The m-HRA Method for Identifying and Assessing Test and Maintenance Human Errors Leading to Unplanned Reactor Trips or Transients

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1. Introduction

Test and maintenance human errors during a full-power operation in nuclear power plants have had a significant contribution to unplanned reactor trips or plant transients. Especially four error modes including wrong object, omission, too little, and wrong action have been recurrently occurring over decades for procedure-based human errors. This study developed the test and maintenance human reliability analysis (in short, m-HRA) method for use in error prediction and reduction by analyzing task characteristics and work conditions associated with test and maintenance activities [1]. The m-HRA method consists basically of two procedures, i.e., the qualitative analysis procedure comprising the error mode analysis, the system impacts analysis, and the work context analysis, and the quantitative analysis procedure estimating human error probabilities of identified error modes considering identified task characteristics and work conditions.

2. The Qualitative Part of m-HRA

The qualitative part of m-HRA includes procedures for analyzing human error potential while performing T&M tasks. The overall stage of this part consists of two large steps: the stage that identifies task properties or characteristics for a given task to match the given task to corresponding human error analysis (HEA) procedures, and the second stage analyzes the potential for human error involving identification of human erroneous actions leading to unplanned RTs and checking of the status of major work conditions affecting the likelihood of the erroneous actions.

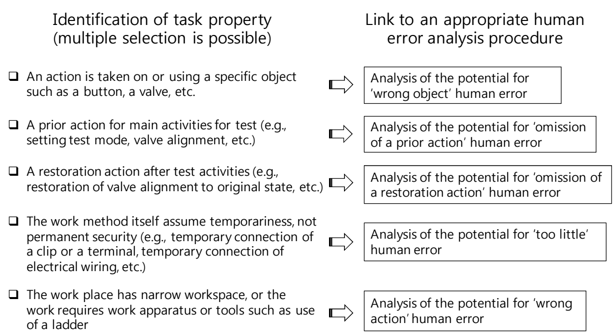

Fig. 1. Link between task properties and human error analysis procedures

Fig. 1 shows the link between task properties by error modes and corresponding human error analysis procedures constituted by error modes.

Each HEA procedure consists of three steps: usually, the first step analyzes the basic error potential for a given error mode, the second step evaluates possible system impacts such as reactor trip or power derate or plant transient for the potential human errors, and the third step checks the status of work context or PSFs affecting the likelihood of the probable human errors. The example HEA procedure for 'wrong object' error mode is given as follows.

- Step 1: Analysis of basic error potential for 'wrong object' selection
  Consider the error potential for 'wrong object' selection when the following items are met.
  - ❑ An object (or objects) with similar appearance with the required one is located at a proximate place => Consider directly neighboring objects as potential objects to be wrongly operated or acted on.
  - ❑ …
- Step 2: Evaluation of system impacts of the identified 'wrong object' errors
  - ❑ Evaluate the possibility of inducing a direct and instant turbine or reactor trip due to a kind of trip signal generation caused from a 'wrong object' selection action.
  - ❑ …
- Step 3: Checking the status of PSFs
  - ❑ Quality of written work procedure or plan, and procedure-utilizing practice
    - ❑ Detailedness and clearness of required actions and components is deficient in the work procedure or plan
    - ❑ Non-adherent following to procedural steps
  - ❑ Familiarity of equipment and work environment
    - ❑ No/deficient experience/training/education (e.g., corrective maintenance for a system/component with no experience before)
  - ❑ …

3. The Quantitative Part of m-HRA

The m-HRA quantitative analysis procedure provides the quantification data including the error probabilities for basic task characteristics and the adjusting factors for reflecting work conditions (or PSFs) for estimating human error probabilities of identified error modes. Various sources of human reliability data have been reviewed, including THERP [2], NUCLARR [3], HEART [4], CREAM [5], K-HRA [6], CORE-DATA [7], NUREG-3309 [8], and Wincek and Maight [9], to check their transferability to the m-HRA framework. Expert judgment data was also used for the m-HRA items for which specific human reliability data are not available. An example of the m-HRA quantification data is shown in Table 1.

Table 1: An example of m-HRA quantification data

Work conditions (PSFs)	Adjusting value	Basis
(1) Quality of written work procedure or plan, and procedure-utilizing practice - Detailedness and clearness of required actions and components is deficient in the work procedure or plan or, - Non-adherent following to procedural steps	3.0[a] 3.0[b]	[a] From HEART, 'An impoverished quality of information conveyed by procedures and person/person interaction') [b] Judged value (judged to be the similar level of influence as the detailedness and clearness of the procedure
(1) Familiarity of equipment and work environment - No/deficient experience/training/education (e.g., corrective maintenance for a system/component with no experience before)	2.0	From CREAM, the adjusting value for training in execution function is adopted
…	…	…

4. Conclusions

The m-HRA method for identifying human erroneous events leading to unplanned reactor trips or transients while performing test and maintenance activities, and for quantifying their probabilities of occurrence, has been introduced. Recently the m-HRA quantification framework was validated against the expert-judged level of human error probabilities for selected 13 human erroneous events. We expect that the m-HRA method can be a useful tool for predicting human erroneous events that might lead to plant transients and reactor trips, and it can also be used for modeling human failure events into the plant trip model or generation risk model.

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