Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2012

Preparedness of Operation Teams' Non-technical Skills in a Main Control Room of Nuclear Power Plants to Manage Emergency Situations

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1. Introduction

Human reliability is one of the important determinants for the system safety [1]. Nuclear Energy Agency reported that approximately half of events reported by foreign nuclear industry were related with inappropriate human actions [2]. The human error problems can be viewed in two ways: the person approach and the system approach. Other terms to represent each approach are active failures and latent conditions. Active failures are unsafe acts committed by people who are in direct contact with systems whereas latent conditions are the inevitable 'resident pathogens' within the system. To identify what kinds of non-technical skills were needed to cope with emergency conditions, a method to evaluate preparedness of task management in emergency conditions based on monitoring patterns was presented. Five characteristics were suggested to evaluate emergency task management and communication: latent mistake resistibility, latent violation resistibility, thoroughness, communication, and assertiveness. Case study was done by analyzing emergency training of 9 different real operation teams in the reference plant. The result showed that the 9 teams had their own emergency task management skills which resulted in good and bad performances.

2. Background

For team characteristics, as the term suggests, latent conditions may lie dormant within behaviors of teams before they combine with active failures and local triggers. Then, how can latent conditions in team characteristics be found and remedied? The recent analysis of Korean accident cases showed that about 50% of them could be prevented from recurrence by rehabilitation of operation and maintenance personnel. Nowadays, computing power has so increased that the plant simulation system can represent almost the same phenomena as real conditions. However, the training sets of infrequent tasks by training designers are limited. Moreover, even though the viewpoint to develop Emergency Operating Procedures (EOPs) has been changed since the TMI accident from the event-oriented the approach to symptom-oriented approach [3], most of training scenarios for emergency conditions are still event specific as stated so there exist so many scenarios to train. To overcome this situation, non-technical (cognitive and social) skills of operation teams must be considered for training.

2.1 Emergency Operating Procedure (EOP)

Emergency operating procedures are inescapable aspects of safety. They can be seen as the laws to be respected in accident situations. But, events like TMI and Chernobyl accidents have shown that procedures alone were not an absolute and invariable guarantee of safety [4]. Before the TMI accident, EOPs were event-oriented. Events were mostly based on design basis accidents (DBAs): mainly, LOCA and SGTR. People learned lessons from these events and tried to modify EOPs to cope with various situations. As a result, symptom-based EOPs were developed and widely used to enhance the safety of NPPs.

All conditions in NPPs can be divided into two classes; normal and off-normal conditions. Off-normal conditions can also be divided into two sub-classes; abnormal and emergency conditions [5]. Fig. 1 shows the coverage of each procedures and general strategy of taking procedures with different approaches to bring the plant back to normal or safe shutdown conditions.

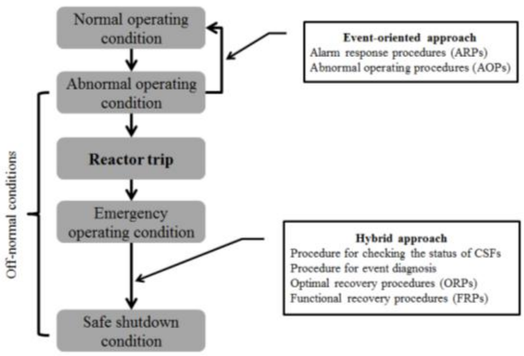

Fig. 1. Coverage of each procedure in various conditions in NPPs

2.2 Non-technical Skills

It has been well understood that the possibility of human error and inadequate team competency are high many industries and organizational, managerial, and personal factors are the important contributors. For this reason, training social and cognitive skills is an issue, particularly in safety critical industries. Non-technical skills are defined as the cognitive and social skills of team members, not directly related to control, system management, and standard operating procedures. These non-technical skills encompass leadership, decision making, situation awareness, workload management and team coordination, etc.

2.3 Training

Training has been defined as "the systematic development of the knowledge, skills and attitudes (KSAs) required by an individual to perform adequately a given task or job" [6]. Training has also been defined in the Glossary of Training Terms (Manpower Service Commission, U.K.) as "a planned process to modify attitude, knowledge or skill behavior through learning experience to achieve effective performance in an activity or range of activities". It implies that the role of training is the right mix of knowledge, skills and attitudes/behaviors of trainees and helps jobholders to perform tasks successfully. Therefore, the term 'performance' is interwoven with training. In order to achieve performance improvement, especially in the nuclear industry, training must lead to the enhancement of professional knowledge and skills both at individual and team levels. It should equip personnel to respond appropriately to emerging challenges like a reactor tip or perturbations of plant parameters. Training should also bring about appropriate changes in attitudes.

3. Case Study

Monitoring is a basic activity of information searching and it can be categorized in various ways. As far as emergency conditions are concerned, there are three types of monitoring as below [7].

Procedure driven monitoring refers to monitoring that is determined by procedures that include explicit directives to monitor a parameter

Data driven monitoring refers to monitoring that is triggered by salient external stimuli such as alarms.

Knowledge driven monitoring refers to monitoring that is driven by an internally generated perceived need for a piece of information. Monitoring patterns were classified in six by using a human cognitive model of Observation-Situation awareness-Control. Six types of monitoring patterns were defined as;

1. procedure driven monitoring → confirmation
2. procedure driven monitoring → controls or decision making
3. data driven monitoring → confirmation
4. data driven monitoring → controls or decision making
5. data driven monitoring → intermediate SA → knowledge driven monitoring → control or decision making
6. knowledge driven monitoring → control or decision making

Based on these 6 monitoring patterns, 9 sets of scenarios for 3teams were analyzed and the inputs for analyses were classified as shown in Fig. 2.

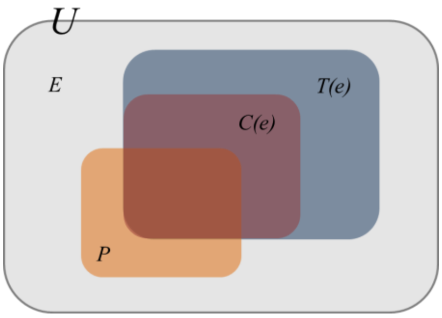

Fig. 2. Information used for each monitoring pattern where;
U: information required to understand all possible plant situations
P: information required to perform procedures
C(e): information presented on information systems for an event *e* at a specific moment
T(e): total information presented on information systems for an event *e*
E: irrelevant information either to an event *e* or to procedures

4. Conclusions

For emergency conditions, operation teams which used knowledge driven monitoring based on procedure and data driven monitoring performed better than teams which used knowledge driven monitoring without procedure or data driven monitoring. Communication integrity collapsed with the repetitive training while other characteristics were not much changed with repetitive training. It is possible to use the proposed method as an indicator of 'what to train' for teams.

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