

Applying Mobile Equipments Usage to PRA Models

Jung Min Kim*, Dong Hwan Jung, Hak Kyu Lim

KEPCO International Nuclear Graduate School, Nuclear Power Plant Dep., 658-91 Haemaji-ro,
Seosaeng-myeon, Ulju-gun, Ulsan, Rep. of Korea

*Corresponding author: ssesse78@gmail.com

1. Introduction

Many nuclear power plants are introducing mobile equipment utilization strategies to cope with severe accidents. Nuclear power plants also conduct Probabilistic Risk Assessments (PRA) to analyze events that could cause core damage. PRA methods quantitatively provide the risk of nuclear power plants in the event of an accident beyond the design basis. Several challenges have been found to apply the newly introduced mobile equipments to PRA, and efforts have continued to address them.

2. Modeling Method and Challenges

2.1 Modeling Method

In most cases, the method of modeling mobile equipments in the PRA is similar to the modeling of existing installed equipment [1]. The PRA modeling process is constructed by the PRA technical elements from the internal event portion of the ASME/ANS PRA standard [2][3].

- Initiating Event Analysis (IE) : Initiating Events are events that may lead to core damage.
- Accident Sequence Analysis (AS) : Accident sequences are graphically modeled in the event tree of the PRA model.
- Success Criteria (SC) : The success reference element is developed to define plant-specific success and failure measurements that support other technical elements of the PRA.
- Systems Analysis (SY) : A fault tree is developed through system analysis to model a combination of failures that result in the loss of the modeled function.
- Human Reliability Analysis (HR) : HRA's objective is to ensure that both pre-initial and post-initial event activities reflect the impact of personnel actions on the risk assessment.
- Data Analysis (DA) : Data analysis is the process of determining the probability of failure for the primary event in the PRA model.
- Quantification (QU) : Quantification is the process of solving the PRA model, analyzing the results, and ensuring that the results are reasonable.
- LERF Analysis (LE) : The LERF analysis is to identify and quantify contributors to large early releases based on plant-specific core damage scenarios.

2.2 HRA-related challenges

The HRA methodology is a challenging task because it is not designed to address many of the human behaviors needed for mobile equipment

utilization strategies [1][4].

- Lack of execution task failure data
- Defining and determining the time of a cue for actions initiated based on crew availability.
- Realistically modeling an execution failure with a large number of execution steps.
- Assessing the initiation of a procedure or task with an entry cue that is based on judgment.
- Lack of quality timing data can weaken both feasibility analysis and quantification.

2.2 DA-related challenges

Sufficient industrial data have not been collected to estimate the failure rate for mobile equipment in use by nuclear power plants. The method in the EPRI 3002003151 report can be used to assess the failure rate of mobile equipment in nuclear power plants by comparing the failure rate of permanently installed nuclear power plant equipment with the failure rate of military equipment [3]. However, there may be significant differences in how mobile equipment is used and maintained in military and nuclear industry.

3. Conclusions

The nuclear industry is continuing its efforts to incorporate mobile equipment utilization strategies into the PRA model. Regarding Data Analysis, the failure rate of fixed equipment with similar functions and usability may be weighted and used as the failure rate of mobile equipment [3]. Regarding HRA, additional data may be utilized to extend existing HRA methods, or engineering judgement may be used to select appropriate substitute values [4].

The application of the above method requires reasonable engineering judgment and a common consensus among expert groups. However, it should be noted that these applications should not deviate from the fundamental methodology of PRA. For example, it is necessary to ensure that

- Procedures for mobile equipment are prepared to prevent human error
- The on-site drill or training plans are properly established
- Assistive lighting or communication measures are properly prepared

To give credit to mobile equipment operation in the PRA, this paper will discuss the necessary conditions for reasonable human error probabilities based on HRA for operator actions in EOP and SAMG in existing PRAs.

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