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Task Analysis for the Human Reliability in Decommissioning Activities

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1. Introduction

In recent years, technological developments of redundancy and protection, which have made systems more reliable, has reduced accidents due to technical failures. However, it is impossible to say that the system is reliable without monitoring the failure rate of all system components, especially the impact of one of the components, human errors, on the system. Although valid values are difficult to obtain, estimates agree that errors committed by man are responsible for 60–90% of the accidents [1,2,3]. There are evident events that are caused by human errors in industrial systems, although minor human errors can seriously reduce the operating performances, such as productivity and efficiency. Therefore, human reliability analysis (HRA) is required to reduce the cause of human errors [1].

The purpose of a human reliability analysis is 'to assess the contribution of operator to the system reliability' and, more accurately predict the 'human error rate' and to determine the associated human-machine system to assess the performance degradation of the system and to evaluate other systems and human characteristics that may affect system behavior [4].

2. HRA Methods

According to the review results of the technical documents, human activities are a fundamental factor that weakens the industrial system, so HRA investigates the human factors that the worker has on the industrial activities [1]. HRA is therefore used to identify, model, and quantify the likelihood of human error [2]. Nominal human error probability (HEP) is calculated on the basis of operator's activities. To obtain a quantitative estimate of HEP, many HRA methodologies use performance shaping factors (PSF), because it provides numerical criteria for characterizing important aspects of human error and adjusting the nominal HEP levels. The PSFs are environmental factors, activities that are personal, or have potential to affect performance in a positive/ negative way. The key step in HRA is therefore to identify and quantify the impact PSF [2]. Another key step is to interpret and simulate human behavior, which is a dynamic process driven by cognitive and behavioral rules, and is also influenced by physical and psychological factors. Although human behavior has been analyzed through a number of studies, it is still difficult to describe all the nuances that distinguish it. It is clear from the literature that the complexity of the human behavioral model to satisfy this is because it prefers to numerically represent the error probability to predict and prevent unsafe behavior. For this reason, the research on human reliability must solve a complex problem between psychology, ergonomics, engineering, reliability analysis, and system analysis [3].

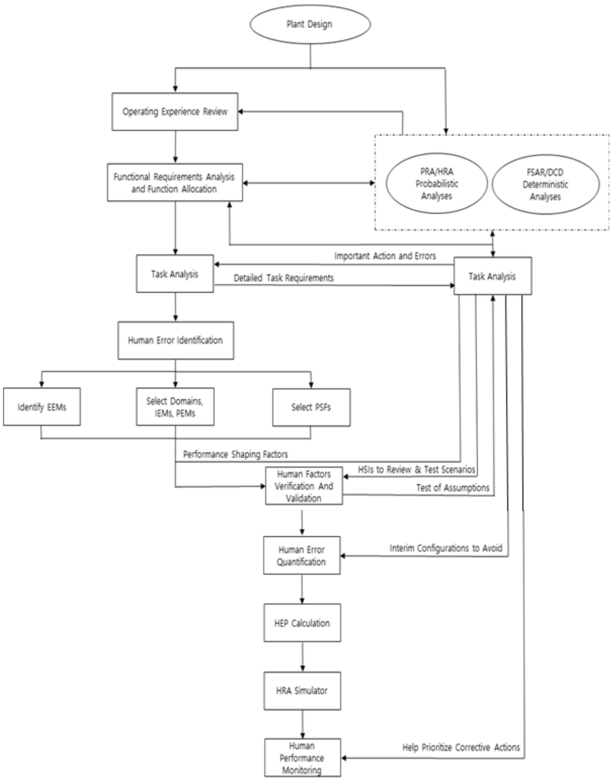

Fig. 1. The role of human actions and procedure in the HRA

3. Task Analysis

Task analysis (TA) is the task of analyzing task objectives, methods, contents and procedures to grasp task characteristics, vulnerabilities and suitability. The scope of task analysis, the content of necessary information, and the method of collecting information vary according to the purpose of task analysis. In addition to detailed information on task, task analysis also provides a variety of information on tasks that are useful for error prediction and prevention. There is considerable redundancy between task analysis and HRA. The HRA method generally uses the results of the TA as a starting point to examine what aspects of the task can contribute to human error. Therefore, the combination of TA and HRA methods will be the most suitable form of analysis.

HTA (Hierarchical Task Analysis) is one of suitable TA method, which is a systematic and detailed task analysis method, and which grasps detailed tasks and conditions and expresses complex task steps in a hierarchy. Based on the results of HTA, PHEA (Predictive Human Error Analysis) is used to identify the error and the probability of occurrence and develop a reduction strategy in the TA. Therefore, analysis is performed in the form of a combination of HTA and PHEA.

A TA is begun with detailed narratives of what personnel have to do, which is sufficiently detailed to define the alarms, information, controls, and task support needed to accomplish the task. The detailed topics to be analyzed in the TA are listed in Table 1.

Table 1. Detailed topics to be performed in TA

Task	Title
Task information	• Working parameters (cutting size, cutting number, precision, etc.) • Output requirements • Feedback needed to indicate adequacy of action taken • Alarms and warnings
Job description	• Activities • Equipment (type, size, constraints….) • Frequency and accuracy of task • physical position (stand, sit, squat etc) • Movement (Lift, push, turn, pull, etc.) • Required force
Working time	• Unit work time considering activities • Additional hours taking into account of working environment
Teamwork and communi-cation	• Coordination needed between the team performing work • Personnel communication for monitoring information or taking control actions
Workload	• Cognitive, Physical • Overlap of task requirements (serial vs. parallel task elements)
Operation Support	• Special and protective clothing • Jon aids, procedures or reference materials needed • Tools and equipment needed
Workplace Factors	• Ingress and egress paths to workplace • Workspace needed to perform the task • Typical environmental conditions (ex, lighting, temperature, noise, etc.) • Breaks taking into account "work environment factors"
Hazards	• Identification of hazards involved such as potential personal injury
Expected Performance Shaping Factors	• Stress • Time pressure (in the critical path activity) • Extreme environmental conditions • Reduced staffing

Based on the Table 1, the TA of the decommissioning activities in nuclear power plants has been performed on the reactor pressure vessel internal (RPVI) cutting process. This segmentation process consists of four main tasks and 13 sub-tasks ranging from control rod guide tube cutting to core barrel cutting.

4. Further Study

Further study will be on an integration of this study with those of other researchers to optimize HRA techniques in the decommissioning activities of nuclear power plants such as extending AHP–SLIM into other HRAs methods to exploit its performance. Additional researches on the HRA methodology is related to PSFs. Currently, there are at least several HRA methodologies using PSFs, but there is no standard set of PSFs used among methodologies in the NPPs. Current PSFs are not defined specifically enough to ensure consistent interpretation of similar PSFs through a variety of methods especially to NPP decommissioning activities. There are very few rules governing the creation, definition, and use of PSF sets.

Within HRA community, there is a widely recognized need for an improved HRA methodology with a more robust scientific basis, in the decommissioning of the nuclear power plants. The methods already developed in these areas are adapting to different situations by expanding their scope.

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