each category to be consistent with Commission guidance.
- Methodologies and evaluation assumptions would be developed for analyzing each category of events consistent with existing LWR practices.
- Source terms would be determined as approved by the Commission.

- A set of events would be selected deterministically to assess the safety margins of the proposed designs, to determine scenarios to mechanistically determine a source term, and to identify a containment challenge scenario.
- External events would be chosen deterministically on a basis consistent with that used for LWRs.
- Evaluations of multi module reactor designs would be considered as to whether specific events apply to some or all reactors on site for the given scenario for all operations permitted by proposed operating practices.

In response to SECY-93-092 the Commission issued a staff requirements memorandum (SRM) on July 30, 1993, which approved the staff proposal.

The approach described in SECY-93-092 has differences from what was proposed for the PBMR during its pre-application activities. The PBMR approach consisted of defining event categories by the frequency of their occurrence, identifying acceptance criteria for each event category and designing the plant for events down to a frequency of 10^{-5} /plant-year. Events less frequent than this would be considered for emergency planning purposes down to 5×10^{-7} /plant-year. Structures, systems, and components (SSCs) would be classified "safety related" if they were necessary to enable the plant to meet acceptance criteria.

DISCUSSION:

As a result of the recent non-LWR pre-application activities, the staff has reviewed the previous Commission approved approach to see if any changes should be considered. Specifically, this review focused on what has happened since 1993 where greater emphasis has been placed on using risk information in the regulatory process. The Commission's expectations in this regard were expressed in the 1995 PRA Policy Statement on the uses of PRA which states: "The use of PRA technology should be increased in all regulatory matters to the extent supported by the state-of-the-art in PRA methods and data and in a manner that complements the NRC's deterministic approach and supports the NRC's traditional defense-in-depth philosophy." The issuance of this policy statement initiated a number of activities to increase the use of PRA in regulatory activities. These included the development of Regulatory Guides 1.174, 1.175, 1.176, 1.177 and 1.178, initiating work to risk-inform 10 CFR Part 50 and implementing the revised reactor oversight process.

In risk-informing the technical requirements of 10 CFR Part 50 (Option 3) the staff has developed a "framework" document to guide the staff which contains an event category approach similar to what has been proposed for the PBMR. In addition, in risk-informing 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," the staff has proposed to allow the use of risk information to replace the single-failure criterion and, in SECY-02-0176, has proposed to use risk information to modify the special treatment requirements on safety-related SSCs in 10 CFR Part 50. Accordingly, much of what has been proposed for the PBMR has, in one way or another, received Commission attention in other programs. Therefore, it may be appropriate to reconsider the approach approved in 1993 to allow more reliance on PRA.

At a public workshop on October 22–23, 2002, the industry participants supported a probabilistic approach for event selection, safety classification, and replacing the single-failure criterion. The public interest group representative did not support such a change due to a lack of confidence in PRAs.

OPTIONS:

The options considered by the staff in addressing this issue are:

- (a) Retain the approach approved by the Commission in its July 30, 1993, SRM where engineering judgement, based upon experience, is used to deterministically select events to be considered in the design with PRA information being used to supplement the selection.

This option uses experience and qualitative judgements regarding likelihood and risk to select events to be considered in the design and to classify SSCs as safety related. In general, bounding events are identified to envelop categories of events. This option would bring PRA into the licensing basis only as a supplement to the deterministic approach.

- (b) Use a probabilistic approach to select events to be considered in the design, to classify SSCs as safety related and to replace the single-failure criterion.

This option would be similar to that proposed for the PBMR. It is, in effect, a risk-based approach. Event categories for anticipated operational occurrences (AOOs), design basis events (DBE) and emergency planning (EP) would be defined probabilistically and PRA would be used to identify those events which fall into each category. Acceptance criteria for each event category would be established. An example of such event categories and their associated acceptance and frequency criteria are shown in the following table. Conservative analysis would be used for AOOs and DBEs (using, for example, a specified level of confidence) and best-estimate analysis for EP. The safety classification of SSCs would be determined based upon the importance of the SSC to meeting the acceptance criteria or staying within the event category (as an example, importance measures could be used for this determination). The single-failure criterion would be replaced with a reliability criterion and the event scenarios identified in the PRA would be examined against this criterion. This could lead to having to consider multiple failures in AOO, DBE, and EP accident scenarios.

The key advantage to this option is that it provides a technology-neutral, structured and consistent way to establish the design basis that realistically considers equipment and human performance. It does, however, require that PRA become part of the licensing basis for the plant with appropriate controls on PRA completeness, quality and documentation, including change control for the PRA.

Example Event Selection Criteria

Event Category	Frequency Range *	Acceptance Criteria
AOO**	$> 10^{-2}/\text{plant-year}$	10 CFR Part 20
DBEs**	$10^{-2}/\text{plant-year} - 10^{-6}/\text{plant-year}$	10 CFR 50.34 or a fraction thereof
EP***	$10^{-6}/\text{plant-year} - 10^{-8}/\text{plant-year}$	N/A

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- * Frequency range applies to initiating event or event scenario
 ** Conservative analysis
 *** Best estimate analysis

(c) Use an approach where probabilistic information is supplemented by deterministic engineering judgement.

This option differs from Option a in that in this option the deterministic engineering judgement is used to complement the PRA, whereas in option a the PRA is used to complement the deterministic engineering judgement. This change in orientation would be appropriate if it is the Commission's view that the use of PRA information has matured to the point that it can play a more prominent role in safety analysis and licensing decisions. Similar to option b, this option would define event categories for AOOs, DBEs, and EP events probabilistically and would use a probabilistic approach for safety classification of SSCs and a reliability approach to replace the single failure criteria. Even though this option places greater reliance on the PRA, it is still considered risk-informed, since it does not place sole reliance on the PRA. It could, however, be considered to go beyond the PRA Policy Statement in the intended use of PRA information. Similar to Option b, this option requires that PRA become part of the licensing basis of the plant, with appropriate controls on PRA completeness, quality and documentation.

RECOMMENDATION:

The staff recommends the Commission take the following actions:

- Modify the Commission's guidance, as described in the SRM of July 30, 1993, to put greater emphasis on the use of risk information by allowing the use of a probabilistic approach in the identification of events to be considered in the design, provided there is sufficient

understanding of plant and fuel performance and deterministic engineering judgement is used to bound uncertainties.^{1 2}

- Allow a probabilistic approach for the safety classification of structures, systems, and components.
- Replace the single-failure criterion with a probabilistic (reliability) criterion.

This recommendation is consistent with Option c above and, if approved by the Commission, would lead to a technology neutral, systematic and consistent approach for establishing key aspects of the licensing basis for non-LWRs, while accommodating their unique aspects. The actual probabilistic criteria for each event category would be developed as a follow-on activity (i.e., as part of the development of a framework for future plant licensing) and would be consistent with the level of safety for future plants approved by the Commission under Issue 1. It is envisioned that this approach would still result in a set of design basis accidents for each plant design (i.e., consisting of key accident scenarios from each event category).

¹Note: The actual design basis events for any particular design would be determined at the time of the staff review of that design. The criteria that would be used to guide this determination would be technology neutral, would include guidance on how to treat uncertainties and would be determined as part of the development of a framework for future plant licensing consistent with the Commission's decisions on the issues discussed in this paper.

²Note: The staff believes that this recommendation is consistent with the Commission's 1995 PRA policy statement and the 1999 Risk-Informed and Performance-Based Regulation White Paper.