Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, November 2-3, 2006

A Study on Human Factors in Maintenance of a Nuclear Power Plant (NPP)

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1. INTRODUCTION

In human factors research, more attention has been devoted to the operation of a nuclear power plant (NPP) than to their maintenance. However, more NPP incidents are caused by inadequate maintenance rather than by faulty operation [1]. There is a trend in NPP toward introducing digital technology into safety and non-safety systems [2]. This lead to changes of maintenance, and support systems such as diagnosis system, augmentation system and handy terminal [1] will be developed. In this context, it is important to identify tasks of human related to each phase of maintenance and their relation in order to apply those to maintenance. However, there are few researches of human factors in maintenance. This paper studies on framework of cognitive task analysis for developing maintenance support systems.

2. CHARACTERIZATION OF MAINTENANCE

Maintenance is an important part of physical asset management in NPP; the physical assets are the systems, structures, and components (SSCs) [3]. In this section, we will address the terminology about maintenance and relation with each other.

2.1 Maintenance Policy, Strategy and Program

Maintenance policy is established to support the overall plant, personnel safety, and financial performance goals. A typical set of maintenance policy objectives for a nuclear power plant can be stated as SSCs availability objectives, personnel safety objectives and economic objectives. The policy objectives stated above are achieved by adopting a maintenance strategy founded on the following two maxims, the first for mission-critical items, perform preventive maintenance, the second items with considerable economic impact, preventive maintenance should be considered and for others, fix after failure, that is depend only on corrective maintenance [3].

Maintenance program is a method to perform the maintenance strategy. Currently, we are able to divide it into two parts. First, corrective maintenance (CM) is the restoration of equipment or components that are degraded or are not performing their intended functions. Second, preventive maintenance (PM) includes actions that detect, preclude, or mitigate degradation of functional structures, systems, and components to sustain or extend useful life. Predictive is a subset of preventive maintenance that uses no intrusive techniques to determine if repairs are needed to preclude failure. This is the condition-based maintenance. Periodic maintenance is time-based preventive maintenance designed to prevent equipment failure [4].

2.2 Human Error in maintenance

"Mistake" is an error in intention formation, such as forming one that is not appropriate to the situation. Mistakes are related to incorrectly assessing the situation or inadequately planning a response. "Slip" is an error in carrying out an intention. Slips result from "automatic" human behavior, when schemas, in the form of subconscious actions that are intended to accomplish the intention, get waylaid en route. Thus, while one action is intended, another is accomplished [2].

3. HUMAN FACTORS IN MAINTENANCE

In this section, we will address task distribution of human who is an operator, an engineer, and a maintainer related to each phase of maintenance. This is described by decision making model of Rasmussen. In this paper, the concept that is distribution of task between human and system when designing of human machine interface [5] applies to maintenance (see Figure1).

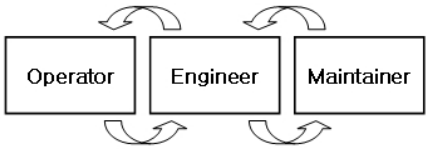

Figure1. Task distribution in maintenance

3.1 Decision making Models

Form an information processing perspective; decisions typically represent a many-to-one mapping of

information to responses. That is, a lot of information in typically perceived and evaluated in order to produce a signals choice [6].

There are developed decision making models that are Decision Ladder (Rasmussen), Rule-based Decision Making model (Rouse) and SMoC (Hollnagel) [7].

3.2 Cognitive task analysis of Corrective Maintenance

In this section, we will explain decision making model of corrective maintenance. Task centered procedure of corrective maintenance is illustrated in Figure2. Human related to each phase of maintenance is not represented and their tasks are not identified in Figure2.

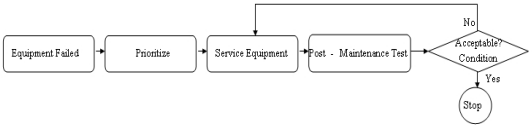

Figure2. Corrective maintenance [3]

Decision making model of corrective maintenance is illustrated in Figure3. First, we divided human related to each phase of maintenance into three parts that are an operator, an engineer and a maintainer. Second, tasks related to maintenance are distributed on the basis of them. Tasks of the operator are detection and observation of sudden failure. This is "Equipment Failed" in Figure2. Tasks of the engineer are identification and evaluation of failure in order to select goal, target and make a procedure. This is "Prioritize" The task of a maintainer is execution that is "service Equipment" and "Post Maintenance Test". If we analyze predictive maintenance, the role of each person who is an operator, an engineer and a maintainer is different with the role in corrective maintenance. For example, the task of operator is few in predictive maintenance and the other human or equipment will perform the task. We will easily know that by this model.

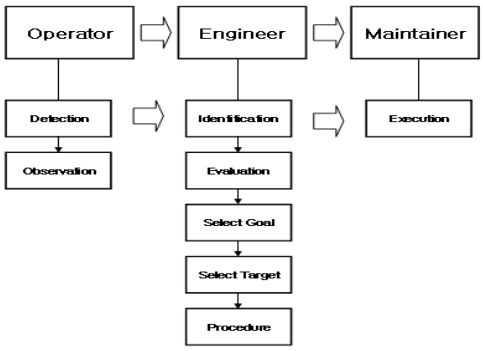

Figure3. Decision making model of corrective maintenance

This model can be described by decision ladder of Rasmussen (see Figure5). Also we can describe their respective decision ladders and identify their relation.

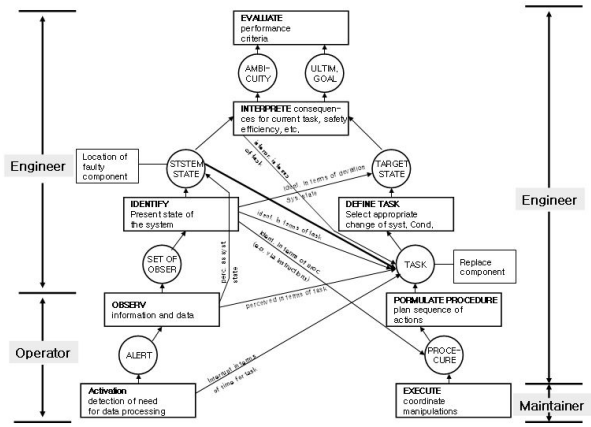

Figure4. Decision ladder of corrective maintenance

4. CONCLUSION

There is trend that is based on digital component in current or advanced NPP. Digitalization leads to an information oriented NPP. Support systems for maintenance, using the information, will be developed.

In this work, decision making model of maintenance is proposed based on Rasmussen's model. This model is useful for identifying cognitive tasks of maintenance on the basis of human when designing support system.

REFERENCE

[1] Katsuji Isobe, Shinya Shibuay, Nobuyuki Tabata. "Human Factors in nuclear power plant maintenance an empirical study." Human Factors Department, Tokyo Electric Power, 1995.

[2] Maintainability of Digital Systems: Technical Basis and Human Factors Review Guidance, NRC, NUREG/CR-6636.

[3] Improving Maintenance Effectiveness Guidelines, EPRI, TR-107042, March 1998.

[4] Guidelines for the Conduct of Maintenance at Nuclear Power Stations, INPO, INPO05-004, June 2005.

[5] J. Rasmussen, "Strategies for State Identification and Diagnosis in Supervisory Control Tasks, and Design of Computer-Based Support Systems", Advances in Man-Machine Systems Research, Vol 1, P 139-193, 1984.

[6] Wickens & Hollands, "Engineering Psychology and Human Performance", Third Edition, Chapter 8, p294.

[7] Hyung Muck Kang, Kyung Soo Park, "A Study on the development a Qualitative Human Error Analysis in a Nuclear Power Plant", KAIST, Dce 28 1994.