Task Analysis for Human Reliability Analysis about Use of Portable Equipment

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1. Introduction

Since the Fukushima nuclear power plant (NPP) accident, mobile or portable equipment have been adopted to increase the defense-in-depth in beyond-design-basis-scenarios. In the United States, diverse, flexible coping strategies called FLEX implemented formal strategies using a combination of installed equipment, portable on-site equipment, and/or off-site equipment that would give operations the requisite flexibility [1]. Korean NPPs are also developing a similar strategy called the Multi-barrier Accident Coping Strategy (MACST) to address extended loss of AC power (ELAP) and loss of the ultimate heat sink (LUHS) [2].

As these strategies are expected to improve the safety of NPPs, Probabilistic Safety Assessment (PSA) should consider and evaluate the benefit from them in terms of the safety. Especially, Human Reliability Analysis (HRA) would be highlighted because the use of portable equipment largely relies on human actions by the plant personnel.

However, HRA methods for the use of portable equipment are not well established up to date. A few organizations and researchers have suggested HRA methods or guidance. Korea Atomic Energy Research Institute (KAERI) suggested a guideline for HRA of portable equipment by using K-HRA method [3]. EPRI [4] and NEI [5] also suggested guidance and examples of HRA for the use of portable equipment using Cause-Based Decision Tree (CBDT) and Technique for Human Error Rate Prediction (THERP) methods. However, a consensus is needed about how HRAs analyze the tasks related to portable equipment.

This study suggests a task decomposition for the HRA of portable equipment. First, this study reviews the approaches suggested by KAERI, EPRI, and NEI. Then, a task decomposition for the use of portable equipment will be proposed by considering the Korean practice. In addition, potential variations caused from plant- and scenario-specific characteristics are also discussed.

2. Review of HRA Methods for Portable Equipment

2.1 EPRI Approach

The EPRI report [4] provides example definitions and guidance on performing HRA for portable equipment using existing methods to produce HEPs. The guidance is in the form of evaluation of a set of examples, with discussion of likely variations and how they might be handled by existing HRA methods. The report basically applies the EPRI HRA methodology that combines CBDT and THEPR methods. In addition, surrogate methods are suggested by using supplementary data and applying the most similar data. It also combines other HRA methods for the actions not covered by the EPRI HRA methodology.

2.2 NEI Approach

The NEI document [5] provides guidance on the treatment of plant mitigating strategies in risk-informed decision making. These mitigating strategies employ plant responses which utilize portable equipment to restore or maintain various safety functions during beyond design basis conditions and the loss of permanently installed plant equipment. This report also provides an example of HRA on the use of portable equipment by using the EPRI HRA methodology.

2.3 KAERI Approach

In [3], KAERI defines basic task activities associated with mitigation strategies using portable equipment, and also provides a practical method to assess human error probabilities (HEPs) for each of basic task activities. It suggested a K-HRA/P (portable) modified from the existing K-HRA method. The report also provides an HRA guideline for external events with some additional factors to be considered for external events.

3. Task Analysis for the Use of Portable Equipment

This section suggested a task decomposition related to the use of portable equipment by the review in Section 2 as well as the consideration of Korean practices.

3.1 Task Decomposition for the Portable Equipment

The task for the portable equipment can be decomposed into four sub-tasks as shown in Fig. 1. In the "Decision making to deploy the portable equipment," main control room (MCR) operators or technical support center (TSC) decide to deploy portable equipment, based on emergency operating procedures (EOPs), MACST operating guideline (MOG), or severe accident management guideline (SAMG). Declaration of ELAP in the EOP may directly indicate the application of a specific equipment. In this case, HRA can be performed for the declaration of ELAP instead of the decision making to deploy.

However, if the decision making is far from the declaration of ELAP in terms of time and procedure, an analysis is needed separately for the decision making. Because any execution is not generally involved in this sub-task, only the diagnosis error can be considered.

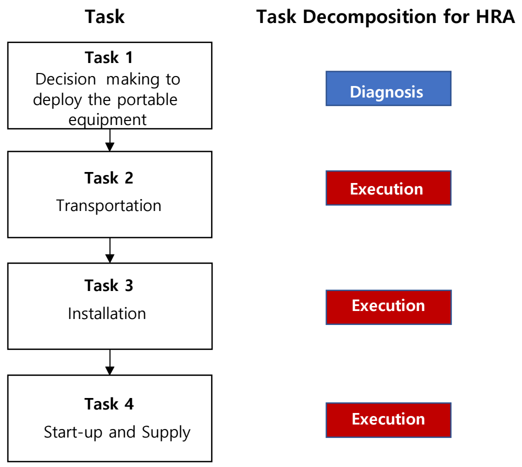

Fig. 1. Task analysis for the HRA of portable equipment

"Transportation" includes moving portable equipment from the storage to the staged place, moving necessary supporting vehicle or equipment like the lift or truck to carry cables or hoses. This sub-task is performed by KEPCO KPS employees and operational support center (OSC) in Korean NPPs. Although some diagnostic or cognitive actions are required in performing this task, important decision making is not involved. Thus, we may ignore diagnosis errors and consider only execution errors.

"Installation" refers to the task of connecting the portable generator and the connection point with a cable and the task of connecting the hose for the generator fuel supply. If the cable or hose are already installed and fixed in the plant, i.e., pre-staged, this sub-task can be simplified into connecting the equipment to the power plant. It is a task where only execution errors can be considered because there are no important decisions and the main task is physical activity.

"Start-up and supply" is the sub-task for starting the portable equipment and operating breakers or valves to supply electricity. This task is generally performed by MCR or Local operators by following system operating procedures or MOGs. When the use of the portable generator is determined, it is assumed that there are no significant decisions, since the procedure for specifying what to carry out starting and supplying is in place.

3.2 Additional Considerations for the HRA of Portable Equipment

This section discusses some useful insights for the HRA of portable equipment.

1) Applicability of existing HRA methods

In general, it seems that exiting HRA methods (i.e., K-HRA method in the KAERI approach and CBDT+THERP method in the EPRI and NEI approaches) are applicable to the portable equipment. However, some tasks such as transportation and installation are not covered in the existing methods. For the analysis of those tasks, two approaches are used in the methods reviewed. One is to use available, supplementary data. For example, the EPRI method used the accident probability per mile for the transportation error that was derived from the Savannah River Site. The second approach is to apply the most similar actions in the existing methods. For instance, the EPRI method applied local valve selection errors in THERP Table 20-13 for analyzing the error in connecting hose to the plant because those tasks are the most similar in the THERP Table.

2) Environmental factors

The scenarios that credit the portable equipment are generally caused by beyond design basis external events, e.g., earthquake, tsunami, wind and flooding. The external events may impact human performances in the mitigation. It may prevent access to equipment or plant, delay the transportation, or increase human error probabilities.

3) Resource management

There is a possibility that the number of some equipment is not enough for the deployment to all the necessary units at the same time if multiple units are affected by the initiating event. The limitation of human resource should be also considered. The transportation and installation of portable equipment requires many people to work together. Therefore, in case of earthquake or night time, insufficient manpower may delay the use of equipment. HRA should consider the availability of equipment and personnel.

4) Performance Shaping Factor effect

Performance Shaping Factors (PSFs) are used to adjust basic HEPs for reflecting scenario- and plant-specific situations. There are many potential variations relating to the portable equipment. First, since many people from different organizations such as MCR, TSC, OSC, and KEPCO KPS participate in the task, the levels of training and familiarity can be different with the organizations. The level of procedure can be also different with sub-tasks. For instance, the detail or completeness of procedures may be different for the decision making, installation, and start-up. Therefore, the evaluation of PSFs effect needs to be performed for each sub-task.

4. Conclusions

This study reviewed HRA methods for the use of portable equipment. Based on the review and Korean practice, a task decomposition was suggested for the

HRA of portable equipment. In addition, this paper provided some insights about the aspects that HRA should consider.

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