The Feasibility Study for Application of Technology-Neutral Regulatory Framework to Korean New Plant Licensing

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1. Introduction

The current regulations for nuclear power plants focus on light water reactors (LWRs), and as such they may not be properly applied to non-LWR reactors such as Generation IV Reactors including Very High Temperature Reactor (VHTR) and Sodium-Cooled Fast Reactor (SFR). For instance, there is no plant state comparable to core damage in pebble bed reactors [1].

Therefore, there are considerable interests worldwide in developing new licensing structure for advanced nuclear power plants. Examples include Technology-Neutral Framework (TNF) being developed by the USNRC (NRC) [2], risk-informed performance-based licensing approach proposed for the Pebble Bed Modular Reactor (PBMR) by PBMR, Pty. LTD [1,3] , Technology-neutral safety requirements developed by the International Atomic Energy Agency (IAEA) [4].

The activities in this regard primarily center around a couple of major topics: 1) how to set risk acceptance criteria, and 2) how to select licensing basis events (LBEs) for new plant licensing. In this paper, the recommendations for Korean new plant licensing are given with respect to these approaches along with suggestions for future research.

2. Recommendations on Risk Acceptance Criteria

For a technology-independent or technology-neutral regulatory framework, an event sequence frequency versus dose consequence chart similar to F-C Curve of NRC TNF[2] as shown in figure 1, or F-C Chart of PBMR, Pty LTD[3] as shown in figure 2 may be developed based on the current Korean regulations. In doing so, the following need to be noted:

1) Definition of Event Types: Since about three decades ago, three different types of potential events that might occur during plant operations have been considered in design and deterministic safety analysis as documented in Chapter 15 of Safety Analysis Report. This tradition perhaps stems from Regulatory Guide (RG) 1.70 [5] that was published in 1978 and is still used. In RG 1.70, initiating events are classified into the following frequency groups: a) incidents of moderate frequency, b) infrequent incidents, and c) limiting faults. Note that it was originally initiating events, but not event sequences, which were classified based on frequency. The classification of event sequences into the three frequency groups still seems necessary because different requirements can be set for each group in the new licensing structure.

2) Applicability of ALARA Dose Requirement: The ALARA requirement defined in 10 CFR 50, Appendix I actually provides limits on planned releases from the nuclear power plant radwaste systems during normal operation, and therefore, it is not directly used in the PBMR licensing approach. However, this ALARA requirement is used to set the dose limit on frequent events (i.e., 1E-2/yr to 1E+0/yr) in the NRC's framework approach. Apparently a deep investigation is needed to find out whether or not the ALARA requirement should be directly used as part of dose limits in the frequency-consequence diagram of Korean licensing framework.

3) Dose Limits on Anticipated Operational Occurrences: The ALARA dose limit of 5 mrem per year is applied to frequent events in F-C Curve of the NRC's framework approach, but a significantly higher dose limit of 100 mrem per year is used in F-C Chart of the PBMR licensing approach. This issue of which dose limit should be applied to AOOs (anticipated operational occurrences) or frequent events is related to the applicability of ALARA dose requirement, and therefore, both issues should be investigated together in the future research.

4) 10 CFR Part 20 Dose Requirement: The normal operation public dose requirement of 100 mrem defined in 10 CFR Part 20 is applied to infrequent events with a frequency of 1E-2/yr to 1E-3/yr in the NRC's framework approach. However, in view of the fact that it is an annual dose as opposed to an event-based dose; it may have to be applied to frequent events or to AOOs as in the PBMR approach.

5) Dose Calculation Method for Infrequent and Rare Events in F-C Curve: The dose during a period of only the worst (maximum based on meteorological conditions) 2 hours following the onset of an event at the exclusion area boundary is used as a dose limit for infrequent events with a frequency less than 1E-3/yr. However, the 24 hour dose is used for rare events. It appears that either 2 hour or 24 hour dose may have to be applied to both infrequent and rare events for consistency in the case of event-based criteria, unless a special reason for use of such different dose calculation methods is found. This issue should be examined in details in the future research.

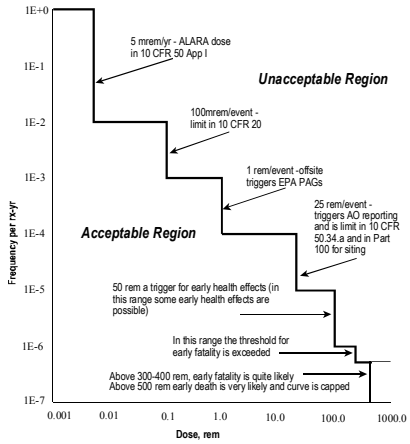

Figure 1. Frequency-Consequence Curve in the NRC's Technology-Neutral Framework[2]

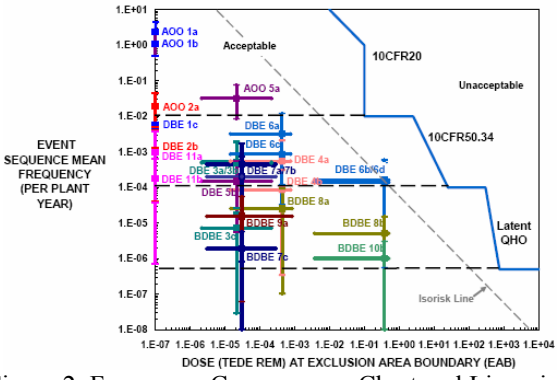

Figure 2. Frequency-Consequence Chart and Licensing Basis Events in the PBMR Licensing Approach[3]

3. Recommendations on Licensing Basis Events

The safety of nuclear power plants has been evaluated thus far primarily based on deterministic thermal-hydraulic analyses, as stipulated in Regulatory Guide 1.70 [5] and documented in SAR Chapter 15. RG 1.70 states how design basis events should be determined, and how the expected response of the plant and the operating staff to these DBEs should be analyzed with estimation of the resulting consequences. These deterministic safety analyses have provided the foundation for ensuring the plant safety although various conservative assumptions should have been made to carry out these analyses.

Note that RG 1.70 has been recently superseded by RG 1.206 [6], specifically Section C.I.15 "Transient and Accident Analyses," for combined license (COL) applications. In RG 1.206, the initiating events are grouped into the following two frequency groups:

1) AOOs, as defined in Appendix A to 10 CFR Part 50 and categorized in RG 1.70, are those conditions of normal operation that are expected to occur one or more times during the life of the nuclear power unit, and

2) Accidents are occurrences that are postulated but are not expected to occur.

One can note that the term AOOs as defined above in RG 1.206 incorporate the AOOs and DBEs as used in the PBMR approach, and the frequent and infrequent events as used in the NRC's TNF approach.

A more thorough comparison of the DBE and LBE analyses may be carried out in the future especially from a perspective of the effectiveness in ensuring defense-in-depth capabilities of the plant against potential events. An integrated decision-making approach taking advantage of both deterministic and probabilistic methodologies may be devised in consideration of a structured process for accident scenario identification, such as the Phenomena Identification and Ranking Table (PIRT) process [7], when developing an alternative method for LBE selection and analysis.

4. Conclusion

The risk-informed and performance-based licensing approaches of TNF in NRC[2] and PBMR, Pty Ltd[3] have great potential to facilitate decision making for safe reactor design by clearly indicating regulatory requirements in terms of frequency of occurrence and expected consequence for the whole spectrum of potential accident sequences and selecting accident scenarios to be used as design or licensing bases in a more rational way than was done in the past. However, they tend to depend too much on a PRA at design stage which has considerable uncertainties, without paying sufficient attention to the traditional safety analysis methodology that has played an important role in ensuring plant safety thus far. Therefore, an effective blend of deterministic and probabilistic approaches taking advantage of both traditional safety analysis methodology and risk insights apparently needs to be developed.

REFERENCES

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