Consideration of the Technology-Neutral Regulatory Framework Development in the United States of America

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1. Introduction

The Nuclear Regulatory Commission (NRC) in the United States of America is developing a technology-neutral regulatory framework for the licensing of future nuclear power plants. The need to develop a risk-informed, performance-based and technology-neutral framework for establishing requirements, which may be technology-neutral or technology-specific, for new reactors is based on the following considerations:

- While the NRC has over 30 years experience with licensing and regulating nuclear power plants, this experience (as reflected in regulations, regulatory guidance, policies and practices) has been focused on current light-water-cooled reactors (LWRs) and may have limited applicability to new reactors. It is expected that future applicants will rely on PRAs as an integral part of their license applications. Hence guidance and criteria on the use of PRA results and insights will be an important aspect of the licensing process.
- It is also expected that the regulations for new reactors will be risk-informed and performance-based. The use of risk metrics in evaluating safety focuses attention on those areas where risk is most likely and the use of performance measures provides flexibility to designers in emphasizing outcomes rather than prescriptive methods of achieving them. A structured approach towards a regulatory structure for new reactors that incorporates probabilistic and deterministic insights will help ensure the safety of these reactors by focusing the regulations on where the risk is most likely while maintaining basic safety principles, such as defense-in-depth and safety margin.
- The provision of a framework that is technology-neutral with respect to important probabilistic and deterministic criteria governing risk acceptance and performance will facilitate the development of a consistent, stable, and predictable set of requirements that are both risk-informed and performance-based. These requirements may be either technology-neutral, and so can be applied to any reactor design in conjunction with technology-specific regulatory guides, or technology-specific, i.e., focused on particular designs.

2. Development of the Technology-Neutral Regulatory Framework

2.1 Scope of the Framework

It is expected that the regulations that derive from this framework will be applicable to all types of reactor designs, including gas-cooled, liquid metal, and heavy and light-water-moderated reactors. This applicability will be accomplished either by having the regulatory requirements specified at a high (technology-neutral) level, or by developing technology-specific requirements for particular designs based on the criteria and guidance offered in the framework.

The framework will address risks from all sources of radioactivity that are present at the plant. These include: reactor full-power, low-power and shut-down operation, and spent fuel storage and handling and the risks from both internal and external events. Therefore, it includes seismic, fire and (internal and external) flood risks, and risk from high winds and tornados. Issues related to security will also be considered. Risks from other sources that are an integral part of the licensing process, e.g., liquid sodium for liquid metal reactors, are also included in the scope of the framework.

The framework will cover design, construction, and operation. Operation includes both normal operation as well as off-normal events, ranging from anticipated occurrences to rare but credible events, for which accident management capabilities may be needed.

2. 2 *Expected Advantages of the Framework*

In addition to utilizing the benefits of PRA, the development of a risk-informed performance-based structure for new plant licensing has several advantages over continuing to use the 10 CFR Part 50 licensing process for designs substantially different than current generation LWRs. While the current Part 50 requirements are used to the extent feasible in developing the alternative, the use of a technology-neutral approach can provide greater efficiency, stability and predictability than continuing to use the 10 CFR Part 50 process.

It would be written to be applicable to any reactor technology, thus avoiding the time consuming and less predictable process of reviewing non-LWR designs against the LWR oriented 10 CFR 50 regulations, which requires case-by-case decisions (and possible litigation) on what 10 CFR 50 regulations are applicable and not applicable and where new requirements are needed. It would require a broader use of design specific risk information in establishing the licensing basis, thus better focusing the licensing basis, its safety analysis and regulatory oversight on those items most important to safety for that design. It would stress the use of performance as the metrics for acceptability, thus providing more flexibility to designers to decide on the design factors most appropriate for their design.

2.3 Key Elements of the Framework

The development of the framework is based on a unified safety concept that derives regulations from the Commission's Safety Goals Policy and other safety principles such as defense-in-depth and safety margin.

The framework for new plant licensing has been developed following a top-down approach. It is built upon the traditional NRC safety mission, beginning with the Atomic Energy Act and encompassing a set of safety, security, and preparedness expectations. The framework describes the NRC's criteria for meeting these expectations and provides guidance for achieving them through meeting a series of defense-in-depth expectations. Defense-in-depth is directed toward compensating for uncertainties and evolves from a set of defense-in-depth principles that are embraced throughout the design. Finally, a set of technology-neutral, risk-informed, performance-based requirements are developed to ensure that defense-in-depth is maintained throughout design, construction and operations. The framework, then, is a hierarchical approach to safety, one that assures that safety, security, and preparedness are maintained throughout design, construction, and operations. The protective strategies address accident prevention and mitigation and consist of the following: physical protection; maintaining stable operation; protective systems; maintaining barrier integrity; and protective actions. Acceptable performance in these protective strategies provides reasonable assurance that the overall mission of adequate protection of public health and safety is met.

A defense-in-depth structure is established such that the uncertainties are addressed that will ensure safety limits are met and that the design, construction and operation have enough safety margins to withstand unanticipated events.

The design objectives parallel and are complementary with the protective strategies, in support of the NRC's defense-in-depth expectations. They provide overall goals that the protective strategies are intended to meet.

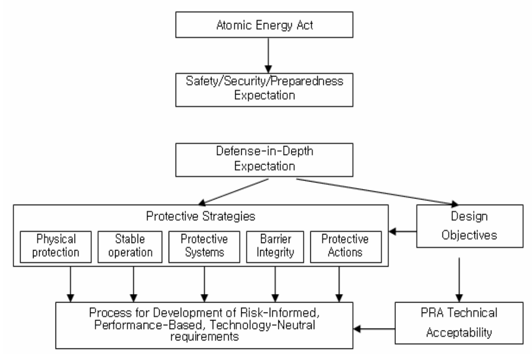

Figure 2-1 The Risk-Informed Performance-Based Technology-Neutral Framework Roadmap

In the framework, design objectives establish two basic parts of the licensing requirements: (1) identification and selection of those events that are used in the design to establish the licensing basis (licensing basis events or LBEs), and (2) the classification of systems, structures, and components (SSCs) by safety significance. The design objectives are derived from the quantitative health objectives (QHOs) of the NRC's safety goals.

The defense-in-depth features of the protective strategies and the combination of design and operations objectives and PRA technical acceptability lead to the establishment of technical requirements that are technology-neutral. Administrative requirements are also developed to ensure that the bases for the technical regulations (risk calculations, plant conditions, and other assumptions) are sound and do not degrade over time.

The approach continues the practice of ensuring that the allowable consequences of events are matched to their frequency such that frequent events must have very low consequences and less frequent events can have higher consequences. A set of probabilistic criteria have been developed to implement the above that address: allowable consequences of events versus their frequency; selection of events which must be considered in the design; and allowable cumulative individual risk to the public from the events which must be considered in the design.

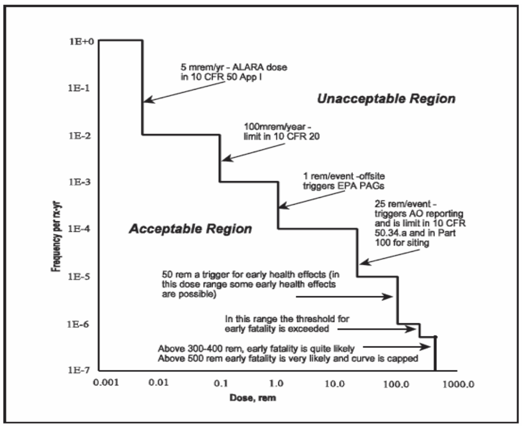

Figure 2-2 Frequency-consequence curve

In addition, a probabilistic approach is used for establishing reliability goals and safety classification of equipment. Guidance on the scope and quality of the risk assessment needed to support the above is also given. The use of the above approach has also led to other considerations such as the use of scenario specific source terms for licensing and the consideration of revised siting dose criteria.

The process for developing technical and administrative requirements from the protective strategies begins with the protective strategies themselves. Then a deductive analysis of the logic of events that can defeat each protective strategy is performed. This leads directly to the questions staff must ask to ensure each protective strategy is accomplished. As a final check, the questions and answers are benchmarked against criteria for LWRs in 10 CFR Part 50, IAEA Standards, and other available historical information as a check on completeness. Finally, the answers to the questions are formulated as topics to be addressed in risk-informed, performance-based requirements.

3. Conclusion

In our country, the KAERI (Korea Atomic Energy Research Institute) has started to develop Generation IV Reactors, such as VHTR (Very-High-Temperature Reactor) for hydrogen production, SFR-600 (Sodium-cooled Fast Reactor), and SCWR (Super-Critical Water-cooled Reactor), under auspices of the MOST (Ministry of Science and Technology). Therefore, it is necessary to construct a new regulatory framework for the new advanced reactors. The aforementioned approach and its feasibility study will be helpful in building our new regulatory framework. And it is necessary to investigate relevant activities of other countries.

REFERENCES

[1] Framework for Development of a Risk-Informed, Performance-Based, Technology-Neutral Alternative to 10CFR Part 50, Working Draft Report, USNRC Office of Nuclear Regulatory Research, 2006. 4