Preliminary Assessment of the Post-initiator Human Actions for the LP&S PSA Using the Korean Standard HRA Method

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1. Introduction

The Korean standard human reliability analysis (HRA) method has been developed recently for the full-power [1] and the low-power and shutdown operation [2]. Hence, there is a need to update the previous HRA, which were assessed based on the ASEP method [3], using the newly developed Korean standard HRA method. This study presents the results of a preliminary assessment of the post-accident human actions in low-power & shutdown (LP&S) operation. This paper summarizes the Korean standard HRA method and the results of the preliminary assessment of the LP&S HRA.

2. The Korean Standard HRA Method

In the standard HRA method, the human failure events (HFEs) are classified largely into pre-initiator and post-initiator HFEs. Post-initiator HFEs can be further divided into the part of a diagnosis error and that of an execution error. Figure 1 shows the framework of the standard HRA method for a detailed quantification of the post-initiator HFEs.

A scheme for a detailed quantification of the diagnosis error and the execution error for post-initiating HFEs is provided as below:

- HEP(D) = basic HEP(D) * W (weighting factors),

- HEP(E) = $\sum_{i=1}^{n}$ [basic HEP(E_i) * HEP(R_i)],

where, basic HEP(D)=f(available time for diagnosis), W=f(MMI, education/training, procedure), basic HEP(E_i) =f(task type(i), stress level(i)), HEP(R_i)=f(available time(i), MMI(i), supervisor recovery(i)).

The basic HEP(D) of a diagnosis error is quantified using the THERP diagnosis curve based on the time available [3]. 'W' is a weighting factor (0.054~50) for the PSFs estimated by using the decision tree. The basic HEP(E_i) (0.001~0.25) of an execution error is determined by the subtask type and the stress level. The recovery HEP(R_i) (0.01~1) for an execution error is estimated by using the decision tree.

The developed standard HRA method is also used for the actions during low-power and shutdown operation,

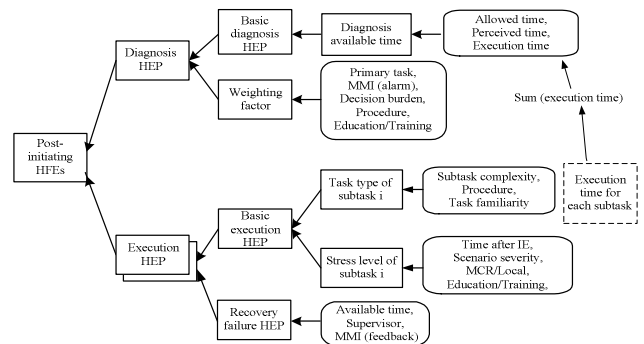excepting the stress level for which the specific conditions of low-power and shutdown state are addressed.

Figure 1. A quantification framework for the post-initiator HFEs

3. Results

A preliminary assessment was performed for the post-initiator HFEs that are modeled in the event sequences of the loss of shutdown cooling event during the LP&S operation. The loss of shutdown cooling event is modeled in the plant operational states such as POS 3, 4A, 4B, 5, 6, 10, 11, 12A, where the shutdown cooling system is in operation. The HFEs that are modeled over these POS's are as follows:

- Operator fails to restore shutdown cooling operation
- Operator fails to perform 2ndary cooling
- Operator fails to makeup RCS
- Operator fails to perform feed and bleed operation
- Operator fails to perform recirculation cooling
- Operator fails to perform gravity feeding operation
- Operator fails to perform feed and steaming operation.

For some example HFEs, the HEP results are given in Table 1, with a comparison with the old HEPs. According to the results, the overall results of the new HEPs are much close to the old HEPs. The main differences in the new HEPs, in comparison with the old HEPs, are the reflection of the plant practices and the opinions of the plant operators. Since this is an initial assessment of the modeled HFEs in the event sequences of the loss of shutdown cooling, the reviews by the plant operating personnel and the independent HRA reviewers should be made.

4. Discussion

This paper summarized the Korean standard HRA method and the results of the preliminary assessment of the LP&S HRA. According to the comparison with the old HEPs, the new HEPs do not show much difference. Further reviews are required to use the HEP results in the PSA model of the reference plant.

REFERENCES

[1] W. Jung, D. Kang, Development of a Standard Method for Human Reliability Analysis of Nuclear Power Plants – Level I PSA Full Power Internal HRA, KAERI/TR-2961/2005.
[2] D. Kang, W. Jung, Development of a Standard Method for Human Reliability Analysis of Nuclear Power Plants – Level I Internal Low Power/Shutdown HRA, KAERI/TR-2962/2005.
[3] A.D. Swain, Accident Sequence Evaluation Program Human Reliability Analysis Procedure, NUREG/CR-4772, 1987.

Table 1. The HEP results for example HFEs

HFEs	Description	Old HEP			New HEP		
		Diag. Err.	Exe. Err	Total	Diag. Err.	Exe. Err	Total
SFR3XRSOP	Operator fails to restore shutdown cooling operation	5.32E-02	7.50E-03	6.07E-02	2.39E-02	2.00E-02	4.39E-02
SFR3XSGOP	Operator fails to perform 2ndary cooling	1.98E-05	1.13E-03	1.15E-03	9.02E-05	1.00E-03	1.09E-03
SFR5XMKOP	Operator fails to makeup RCS	1.98E-05	9.29E-05	1.13E-04	1.10E-04	1.25E-03	1.36E-03
SFR4AFBOP	Operator fails to perform feed and bleed operation	4.95E-03	1.67E-02	2.17E-02	8.48E-03	3.00E-03	1.15E-02
SFR4ARCOP	Operator fails to perform recirculation cooling	N/A	1.21E-03	1.21E-03	5.73E-05	7.50E-04	8.07E-04
SFRAXGFOP	Operator fails to perform gravity feeding operation	3.81E-04	6.50E-05	4.46E-04	2.52E-03	7.50E-04	3.27E-03
SFRAXFSOP	Operator fails to perform feed and steaming operation	3.42E-02	3.84E-02	7.26E-02	1.44E-02	5.00E-03	1.94E-02