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Preliminary Consideration for the Development of Regulatory Level 2 PSA Model

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1. Introduction

In order to assess the validity of PSA (probabilistic safety assessment) results and to establish regulatory requirements for relevant safety issues most of the regulators want to develop an independent and convenient risk assessment model including Level 2 PSA area. As this model and framework should be implicitly independent on the licensee's PSA model, it has a primary objective directly for applying to the risk-informed regulatory affairs and for supporting those kinds of works. According this, the regulator can take an objective view for the uncertainty of risk information made by the licensee and keep up the capability and decision-making framework for overall risk assessment results. In addition, the regulatory model may be used to verify and validate the operational risk levels of all engineered safety features of nuclear power plants (NPPs) [1].

An issue for plant-specific application of safety goals was previously identified in the US NRC's risk-informed regulatory guidance development activities, and discussed in many Commission papers, e. g. SECY-97-287, which identifies the goal for large early release frequency (LERF). LERF defines a containment performance criteria derived from the quantitative health objectives. As we know, the LERF was chosen to assess risk significance in Regulatory Guide 1.174 (2002) again, which provides one measure of the performance of the containment barrier, and represents a surrogate for early health effects.

2. Development of LERF Model based on Level 2 PSA

The Level 2 PSA provides an overview of the spectrum of possible core damage accidents that could occur and insights into the important phenomena that could lead to containment failure and the release of radioactivity to the environment.

The acceptability of the methodology on Level 2 PSA since the early studies in the 1980s is due largely to the significant progress made in the understanding of severe accident and source term phenomenology, and so on. Based on the current consistent framework for the Level 2 PSA, it can give different ranges of output for identifying the principal contributors to the risk. However, it is noted that the major concern in Level 2 PSA may be whether the mitigating systems can provide an adequate level of protection to prevent a large and early release of radioactive material to the environment.

Figure 1 shows the overall flowchart for performing Level 2 PSA and/or LERF evaluation connecting with Level 1 output. As denoted in Figure 1, we can categorize three scopes of methodology for estimating the LERF metric as follows:

(1) Full scope – Level 2 PSA
(2) Semi scope Level 2 PSA except source term analysis (e.g. IPE scope)
(3) Simplified approach using CET (Containment Event Tree) structure

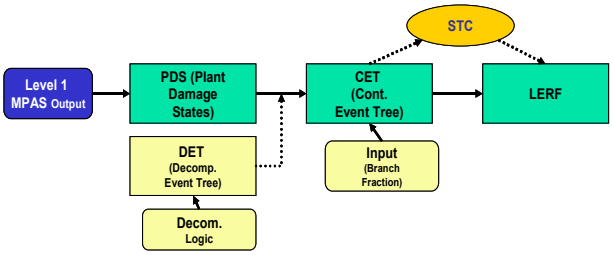

Figure 1. Representation of the overall flowchart for Level 2 PSA and/or LERF evaluation

As the regulatory PSA fundamentals as named *MPAS* [1] for overall CDF and LERF evaluation is being developed and will be a basis for the risk-informed regulation, the LERF evaluation model can be also applied as a basic decision-making rationale in terms of assessment for events/incidents' significance and for issue resolution. Furthermore, the model must give the capability to evaluate all kinds of licensee's actions for operation and maintenance in relation to the containment feature which needs to meet the safety goals for NPPs.

3. Insights on the Standard Requirements and Acceptance Criteria related to LERF metric

3.1. Regulatory Requirements based on the ASME PSA Standard

The PSA standard proposed by ASME/NRC in 2002 [2] has a major objective for reviewing all kinds of information relating with PSA quality and for supporting risk-informed decisions for commercial NPPs. The

standard also prescribes a method for applying the requirements set forth for specific applications.

In current version of the ASME PSA Standard [2], there are four (grouped) high level requirements (except for those of documentation) for accepting the PSA quality as follows:

(1) Core damage sequences shall be grouped into plant damage states based on their attributes.
(2) The evaluations shall include overall analysis of the credible phenomena, containment system performance, and containment structural capability.
(3) The LERF of different containment failure modes shall be quantified.
(4) The LERF shall be quantified in a manner that captures factors important to risk and supports an understanding of the sources of uncertainty.

In interpreting the above, the supporting requirements of the items (2) and (4) are quite difficult to meet, especially if anyone want to estimate the LERF by the simplified methodology No.(3) as described in Section 2.

3.2. Acceptance Criteria for the Risk-informed Decisions

The proposed risk-acceptance guidelines presented in the reference [3] were based on the baseline value of the risk metric which was also same for LERF. Figure 2 shows three areas established in the two planes generated by a measure of the baseline risk metric and the change of the metric, i.e. LERF. It is noted that the baseline of 10^{-7} of LERF seems to be a "very small," so up to the 100% change of the metric can be accepted in terms of risk-informed.

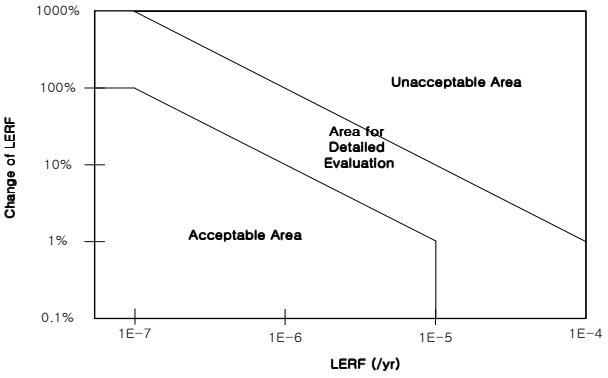

Figure 2. Proposed acceptance guidelines for regulatory decision making in terms of LERF evaluation [3]

4. Pending Issues from the Consideration of CET

The proposed CET [4] in this study for regulatory PSA model is shown in Figure 3, which considers many important attributes on some operator actions, pressure/temperature-induced SGTR phenomena, primary pressure conditions, etc. The pending issues for developing LERF model are, therefore, directly related to these attributes. The other considerable points for developing and quantifying CET model exist in the practical way going close to the intents of standard requirements which relate the items (2) and (4) as provided in Section 3.1.

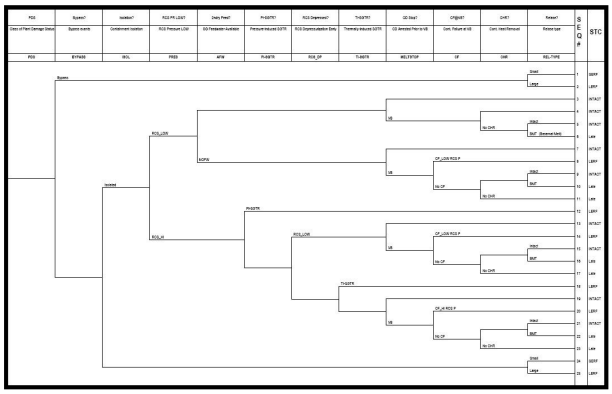

Figure 3. Proposed CET in this study

5. Summary and Further Works

The state-of-the art for estimating LERF was considered for the regulatory risk-informed decisions. The consideration was mainly focused on (1) the relationship between Level 2 PSA and LERF evaluation methodology, (2) the standard requirements in terms of modeling preparation and the acceptance criteria, and (3) some pending issues for developing a simplified LERF model.

This study is preliminarily presented and will be updated for establishing detailed evaluation model and preparing the technical basis.

REFERENCES

[1] C. J. Lee, et al., Development of Multipurpose Regulatory PSA Model, KNS Fall Meeting, 2004.

[2] Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications, ASME RA-S-2002, 2002.

[3] C. J. Lee, et al., Development of Regulatory Technology for Establishing Safety Goals and Acceptance Criteria of Risk-informed Applications, KINS/RR-117, March 2002.

[4] C. J. Lee, et al., State of the Art on LERF Assessment Methodology, KINS/RR-377, Jan. 2006.