# Basic Human Error Probabilities in Advanced MCRs when Using Soft Control

Inseok Jang [a], Seung Jun Lee[b], Poong Hyun Seong [a*], Hyun Gook Kang[a]
[a] *Department of Nuclear and Quantum Engineering, KAIST*
[b] *Integrated Safety Assessment Division, Korea Atomic Energy Research Institute*
*373-1, Guseong-dong, Yuseong-gu, Daejeon, Republic of Korea, 305-701*
[*] Corresponding author: phseong@kaist.ac.kr

## 1. Introduction

In a report on one of the renowned HRA methods, Technique for Human Error Rate Prediction (THERP), it is pointed out that "The paucity of actual data on human performance continues to be a major problem for estimating HEPs and performance times in nuclear power plant (NPP) task" [1].

However, another critical difficulty is that most current HRA databases deal with operation in conventional type of MCRs. With the adoption of new human-system interfaces that are based on computer-based technologies, the operation environment of MCRs in NPPs has changed. The MCRs including these digital and computer technologies, such as large display panels, computerized procedures, soft controls, and so on, are called advanced MCRs [2]. Because of the different interfaces, different Basic Human Error Probabilities (BHEPs) should be considered in human reliability analyses (HRAs) for advanced MCRs.

This study carries out an empirical analysis of human error considering soft controls. The aim of this work is not only to compile a database using the simulator for advanced MCRs but also to compare BHEPs with those of a conventional MCR database.

## 2. Soft control

### *2.1 Definition and general characteristics of soft control*

In NUREG-CR/6635, soft controls are defined as "devices having connections with control and display system" that are mediated by software rather than physical connections [2]. This definition directly reflects the characteristics of advanced MCRs, including that the operator does not need to provide control input through hard-wired, spatially dedicated control devices that have fixed functions. Because of this characteristic, the function of soft control may be variable and context dependent rather than statically defined [2, 3].

General characteristics of soft controls are as follows: multiple locations for access, serial access, present and available, physical decoupling of input and display interfaces, interface management control, multiple modes, software-defined functions, and interface flexibility [2, 3].

### *2.2 Task analysis for soft control*

SHERPA [4] is useful when hierarchical tasks such as human involved tasks and procedures are analyzed. As an example, Fig. 1 shows a task analysis using SHERPA. The goal of the task is to reset the safety injection and auxiliary feedwater actuation signal. In order to achieve the goal, the operator selects "Reactivity system screen" from the operator console and resets the safety injection signal. For reset of the safety injection signal, there are other subtasks: "Press bypass button from the operator console", "Press the acknowledge button", and finally "Press bypass button using the input device for the safety component". Another subtask, "Reset the auxiliary feedwater actuation signal", performed to reset the safety injection signal, is then analyzed.

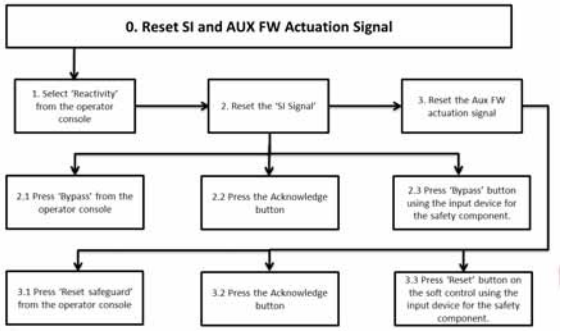


Fig. 1 Task analysis using SHERPA

## 3. Experiment in Simulation Environment

### *3.1 Compact Nuclear Simulator (CNS)*

As the name indicates, this simulator is compact and is not a full scope simulator. The reference plant of this simulator is Kori 3 Nuclear Power Unit in Korea, which is a Westinghouse 3 Loop PWR plant. Te interface of CNS is fully digitalized to make the experimental environment similar to an advanced MCR.

### *3.2 Experiment*

In order to measure human error rate in an emergency situation, experiments with 21 students majoring in nuclear engineering majors are performed under a Steam Generator Tube Rupture (SGTR) accident scenario. The number of human errors is

checked in a prepared checklist created from the task analysis and BHEPs are calculated.

## 4. Results

### *4.1 Basic Human Error Probabilities*

According to the experiment procedure, the number of errors made by subjects was recorded in the prepared checklists. In his study, PSFs were not investigated, because BHEPs according to human error modes should be determined in advance in the HRA process and then PSFs should be applied to the BHEPs for the final modified HEP.

Human errors that occurred were classified using the human error modes defined: E1 (Operation omission), E2 (Wrong object), E3 (Wrong operation), E4 (Mode confusion), E5 (Inadequate operation), and E6 (Delayed operation). BHEPs for each error mode were calculated, as shown in Fig. 2.

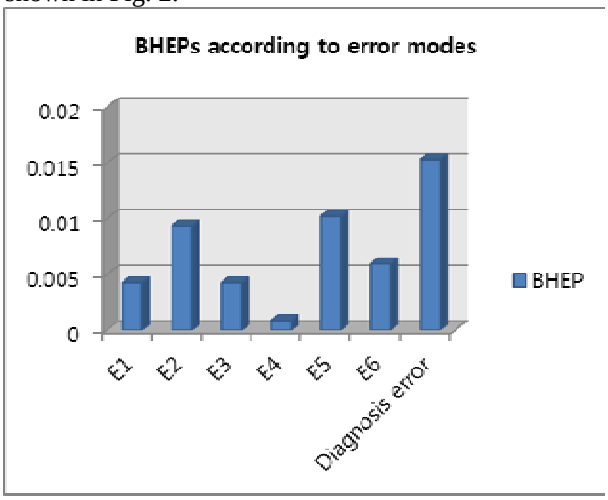


Fig. 2 Basic Human Error Probabilities (BHEPs) according to error modes

The number of human errors and probabilities of human errors according to human error modes are tabulated in Table I.

Table I: Number of human errors and probabilities of human errors according to error modes

| | Number of human errors | Probabilities of human errors |
|---|---|---|
| E1 (Operation omission) | 5 | 0.00425 |
| E2 (Wrong object) | 11 | 0.00935 |
| E3 (Wrong operation) | 5 | 0.00425 |
| E4 (Mode confusion) | 1 | 0.00085 |
| E5 (Inadequate operation) | 12 | 0.01012 |
| E6 (Delayed operation) | 7 | 0.00595 |
| Diagnosis Error | 9 | 0.0153 |

Several BHEPs were compared with established HEP data in the form of THERP tables. In the case of omission error in THERP table 20-7, HEP is 0.01 while the probability of operation omission in this study is 0.00425. This comparison implies that the soft control environment reduces human error regarding operation omission. In the case of selection errors in THERP table 20-13, HEP is either 0.003 or 0.005 while the probability of a wrong object in this study is 0.00935. If the Error Factor (EF) in the THERP table is considered, HEPs in the results of this study and the THERP table were similar.

## 5. Conclusions

This paper investigated Basic Human Error Probabilities (BHEPs) according to human error modes in a soft control operation environment empirically, because there is no BHEP database related to the use of soft control in the HRA method.

The errors made by 21 subjects were then checked on error check lists, classifying human error modes during the accident scenario. Using the results of the error checklists, several statistical and graphical analyses were implemented, such as the number of human errors according to subjects, the number of human errors according to human error modes, and BHEP according to human error modes. Moreover, BHEPs using soft control were compared with various THERP tables to investigate the level of human error reduction when using soft control. These comparisons implied that the soft control environment reduces human error related to operation omission, but there was no significant effect on error regarding wrong operation and wrong object.

## REFERENCES

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