Current human reliability analysis issues in domestic nuclear power plants[1]

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1. Introduction

Probabilistic safety assessments (PSA) have been used for several decades to visualize the risk level of commercial nuclear power plants (NPPs), which incorporate the consideration of human error probabilities (HEPs) with the failure frequencies of safety critical components [1]. This implies that the precise estimation of both mechanical failure frequencies and human error probabilities (HEPs) is essential for ensuring PSA quality. Therefore, considerable efforts have been made worldwide to estimate HEPs as precisely as possible, by applying various human reliability analysis (HRA) techniques.

However, such a large number of different HRA methods indicates that the calculation of an HEP is very sensitive to its context or purpose. Accordingly, it is necessary to identify key limitations that hamper HRA practitioners to properly model or incorporate actual contexts in which human operators have to accomplish required tasks [2].

For this reason, this study proposes a catalog of HRA issues in domestic Korean NPPs based on a survey of 14 subject matter experts (SMEs) from six different organizations who have worked as HRA method developers, practitioners, and regulators.

2. Methodology

The first step of the survey was to collect a group of SMEs with sufficient knowledge or experience with respect to the HRA of domestic NPPs. In this light, a total of 14 SMEs were invited from six distinctive affiliations, including a research institute, regulatory body, utility and its contractors. Fig. 1 depicts the overall process of this study to identify a catalog of significant HRA issues.

The SMEs suggested a total of 39 remaining and emerging HRA issues; many focused on similar contents though, so they were regrouped into 19 common issues belonging to six categories: (1) a technical basis for the K-HRA (Korean HRA) method, (2) an HRA method for dealing with diverse external events, such as earthquakes or flooding, (3) an HRA method applicable to a digital main control room (MCR) environment, (4) an HRA method for supporting both the modeling of multi-barrier accident copying strategy (MACST) and Level 2 PSA, (5) an HRA method for supporting multi-unit PSA, and (6) HRA cross-cutting issues.

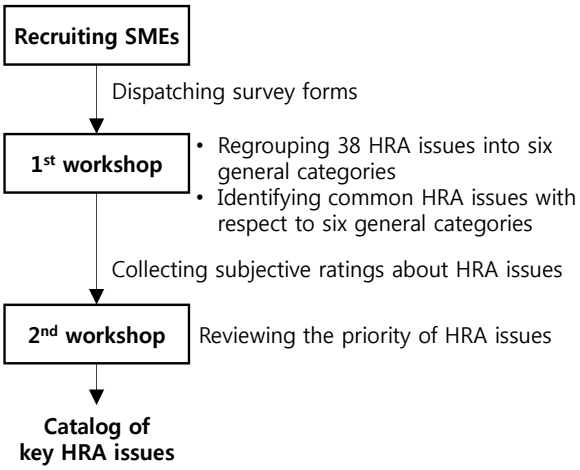

Figure 1. Overall process to identify significant HRA issues

After that, the SMEs rated the *Urgency* and *Importance* of each common issue and as a result, five significant HRA issues were identified that should be resolved to enhance HRA quality. Table 1 summarizes the criteria of the subjective ratings with the associated scales used in this survey.

Table 1. Subjective rating criteria used in this survey

Criterion	Scale	Meaning
Urgency	High	Short-term issue
	Medium	Mid-term issue
	Low	Long-term issue
Importance	High	Directly related to safety or operational licence issues
	Medium	Indirectly related to safety or operational license issues
	Low	Irrelevant to either safety or operational licence issues

Based on these subjective rating criteria, the priority of each refined issue was characterized by assigning specific numbers to the *Urgency* and *Importance* scale: 3, 2, and 1 for *High*, *Medium*, and *Low*, respectively. All refined issues were then ranked by aggregating the averaged *Urgency* and *Importance* scores.

[1] This paper is the summary of a paper *Remaining and emerging issues pertaining to the human reliability analysis of domestic nuclear plants*, which is submitted to Nuclear Engineering and Technology.

3. Significant HRA issues

Five significant HRA issues that were picked out from the subjective rating of SMEs were; (1) providing a technical basis of the K-HRA method, (2) developing an HRA method for diverse external events, (3) developing an HRA method for a digital environment, (4) developing an HRA method for mobile equipment, and (5) developing an HRA method for tasks included in severe accident management guidelines. Besides, although the necessity of a multi-unit related HRA method was not selected as a significant HRA issue, its importance is increasing because such modeling is crucial not only in multi-unit PSA model development but also for evaluating the safety performance goals. For this reason, developing an HRA method to support multi-unit PSA is selected as the sixth significant HRA issue.

4. Discussion and conclusion

From the point of view of enhancing NPP safety, one of the prerequisites is to precisely identify potential causes that may result in undesired consequences. In this regard, PSA results are valuable because they allow us to systematically investigate a large number of likely paths leading to undesired consequences. This means that the quality of HRA results is essential for accurately assessing the safety of NPPs based on PSA. To this end, the first step is to distinguish the specific HRA issues to be resolved for improving HRA quality.

This study prioritized such HRA issues through 14 SMEs who have sufficient experience with the HRAs of domestic Korean NPPs. As a result, six significant HRA issues were picked out. It is true that the underlying idea of this study is a lack of theoretical basis in aggregating the subjective opinions from SMEs because the two cut-off values (2.7 and 5.5) were chosen based on their consensus. However, the result of this study is still insightful because of the wide spectrum of SMEs that participated in the collection of HRA issues. In other words, although the catalog of significant HRA issues identified in this study is a preliminary version, the implication of this catalog is quite positive because it is the first tangible outcome representing the consensus of domestic HRA practitioners. Accordingly, the catalog of significant HRA issues would be a good starting point to enhance the safety of NPPs by improving PSA and HRA quality.

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REFERENCES

[1] U.S Nuclear Regulatory Commission (NRC). An approach for determining the technical adequacy of probabilistic risk assessment results for risk-informed activities, Regulatory Guide 1.200, Part 3.

[2] Chang, Y. J., Xing, J., and Peters, S. Human reliability analysis method development in the U.S Nuclear Regulatory Commission, 13th International Conference on Probabilistic Safety Assessment and Management (PSAM 13), October 2-7, Seoul, Republic of Korea, 2016.