

## Expectations for Safety

ISSUE 1: How to implement the Commission's expectations for enhanced safety in future non-light-water reactors.

### BACKGROUND:

The Commission's Policy Statement on Severe Accidents (50 FR 32138), August 8, 1985, stated that the Commission expects new plants to achieve a higher standard of severe accident safety performance than prior designs.

The Commission's "Policy Statement on the Regulation of Advanced Nuclear Power Plants" (51 FR 24643), July 8, 1986, stated that the Commission expects advanced reactors to provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions. In addition, in that same policy statement the Commission stated that it expects, as a minimum, at least the same degree of protection of the public and the environment that is required for current generation light-water reactors (LWRs) and that advanced reactor designs will comply with the Commission's Safety Goal Policy Statement.

For the evolutionary and advanced light-water reactors (ALWRs) both the industry and the staff have taken steps to implement the Commission's expectations. In the late 1980s and early 1990s, the industry (led by the Electric Power Research Institute [EPRI]) developed a "Utility Requirement Document" (URD) for ALWRs which defined the requirements that utilities desired in ALWRs. These utility requirements included reduced core damage frequency (CDF) and radioactive material release objectives from those achieved by current generation LWRs as well as other plant features that EPRI considered would make future LWRs "substantially safer than existing plants." The staff reviewed the URD and documented its findings in NUREG-1242, "NRC Review of EPRI's ALWR-URD." In summary, the staff found that a plant designed and operated in accordance with the URD would meet NRC requirements and expectations for enhanced safety.

For non-LWRs the staff reviewed three conceptual designs sponsored by the U.S. Department of Energy (DOE) (one high-temperature gas-cooled reactor, the Modular High-Temperature Gas-Cooled Reactor (MHTGR), and two liquid metal reactors, Power Reactor Innovative Small Module [PRISM] and Sodium Advanced Fast Reactor [SAFR]). These designs were submitted in the late 1980s for the pre-application review in accordance with the "Commission's Policy Statement on the Regulation of Advanced Nuclear Power Plants." Each of these designs had as an objective enhanced safety through the use of simplified, passive safety systems, less reliance on human actions, and greater prevention of core damage. The staff issued the following pre-application safety evaluation reports on these designs.

- NUREG-1338 (Draft), "Preapplication Safety Evaluation Report for the Modular High-Temperature Gas-Cooled Reactor (MHTGR)," June 1995.
- NUREG-1368, "Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid-Metal Reactor," February 1994.

- NUREG-1369, “Preapplication Safety Evaluation Report for the Sodium Advanced Fast Reactor (SAFR) Liquid-Metal Reactor,” December 1991.

Although steps have been taken toward incorporating enhanced safety into future designs, the Commission has not required enhanced safety through the promulgation of generic requirements. In fact, in its staff requirements memorandum (SRM) of June 15, 1990, “SECY-89-102—Implementation of the Safety Goals,” the Commission explicitly stated that it will not use the industry’s design objectives for advanced plants (e.g.,  $10^{-5}$ /reactor year CDF) as the basis to establish new requirements. The Commission has, however, on a design-specific basis, required enhancements on the certified evolutionary LWR and ALWR designs (ABWR, System 80<sup>+</sup> and AP-600) in areas of higher uncertainty to help ensure a higher standard of severe accident performance and has approved those features in the design certification rulemaking for these designs.

#### DISCUSSION:

In past activities related to future reactors (both LWRs and non-LWRs) the Commission has, for the most part, relied on industry to provide enhanced safety in new designs and has only proposed enhancements in specific areas of high uncertainty (e.g., SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor [ALWR] Designs, April 2, 1993). In addition, siting locations or the number of units on a site were not a part of the previous reviews except for the issue of modular reactors, where several smaller reactors were needed to achieve the electrical output of one large unit.

Currently, there is a possibility that one or more applications for new plants will be forthcoming in the near future and siting locations will likely be considered through the early site permit process. Three potential early site permit applications are currently under discussion, all involving sites with existing nuclear power plants, and possibly including multiple units.

Traditionally, risk calculations related to the Safety Goal quantitative health objectives (QHOs) have been done on a per plant basis and the guidelines developed and used in the risk-informed process (e.g., Regulatory Guide 1.174, Option 3 Framework) were based on risk from an individual plant. The Safety Goal Policy itself implies that the risk should be calculated on a per site basis. In defining the population at risk in applying the QHOs, the Safety Goal Policy refers to the “plant site.” To be properly risk-informed, the assessment should consider the integrated effect of multiple plants. This has implications for the level of safety for future LWRs as well as non-LWRs.

Accordingly, the possibility of additional nuclear power plants (some on sites with existing plants) raise the following fundamental question for Commission consideration:

“How should the integrated risk of multiple units on a site be accounted for?”

At the public workshop held October 22–23, 2002, the industry participants supported a process similar to that used in certifying the evolutionary LWR and ALWR designs (ABWR, System 80<sup>+</sup>, and AP600) where the designers proposed designs with enhanced safety characteristics and each design was reviewed on its own merits, with additional safety enhancements targeted only at areas of high uncertainty.

## OPTIONS:

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

- (a) Do not generically require enhanced safety on future non-LWRs, but rather rely on industry to propose designs with enhanced safety characteristics and, through a process similar to that used in the evolutionary LWR and ALWR design certifications, impose any additional enhancements with Commission endorsement only to address areas of high uncertainty.

This option would, in effect, maintain the status quo and is consistent with the overall philosophy in the Nuclear Energy Institute's (NEI's) May 2002 white paper on "A Risk-Informed, Performance-Based Regulatory Framework for Power Reactors." It also would have the least impact on future LWRs (those under review as well as those already certified). All future designs currently under consideration have claimed enhanced safety. The staff would review each design on an individual plant basis and licensing criteria and risk metrics for non-LWRs would be directed toward the same level of accident and core damage prevention as current criteria as well as the same level of accident mitigation. Any safety enhancements would be applied on a plant-specific basis to address areas of high uncertainty. The incremental increase in risk to the surrounding population from additional reactors on a site would be expected to be small due to the enhanced safety characteristics of the new designs, which are likely to be an order of magnitude better than current designs.

- (b) Require an enhanced level of safety on future non-LWRs.

This option would generically impose criteria and risk metrics on future non-LWRs directed toward improved accident and core damage prevention as well as improved accident mitigation. Setting higher standards for the level of safety to be achieved could also help compensate for the greater uncertainties associated with new non-LWR designs. For example, enhanced accident and core damage prevention in a design could help compensate for uncertainties in the severe accident area, since the risk from severe accidents would be lower. This option would also help keep the incremental increase in risk to the population around a site small. This option is not consistent with NEI's May 2002 white paper and would apply equally to future LWRs as well as non-LWRs.

- (c) Require an enhanced level of confidence in the performance of plant systems, structures and components.

This option would utilize criteria and risk metrics directed toward the same level of safety as current criteria; however, to compensate for the reduced experience with non-LWRs, enhanced research and development, testing, and NRC oversight (e.g., fuel quality) could be required to increase confidence in the performance of plant systems, structures and components, and confirm plant safety. This option would be similar to Option a in other aspects.

- (d) Do not generically require enhanced safety on future non-LWRs, but rely on industry to propose designs with enhanced safety characteristics. Use a process similar to that used in the evolutionary LWR and ALWR design certification reviews to impose any additional enhancements, including enhancements to establish increased confidence in the design and/or performance of plant systems, structures or components with Commission endorsement.

This option is a combination of options (a) and (c) above and acknowledges that enhancements recommended by the staff can be related to the reactor design as well as to programs and processes (e.g., oversight) needed to ensure confidence in the performance of plant systems, structures, and components.

RECOMMENDATION:

The staff recommends that the Commission take the following actions:

- Approve implementation of enhanced safety through a process similar to that used in the evolutionary LWR and advanced light-water reactor (ALWR) design certification reviews (i.e., reactor designers are expected to propose designs with enhanced safety characteristics and the staff reviews each design on its own merits and, on as needed basis, recommends additional enhancements in areas of high uncertainty subject to Commission endorsement). Such enhancements could include additional design features, additional testing by the designer, or additional confirmatory testing and/or oversight by NRC in areas of large uncertainty, and would be recommended with the intent to achieve a level of safety and confidence similar to that achieved in the evolutionary and ALWR design certifications.
- In implementing the above, apply the following considerations:
  - When using probabilistic or risk information, modular reactor designs should account for the integrated risk posed by multiple reactors necessary to achieve the overall electrical output desired.
  - The incremental risk to the surrounding population from adding additional units to an existing site is expected to be small due to the enhanced safety characteristics of new designs.

This recommendation is consistent with Option d above. The recommendation is intended to help ensure that the intent of the Commission's Safety Goal Policy is met.

In the longer term, the Commission may wish to consider a revision to the Policy Statement on the Regulation of Advanced Nuclear Power Plants to include the above recommendation (if approved by the Commission) as well as to expand the scope of the policy statement to include fuel cycle and security considerations for future reactors.