A Human Error Analysis Procedure for Identifying Potential Error Modes and Influencing Factors for Test and Maintenance Activities

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1. Introduction

Periodic or non-periodic test and maintenance (T&M) activities in large, complex systems such as nuclear power plants (NPPs) are essential for sustaining stable and safe operation of the systems. On the other hand, it also has been raised that human erroneous actions that might occur during T&M activities has the possibility of incurring unplanned reactor trips (RTs) or power derate, making safety-related systems unavailable, or making the reliability of components degraded [1,2]. Contribution of human errors during normal and abnormal activities of NPPs to the unplanned RTs is known to be about 20% of the total events [3].

This paper introduces a procedure for predictively analyzing human error potentials when maintenance personnel perform T&M tasks based on a work procedure or their work plan. This procedure helps plant maintenance team prepare for plausible human errors. The procedure to be introduced is focusing on the recurrent error forms (or modes) in execution-based errors such as wrong object, omission, too little, and wrong action.

2. Extraction of Performance Shaping Factors by Error Modes

This section describes the selection process of performance shaping factors (PSFs) affecting the likelihood of human execution-based errors for specific error modes while maintenance personnel perform T&M tasks on the basis of work procedures or their own work plans. The selection of PSFs specific to an error mode is done through the following stages: (1) analysis of human erroneous actions involved in the T&M induced unplanned RTs, (2) review of literature dealing with maintenance-related PSFs, (3) review of human error prevention techniques being utilized in domestic nuclear power plants, and (4) integration of all the resultant PSFs by error modes gained through three stages.

PSF list for the 'wrong action' error is given for instance as follows.

- Narrowness of a work space
- Closeness of critical components (that might induce plant transient or RT when inadvertently contacted)
- Use of work apparatus or tools
- Demand of protective clothing or safety devices
- Lack of familiarity with work environment
- Work control: time of day, work hours (fatigue)
- No/deficient supervision on work activities: no detailed evaluation of the work vulnerability and its effect on the system in advance of work activity, no verification of task performance (or execution)

3. Human Error Analysis Procedure for T&M Tasks

This section introduces a procedure for analyzing human error potential in performing T&M tasks. The overall stage of this procedure consists of two large steps: the first stage identifies task properties or characteristics for a given task, as a simple task analysis, to match the given task to potential 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 PSFs affecting the likelihood of the erroneous actions.

Fig. 1 shows the identified task properties by error modes for linking them with appropriate human error analysis procedures constituted by error modes.

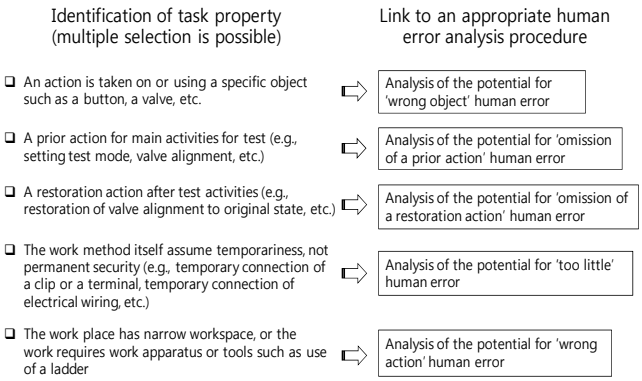

Fig. 1. Link between task properties and HEA procedures

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. Human error potential for the 'wrong action' error mode is analyzed using the following HEA procedure.

- Step 1: Analysis of basic error potential for 'wrong action' errors
  Consider the potential for a 'wrong action' error when it is judged that an inadvertent contact with peripheral devices or components could be possible while conducting T&M activities in a local place. In case specific work apparatus or tools are used in that work space, the extended work area due to the use of those apparatus or tools should be considered.
  - There are other important devices/components within the work area where replacement/installation/withdrawal of a specific device/component is conducted in a narrow work space.
  - Work apparatus such as a ladder or a workbench are used for T&M activities in a local place, where important devices/components are located. It seems that this could make an inadvertent contact more probable.
  - Other situations for inadvertent contacts

- Step 2: Evaluation of system impacts of the identified 'wrong action' errors
  This step evaluates possible impacts on the plant system of the potential 'wrong action' errors identified in Step 1, and then identifies important devices/components that might lead to plant transients or turbine or reactor trips.
  - Evaluate the impact on the system that might be propagated by the corresponding valve close/opening or switch operation due to an inadvertent contact.
  - Other possibilities of the impact on the system

- Step 3: Checking the status of PSFs
  Once the system impacts of the potential 'wrong action' errors are evaluated, then check the status of the following PSFs affecting the likelihood of the identified 'wrong action' errors.
  - Use of work apparatus or tools
  - Narrow work space
  - Demand of protective clothing or safety devices
  - Familiarity of equipment and work environment
    - No/deficient experience/training/education (e.g., corrective maintenance for a system/component with no experience before)
  - Warning mark on the procedure and subject of action verification
    - No warning mark on the corresponding task step
    - No subject of concurrent/independent verification of the corresponding task step
  - Other work control and management factors
    - Work occurs at night or early morning time
    - Work hours exceed the predefined time for regulation
    - No/loose supervision on work progression and no/loose verification on task execution for the personnel both inside or outside the company
    - No/loose adherence of step-by-step progression of the procedure by referring to every step of the written procedure

3. Conclusion

In this paper, the HEA procedures that are able to analyze the potential for T&M human errors leading to unplanned reactor trips or plant transients have been introduced. The four HEA procedures deal with four recurrent error modes that have happened during T&M activities and contributed to the unplanned RTs in Korean NPPs. The proposed HEA procedure can be used to identify potential human error modes leading to potential negative impacts on the plant and analyze contributing factors to the occurrence of potential errors, while performing T&M works in normal operating conditions.

REFERENCES

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