Knowledge Dependency Analysis of Plant Operators using Consistent Protocol Formulation

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1. Introduction

Safety and reliability of nuclear power plant (NPP) operation are now achieved by elaborate and systematic operator education. However, it is still difficult to completely deny the possibility of operators' cognitive overload caused by very complicated plant abnormal consequences. This cognitive overload may confuse the operators in important decision making processes and thus reduce safety margins in settling or recovering the target plants.

Nowadays, many efforts are devoted to human factor analysis and simulation, mainly to optimize man-machine interface design and cooperative task allocation within an operation crew in future generation nuclear power plants. However, it is not easy to realize optimum rationalization of crucial information in every abnormal plant situation. At the same time, methodology for enhanced reliability and safety must be sought also for the existing power plants. Therefore, it is important and essential to establish a methodology acting on minds of power plant operators to form a well organized and effective knowledge of the target plant.

The authors have launched a research program to establish a methodology to support human operators in forming this kind of integrated plant knowledge (hereafter referred to as "plant mental model"). The final goal of this research is to build an off-line intelligent computer-aided instruction (ICAi) system to monitor the subject operator's mental model, and to support plant operators in acquiring, correcting, and integrating plant knowledge.

This paper explains first an experiment with a training simulator and on-duty operators. A formulation scheme of operator protocols is described next. This formulation scheme has enabled some computerized analysis which is shown next. Future direction of both protocol formulation and analytical tool development are discussed in the last part in this paper.
2. Experiment

2.1 Criteria of simulated anomaly given to the subject operators

Observation of the current on-duty operators' behavior is undoubtedly the fundamental information resource for this kind of research. An abnormal situation was given to two on-duty plant operation crews in a computer-simulated control room, to obtain the behavioral data of the operators. The following criteria have been introduced for adequateness of the simulated anomalies:

1. The anomalies should be more complicated than those included in the training curriculum
2. The root cause should be uniquely derivable from the observable parameters, from the knowledge of plant functions and structure to be provided in the training curriculum, and from the available documents in the control room.

2.2 Characteristics of the selected anomaly

The selected anomaly is "Terminated steam supply to a feed water heater", where steam flow into a feed water heater as heat source is terminated due to erroneously closed check valve at the steam supply line from a high pressure turbine[3]. This anomaly is hard to diagnose because the operators can not observe the anomaly propagation sequentially. (Figure1)

![Figure 1 Terminated Steam Supply to a feedwater heater](image)

The authors would like to emphasize that the subject operators were asked to concentrate on cause identification. i.e., they were forced to maintain power generation until they become sure about the anomaly cause. This request is very important because, in the real plant operations, the operators can shutdown the reactor before cause identification, to minimize possibility of hazardous consequences.