A study for the development of a HRA calculator of nuclear power plants

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1. Introduction

According as the demand of risk-informed regulation and application increase, the quality of a probabilistic safety assessment (PSA) has become more important. As part of enhancing the PSA quality, a study started to standardize the process and the rules of human reliability analysis (HRA) which was known as a major contributor to the uncertainty of PSA. Performing HRA requires a lot of data to keep the quality of results. KAERI is developing the HRA calculator to manage the human failure events (HFEs) and to calculate the diagnosis human error probabilities and execution human error probabilities.

This paper introduces the development process and an overview of a standard HRA method. The study was carried out in three stages; 1) development of the procedures and rules for a standard HRA method, 2) design of database schema, 3) design of graphic user interface of HRA calculator.

2. Standard HRA method

In the standard method, it is assumed that human error probability can be assessed by analyzing diagnosis part and execution part separately. And the method separates human tasks of NPPs into pre-initiating and post-initiating HFEs. Pre-initiating HFEs are the human errors which are occurred in daily routine tasks such as tests, maintenances and calibrations during normal operation. That kind of routine tasks are performed based on procedures and pre-defined task plan, so the role of diagnosis part of human behavior is almost negligible. Therefore diagnosis error does not need to be assessed for the pre-initiating HFEs. On the other hand, human tasks related to post-initiating HFEs need both parts of human behavior, diagnosis and execution. According to the human behavior model, the standard method has two separate analysis processes for pre-initiating and post-initiating HFEs.

Diagnosis human error probability (HEP), HEP(D), can be estimated as follows.

$$HEP(D) = \text{Basic HEP}(D) * M \text{ (weighting factor)}$$

where, Basic HEP(D) = f(diagnosis available time)
M = f(MMI, education/training, procedure)

Basic HEP of diagnosis error can be represented as a function of the available time for task diagnosis. M is a weighting factor on which is fixed by considering some PSFs related diagnosis process, level of man-machine interface (MMI), quality of education / training, level of procedure.

The standard method also presents a framework for analyzing execution HEP. To assess the execution HEP, HRA analyst breaks down the execution part of a task into a sequence of sub-tasks. A set of technical rules to split the execution part is presented in the standard method. Execution HEP can be estimated as follows.

$$HEP(Ei) = \sum [\text{Basic HEP}(Ei) * HEP(R)]$$

where, Basic HEP(Ei) = f(task type(i), stress level(i))
HEP(R) = f(recovery potential (i) by supervisor or worker himself)

The standard HRA method explicitly provides all kinds of rules and decision information needed to do HRA. It covers the dependent analysis of HRA.

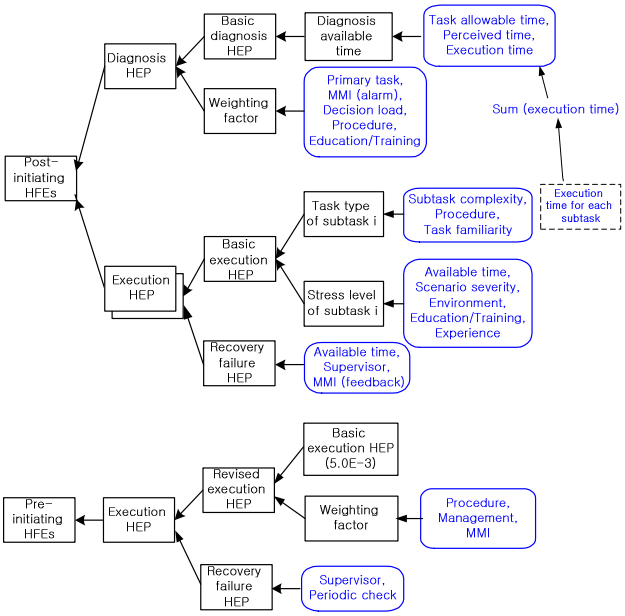

Figure1. Framework of the standard HRA method

3. Design of HRA Calculator

3.1 Database design

We designed four main tables to meet the requirement of HRA calculator system. BASIC HFE table includes basic information such as event, scenario, analysis and review information. Diagnosis HE table includes the information related with diagnosis actions. It consists of task allow time, cue/alarm information and some weighting factors such as MMI, education level, etc.

Execution HE table stores basic execution information and subtasks of execution activities. We classified the following data to build the database schema.

[BASIC Human Failure Event]
- -Event Info (Event name, description, type)
- -Scenario (description, sequence)
- -Task Info (frequency, procedures, etc)
- -Remarks (analyst, analysis date, reviewer, review date)

[Diagnosis Human Error]
- -Task allowable time
- -Cue/Alarm (time, recognition time)
- -weight factor (MMI, decision load, education/training, Procedures)

[Execution Human Error]
- -Basic (education/training, procedures)
- -Subtasks (task name, Equipment, worker, place)
- -Subtask Type (complexity, procedure, task familiarity)
- -Stress level (available time, scenario severity, Environment, Experience, education/training)

Figure2 shows the entity relation diagram of human reliability analysis supporting system. The EventID is the primary key to ensure uniqueness of the records and is used to join with other tables.

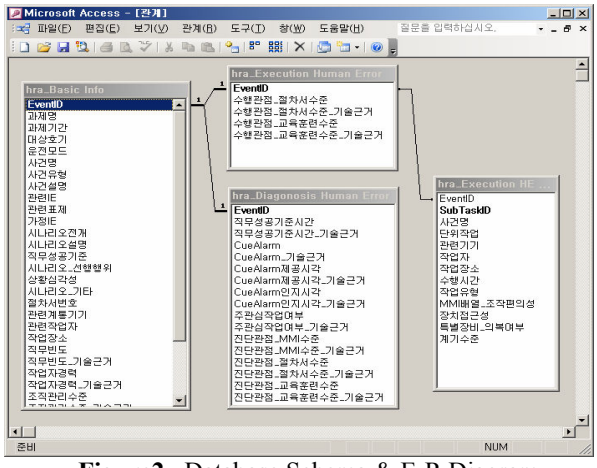

Figure2. Database Schema & E-R Diagram

3.2 User Interface design

We designed the user interface of HRA calculator to input the analysis data and output the results. Figure2 shows the basic GUI design of HRA Input form. We planned to input the HRA data with this form and the diagnosis and execution calculation results are also included in this form.

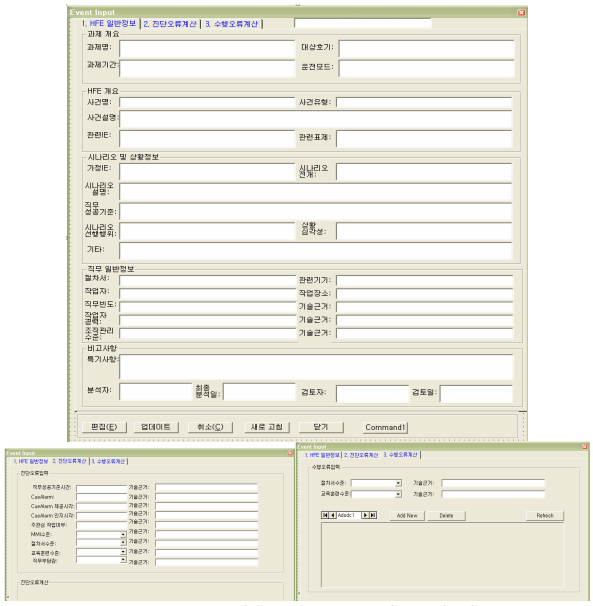

Figure. 3 Graphic User Interface design

4. Conclusion

This paper presents the standard HRA method and the design of database schema and graphic user interface. The standard method focuses on standardizing the process, PSFs and decision rules to minimize the uncertainty caused by HRA analysts. KAERI used the standard method to perform HRA for upgrading the KSNP PSA model. The Implementation of HRA calculator is under developing with visual basic language and Microsoft access database. The HRA calculator will be a good supporting tool to help the analysts to evaluate the human reliability analysis of KSNP PSA model.

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