Application of K-HRA Method in International HRA Empirical study

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1. Introduction

In order to better understand the characteristics of the K-HRA[1], the method was subject to evaluation within the framework of the "International HRA Empirical Study[2]." Without knowledge of the crews' performances, K-HRA analysis team performed predictive error analyses under four predefined accident scenarios. This paper gives an overview of the application with major findings of K-HRA from the empirical study.

2. International HRA Empirical Study

The empirical study was initiated to understand the performance, strengths, and weaknesses of HRA methods against empirical data that was collected from the Halden Reactor Project's HAMMLAB simulator[3].

An overview of the study, which consists of four high level tasks, is presented in Fig. 1. These tasks are:

- Task 1: to define the scenarios and of the Human Failure Events (HFEs) to be analyzed.
- Task 2: to analyze the HFEs with HRA methods, which produce the relevant PSFs and error probability with regard to each HFE.
- Task 3: to analyze the crew's performance of the simulator experiments, which produce the empirical or reference data for the comparison.
- Task 4: to compare the predicted outcomes against the empirical data (the observed outcomes).

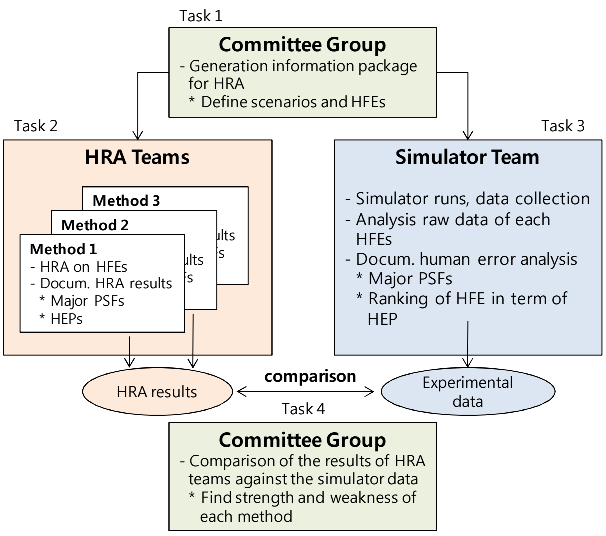

Fig. 1. Overview of the HRA empirical study

Total 12 HRA methods including K-HRA participated in the empirical study. Two scenarios were experimented both with a base case and a complex case. The first scenario was a steam generator tube rupture (SGTR) and the second one a loss of feedwater (LOFW). In the base case of scenarios, no additional difficulties were implemented in the scenario, meaning that they represented a familiar and routinely practiced case for the crews. On the other hand, the complex case included additional failure events and misleading indications of conditions at the plant, making it considerably more difficult for the crews to diagnose the situation.

3. K-HRA Method

K-HRA is a first-generation HRA method, which is a kind of modified method developed by KAERI based on the ASEP HRA and the THERP. In the K-HRA, human error probability (HEP) for a HFE can be quantified by assessing two parts separately, a diagnosis part and an action part. HEP of a diagnosis part is primarily determined by available time for diagnosing a relevant event, and the HEP is modified based on other PSFs. Fig. 2 shows the framework of the K-HRA method. A set of comprehensive performance shaping factors (PSFs), as shown in the box on the right side of Fig. 2, is used in the qualitative and quantitative analysis of the K-HRA method.

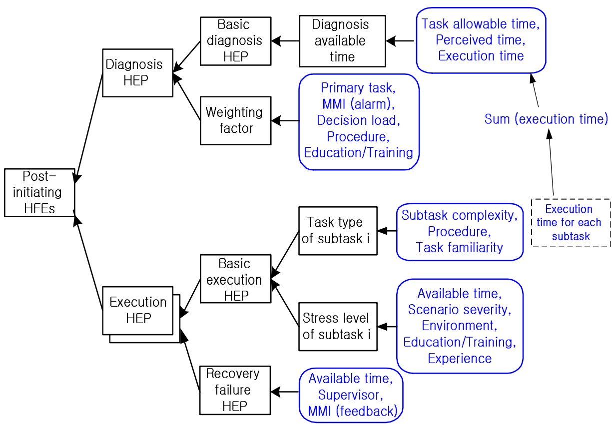

Fig. 2. Framework of the K-HRA method

4. HRA for HFEs under SGTR scenarios

Among several HFEs that were defined for the empirical study, this paper just introduces an HRA application of the HFE on the crew task, "the crew fails to identify which SG is ruptured and isolate it within a time limit under SGTR scenario." The HFEs were designated as HFE-1A and HFE-1B corresponding to the base and the complex case respectively.

The task of the HRA analysis teams was to predict HEP of the operator task defined, e.g., isolation of the ruptured SG, and to qualitatively assess which PSF affect positively or negatively to success or failure of the crew.

4.1 Qualitatively analysis

The qualitative analysis of K-HRA consists of a modeling of the scenario with a timeline analysis and a description of the basic information of each crew task. From the description of the basic information of each HFE, main aspects of the relevant task, e.g., initiating event, scenario, time windows, support from procedures and MMI, practical maneuvers needed in the task and other noteworthy information, are characterized and represented in terms of PSFs. HRA team submitted the result of the qualitative analysis in forms of Table I as requested by committee group, what are the major driving PSFs and what are their influencing power to the HEP. Table I shows a result of the qualitative analysis for HFE-1A.

Table I. Major driving PSFs and their influencing power for HFE-1A

High level structure	Relevant PSFs	Influencing power[1)]
Basic Diagnosis HEP	Available time for diagnosis	High-High (-)
Weighting factors for Diagnosis HEP	MMI (alarm/indicator)	Medium (+)
	Procedure	Neutral
	Experience/Training	High (+)
	Decision load	Neutral
Basic Execution HEP	Sub-action type (complexity)	High (-)
	MMI (switch layout)	Neutral
	Procedure	Neutral
	Task familiarity	Neutral
	Available time	High-High (-)
	Scenario severity	Neutral
	Experience/Training	Medium (+)
	Work Environment	Neutral
Recovery HEP	Available time	High High (-)
	Supervisor	High (+)
	MMI (infor. feedback)	High (+)

[1)] Influencing power of a factor: (-) negative influence, (+) positive influence

For the analysis of HFE-1A, the time available to the crew was judged as being the main driver and limiting factor to success. Time shortage is a critical factor to derive the HFE in both sides of diagnosis and execution part. On the other hand, good MMI in HAMMLAB and high level of Experience/Training will effect a decreasing the HEP with regard to the diagnosis part.

4.2 Quantitative analysis

Quantifying the HEP of HFE-1A was performed by the K-HRA method. Quantifying the HEP in K-HRA is straightforward: a simple set of level assignments is made along potential driving factors for execution and diagnosis to compute the basic HEP. Separate basic HEPs are generated for execution and diagnosis and summed together. The entire quantitative analysis is based on a decision tree but is accomplished in a straightforward spreadsheet, whereby input states generate clear HEP outputs.

Fig. 3 shows the result of quantitative analysis for HFE-1A and HFE-1B. It indicates that K-HRA offered a moderately good prediction in HEP quantification as compared to the results of other HRA methods.

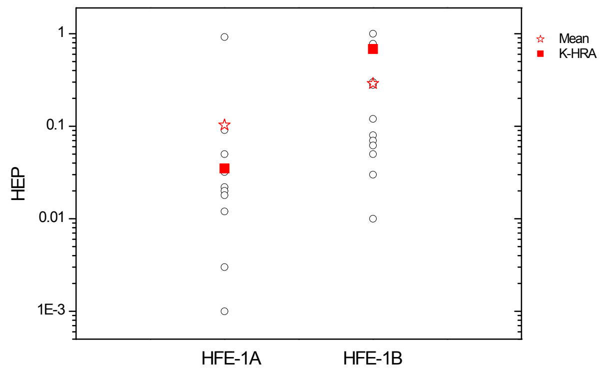

Fig. 3. HEPs of the HFE-1A and HFE-1B

5. Conclusions

This paper summarized an overview of the K-HRA method with major findings from the international HRA empirical study. The empirical comparison gives confidence that the K-HRA method is a feasible and cost effective method to predict relevant PSFs and to estimate HEP [4]. And a few items were identified for further study to improve the K-HRA method. Particularly the method may not control for double-counting of similar effects of a PSF and does not consider the orthogonality of PSFs. Considering the interplay of drivers may further enhance the method's predictive power.

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