A study on Screening Method for Developing External Hazard PSA Models

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1. Introduction

KHNP has carried out the LPSD project from January 2013 through December 2015 as a post Fukushima action. It has recently completed upgrading and developing PSA models for the operating NPPs in Korea [1]. During the project, several requirements of ASME PRA Standard were considered to meet the needs for standardization. PSA recently became a part of a PSR and the accident management plan has recently been included in nuclear safety Act for both existing and constructing nuclear power plants. Therefore, the scope of performance has continuously been extended. As a result, we must consider many inintiating events(IEs) for external hazards such as tsunami, typoon, Loss Of Ultimate Heat Sink(LOUHS) and so on. There are many difficulties to assess reliable risks using PSA models because of the technical limitations in current status. Due to the limitation of resources and absense of well developed methodologies for certain external events, we should establish a screening method for those external events.

2. International Status for Screening External IEs

2.1. General methods

In general, to select hazards scenarios with no correlation between hazards, limited to one NPP and all reactor states, we usually follows steps as follows[2];

1) Develop an exhaustive as far as possible list of internal / external hazards which can challenge some NPP safety functions and lead to hazards scenarios
2) Perform plant response analysis and grouping of hazards scenarios that have a similar impact on the NPP for each plant operating state,
3) Estimate occurrence frequency of the grouped hazards scenarios
4) Perform bounding probabilistic analysis in order to select the hazards scenarios to be considered in detail each hazard PSA
5) A list of hazards scenarios can be justified for each hazard PSA

2.2. International Atomic Energy Agency (IAEA)

The approach for identifying IEs and hazards as endorsed by the IAEA is described in the IAEA safety requirements such as SSR2/1, SSG-2 and SSG-3. These guidelines say that hazards are included in the identification process for initiating events by their adverse effects. SSR-2/1 describes that all foreseeable internal and external hazards, including the potential for human induced events directly or indirectly to affect the safety of nuclear power plants, shall be evaluated. Hazards shall be considered for the determination of the postulated initiating events and generated loading for use in the design of relevant items important to safety for the plant.

Table 1. Possible Subdivision of Postulating Initiating Events [3]

Occurrence (1/reactor year)	Characteristics	Plant state	Terminology	Acceptance criteria
10^{-2}–1 (expected over the lifetime of the plant)	Expected	Anticipated operational occurrences	Anticipated transients, transients, frequent faults, incidents of moderate frequency, upset conditions, abnormal conditions	No additional fuel damage
10^{-4}–10^{-2} (chance greater than 1% over the lifetime of the plant)	Possible	Design basis accidents	Infrequent incidents, infrequent faults, limiting faults, emergency conditions	No radiological impact at all, or no radiological impact outside the exclusion area
10^{-6}–10^{-4} (chance less than 1% over the lifetime of the plant)	Unlikely	Beyond design basis accidents	Faulted conditions	Radiological consequences outside the exclusion area within limits
$<10^{-6}$ (very unlikely to occur)	Remote	Severe accidents	Faulted conditions	Emergency response needed

2.3. U.S. Practice

In the USA, screening requirement is described in Part 4 of the ASME/ANS Standard. All potential external events that may affect the site must be identified and a screening process follows based on screening criteria. Guidance was given for conducting external events analysis regarding the IPEEE program. In section 5 of NUREG-1407, “Procedural and submittal Guidance for the Individual Plant Examination of External Event for Severe Accident Vulnerabilities”, one or more following steps should be performed.

1) Determine if the hazard frequency of the original design is acceptably low (i.e., less than 1E-5 per year)
2) If the event cannot be screened out based on the hazard frequency, perform a bounding analysis to show that CDF contribution of the hazard would not exceed 1E-6/year
3) Conduct PSA modeling

2.4. European Practice

All European countries list hazards such as earthquake, floods, lighting and man-made hazards like airplane crashes, transportation accidents, explosions. Some countries consider special additional hazards like volcanisms, heavy load drops and tornados. Their hazard lists refer to different documents issued by IAEA, ASME, WENRA or others. Even though they

consider external hazard models, it doesn't mean that they have specific guidelines for a screening process.

3. A proposal for External Hazard Screening in Korea

KHNP has applied NUREG-1407 methodology to screen out external hazard initiating events which have very low frequency of occurrence since PSA models were developed to achieve the operating licenses (OLs) for new plants in late 1990's. However, the regulatory environment in Korea was currently changed and a methodology for multi-unit risk assessment for planed NPPs has been required, which means that external hazard screening criteria should be re-established to identify and integrate the risks caused by single unit initiating events and multi-unit initiating events.

The screening process is generally performed in two phases such as qualitative and quantitative methods.

If the external hazard has the potential to result catastrophic levels of destruction on the plant and regional scale offsite consequences, those scenarios cannot be screened out from the PSA modeling. Such scenario should be subject to the need for practical elimination [4]. The quantitative screening criteria must be established by considering the progress of accident scenarios. If the event is very slow in development and fully efficient protection can be put in place on the NPP, we can screen out that event.

For the next step, if NPPs have safety systems to mitigate accidents induced by external events, we can use the quantitative screening criteria suggested by NUREG-1407(i.e., initiating event frequency is less than 1E-07 per year). In case of some accident scenarios which can directly proceed to core damage, it seems to be needed to apply to the bounding approach even if frequencies of considered IEs are less than 1E-07 which means that CDF contribution of the hazard would not exceed 1E-08/year. In addition, we have to consider multi-unit IEs as requested from the regulatory authority. However, it is difficult to establish the criteria for multi-unit accidents because we must consider correlation factors between units at the same site and there are no clear and comprehensive methods to address that. In such cases, we think that it is important to preferentially evaluate the validity of multi-unit PSA rather than hastily establish screening criteria such as using the same criteria for a single unit.

4. Conclusions

In this paper, we summarized international status of a screening process for external hazards and proposed a concept of qualitative and quantitative screening processes with simple descriptions. In Korea, PSA should be included in accident management plan in accordance with national laws which have been enacted recently. Therefore, a single-unit based screening method must first be established to satisfy the safety goal specified in accident management plan. In the long term, an optimized method for screening potential events which can challenge multi-unit sites should be developed. These activities are to improve the safety of NPPs. It will ultimately contribute to corresponding with the public concern raised by the Fukushima accident.

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