Review of Integrated Risk-Informed Decision Making Methodology using Risk Insights – Current Status and Perspectives

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1. Introduction

Recently, EPRI (Electric Power Research Institute) in U.S. issued a report named as "A Framework for Using Risk Insights in Integrated Risk-Informed Decision-Making" in which includes new ideas of using risk insight to evaluate defense-in-depth (DID) and safety margin (SM). [1] Traditionally, DID and SM are the basic principles of Risk-Informed Decision Making (RIDM) framework in the nuclear safety [2] and were recognized as deterministic and qualitative factor so that these principles should be evaluated deterministically. Checklist or computer code calculation by fixed input for boundary and initial conditions is used to check the appropriateness of these principles.

In this paper, we review the overall framework of EPRI report to provide the understanding of the key concepts of using risk insight. In addition to the perspectives suggested in the report, we discuss the perspective on the construction of Korean specific framework for Integrated RIDM

2. Review of overall Framework

In this section, entire review of the proposed framework of the IRIDM is provided focusing on the use of risk insight. Overall framework for IRIDM using risk insight, assessment impact on main principles, and information presentation are the major part of the methodology. Each part is separately described in the following sub sections

2.1 IRIDM Principles

U.S. NRC issued R.G.1.174 [2] as the basic guideline for risk-informed application. The five central principles of (1) meeting current regulation, (2) DID, (3) acceptable level of risk, (4) SM, and (5) performance monitoring should be expected to be addressed in the decision making process. In the IRIDM methodology of EPRI, they adhere to use same principles as the basis of the IRIDM process because the combination of such principles represent the state of the art of the philosophy for nuclear safety in the world. It was mentioned that IAEA and OECD/NEA are also use similar principles in their framework for IRIDM.

2.2 Overall Framework for IRIDM using Risk Insights

Based on the five principles, EPRI report proposed the decision making process using risk insight as shown in Figure. 1

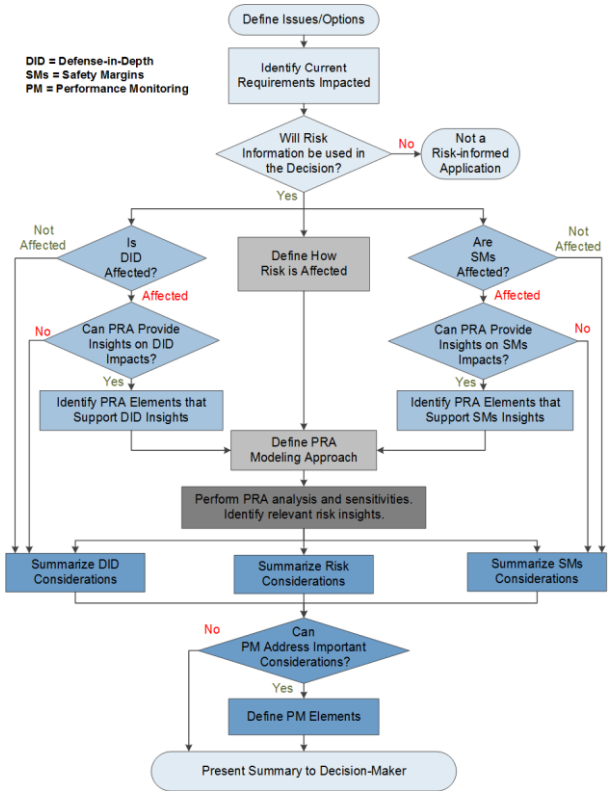

Fig. 1. Process for supporting IRIDM (EPRI [1]).

The issue in the first upper block is defined as a kind of problem, which is detected or analyzed to be vulnerable in current nuclear power plant (NPP). Also, option is mainly defined as the utility's proposal to regulatory body to enhance safety or economics in their NPPs. Although the process in Figure. 1 is consisted of the blocks of once-through type, it is mentioned that the process is basically iterative because the option or issue can be changeable during the progress of process.

2.3 Impact Assessment for Qualitative Principles

For the assessment of impact for the proposed issue or option, qualitative principles such as DID and SM is assumed to be balanced in any NPP before adapting the issue or option.

The definition of DID by NRC is described as “an element of the NRC’s Safety Philosophy that employs successive compensatory measures to prevent accidents or mitigate damage if a malfunction, accident, or naturally caused event occurs at a nuclear facility” [3] . Traditionally, the integrity of DID in a NPP is test by considering the impact on integrity of the following barriers.

- Fuel cladding
- Primary coolant boundary
- Containment
- Emergency planning

When there is any change of the barriers in term of following characteristic, it is believed that the DID is affected.

- Change in the failure probability in the barrier
- Change in the hazard group to make the barrier be vulnerable
- Change in the independence of the barrier
- Change in the existing dependency among barriers

The evaluation using high level characteristic mention may not easy to systematically identify all possible impact on DID. The EPRI report propose the method of identification of DID impact using PSA insight. The key idea is to search for the system or function, which is used to protect the barrier integrity. The above 4 characteristics of barriers is replaced with the following question

- Is there a change to the relative significance of initiating events?
- Is there a change to the mitigating capability for prevention of core damage?
- Are there changes that could affect the reliability of human performance?
- Is there any change in containment performance (Level 2) and Radiological Consequences (Level 3)?

From the risk profile for any issue resolution or option proposal, if one find the above question is yes, there is change in DID. For the changed DID, risk profile can also provide the significance of the impact on DID by calculation risk measure for the DID change.

For the characterization of SM change, EPRI report suggest that the issue or option can be separated with the cases in which the PSA can make different roles. The report assumed there are three different cases of issues or options as follows;

- PSA can directly address the SM
- The PRA can provide insights on SM
- The PRA is not directly helpful

As for the case 1, the change of seismic fragilities is exampled because this case is directly reflected in the seismic PSA model. As an example of case 2, the change of seismic hazard curve was mentioned with the case 3 for fuel design change.

To investigate the impact on SM, SM should be defined correctly. Figure 2 shows the two margin concept from the operating point to failure point. The report define SM as the difference from the failure point to safety limit. The safety limit is defined as the point by which regulatory body design or operation of NPP would be ultimately limited considering sufficient margin from real failure point.

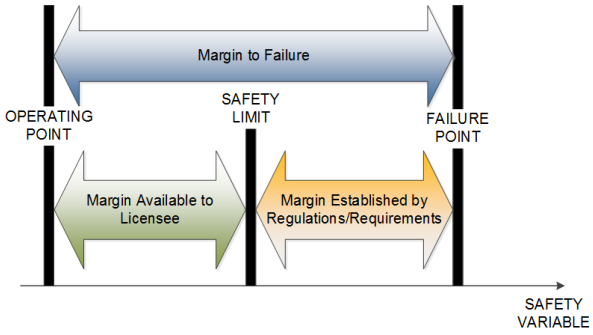

Fig. 2. SM and the safety limit (EPRI [1]).

It was discussed that there may be two cases of SM change. One is the change of safety limit and the other is the change of failure point. The change of failure point frequently occurs when new finding or analysis for a NPP reveals the performance of SSC is degraded. As for the characterization of SM, the report do not provide whole process instead case studies are exampled to help understanding of SM characterization. As for the significance evaluation of SM change, although not all case can be handled, the risk measure can be used to quantify the significance of SM change by quantifying the change of success criteria in SSC, which results from the change of SM.

3. Perspective on the further development of IRIDM process

EPRI report introduced new approach to handle the IRIDM principle with more risk informed way and quantitatively. However, there are still many ambiguous things in the process. The report suggest the following future activity to complement current works.

- Integration of various guidance contained across multiple application area
- Specific guidance to address DID and SM more specifically
- Risk visualization tools development to enhance the rubric and flowchart which is used to summarize the overall risk information for decision maker

As was mentioned in the report, some IRIDM principles is not easy to characterize quantitatively. Checklist or deterministic code calculation was used to address these principles. The risk-informing of such principles is the essential part of the IRIDM process.

As for the current domestic circumstance of introducing IRIDM , it is believed that the high level philosophy of the domestic IRIDM may be identical with that of EPRI However, the methodology introduced by EPRI report should be refined to be used to real situation. Especially, the structured process should be developed to identify and characterize the DID and SM.

4. Conclusion

Recent EPRI report for IRIDM framework using PSA insight in the characterization of IRIDM principles We mainly focused on the characterization of DID and SM in this paper, which these two principles was considered to be more deterministic rather than probabilistic. The report shows the possibility that these principles can be characterized or their addressment can be influenced by risk insight. Although there is still things to be resolved in this approach, it has possibility to be new paradigm for IRIDM for nuclear safety.

REFERENCES

[1] A Framework for Using Risk Insights in Integrated Risk-Informed Decision-Making, CA: 2019. 3002014783.
[2] U.S. Nuclear Regulatory Commission. An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis. Regulatory Guide 1.174, Revision 3, Washington, DC, January 2018 (Adams Accession No. ML17317A256)
[3] U.S. Nuclear Regulatory Commission. Staff Requirements – SECY-98-144 – White Paper on Risk-Informed and Performance-Based Regulation. Washington, DC, March 1, 1999 (Adams Accession No. ML003753601).