Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2015

An Approach to Human Error Hazard Detection of Unexpected Situations in NPPs

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1. Human Errors and Unexpected Situations in NPP

After Fukushima nuclear power plant (NPP) accident, most of studies in a nuclear field are focusing on a safety study about the extreme situation accident such as a severe accident. They are mainly dealing with hardware safety little focusing to the human errors at the extreme situation. Fukushima accident is a typical complex event including the extreme situations induced by the succeeding earthquake, tsunami, explosion, and human errors.[1] And it is judged with incomplete cause of system build-up same manner, procedure as a deficiency of response manual, education and training, team capability and the discharge of operator from human engineering point of view.[2,3] Especially, the guidelines of current operating NPPs are not enough including countermeasures to the human errors at the extreme situations. Therefore, this paper describes a trial to detect the hazards of human errors at extreme situation, and to define the countermeasures that can properly response to the human error hazards when an individual, team, organization, and working entities that encounter the extreme situation in NPPs.

2. An Approach to Detect Human Error Hazards in Unexpected Situations

2.1 Definition of unexpected situation

A terminology about an extreme situation is already using in a general industry and a nuclear industry. A term of an extreme situation using in a general industry not coincided with our concept due to difference of the environment and other conditions and an extreme situation using in nuclear industry is dealing with a severe, emergency and harsh situation. Severe accident is defined mainly based on overwhelm loss of accident consequences, an emergency situation deals with urgency of time and a harsh situation describes the behavior limited by any condition. However, the extreme situation considering in this paper focuses to some other aspects of human in a situation.

Table 1. Example of extreme situation contents dealing in a general situation and nuclear industry.

General industry	Nuclear industry
Extreme high or low temperature	Loss of Coolant Accident (LOCA)
High pressure	High Energy Line Break (HELB)
Corrosion	Tsunami
Toxicity	Extreme high or low temperature

Table 1 shows contents of extreme situation contents dealing in general industry and nuclear industry. The general industry considers harsh environmental factors such as a temperature and pressure that can affect to system and human. Nuclear industry mainly considers the situations induced by a predefined set of severe and emergency events such as a Loss of Coolant Accident (LOCA) and High Energy Line Break (HELB). But it is just about the hardware safety not considering human error hazards involved during the operation of nuclear power plants. Therefore, we need to another approach to the hazards related to human errors in extreme situation in NPPs.

Before introducing this study, we should redefine the term of extreme situation suggesting this study to clear up. We finally decided the term of extreme situation as the unexpected situation. The unexpected situation is the situation that individuals, team, organization and system cannot properly take an action by deviating from physical, physiological and mental preparations, and cannot built-up a systematic response even if the situation can be predefined or not as well as unexpected or not. The loss of functional, personal and organizational competence for coping with accident situation is also considered as the unexpected situation.

We propose several steps to detect the human error hazards when individual, team, organization, and incomplete system encounter the unexpected situation in NPPs. Since human errors have a potential hazard in unexpected situations, a lot of indefinable accidents in NPPs might be still occurred by the human errors. Therefore we need to prepare the responses and additional guidelines for coping with the human errors in unexpected situation of NPPs. We will describe the detection process of human error hazards and a case study upon a previous event.

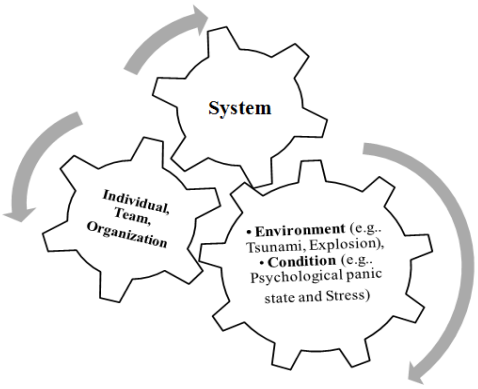

Figure 1. The definition of unexpected situation

Figure 1 shows a schematic definition of the unexpected situation applied in this study. In other words, if the extracted hazards combine with other environmental factors and conditions, it will run up the unexpected situation in NPPs. For example, operators working in main control room cannot more take any measure by damaging physically, psychologically, and functionally, when fired and exploded suddenly in NPPs. Like this, the more unexpected situations in accidents may happen anytime, anywhere in NPPs. Therefore, a study of the human error hazards in unexpected situations should be performed by analyzing more accident cases, and should suggest the countermeasures and guidelines to reduce the human error hazards occurring in NPPs.

2.2 Steps proposed for detecting human error hazards

There need a several steps for detecting human error hazards. Figure 2 is showing the 6 steps from the case revisit to the final definition of human error hazards.

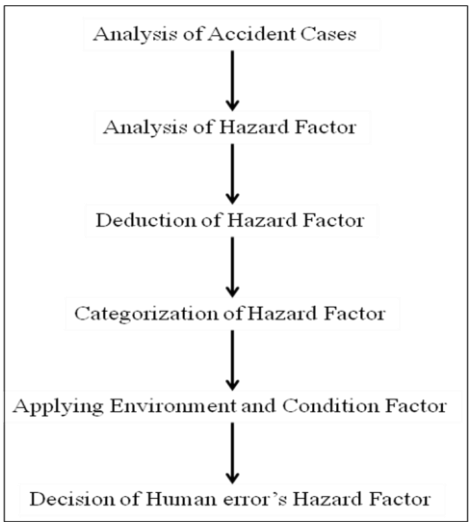

Figure 2. Proposed steps for detecting human error hazards in unexpected situation.

First of all, accident cases are selected and analyzed the representing various accidents in NPPs, and then influencing factors were identified through detailed sequences of the accidents. After that, we extract plausible changes of the influencing factors. Deduction of the hazards should apply environments factor such as not only a tsunami, earthquake fire, and etc., but also other conditions such as a psychological panic state and individual/team fatigue. In others word, the unexpected situation is no single accident. It is a complex situation by combining with many other influencing factors.

3. A Trial Application on the Human Error Hazards in Unexpected Situations

This section minutely describes the detection process of human error hazards with a case. We mainly apply the proposed approach to the accident cases through the documents and the reports issued from International Atomic Energy Agency (IAEA) since the reference of NPPs accident occurred by human error are not easy to obtained in form of open data and information.[4] Thus, we decided on Fukushima NPP accident and Station Black-Out (SBO) accident in Kori unit 1 to extract the human error hazards. The cases of Fukushima NPP accident and Kori unit 1 may be ideal for this case study because those cases are overtly described in documents including human errors especially. Therefore, we analyzed two cases following the detailed sequences and the causes of the accidents.

Table 2 indicates an analysis result of the SBO accident at Kori unit 1. The accident cases have analyzed a detail of a sequence following the time-line of the accident, and then we extracted hazards from influencing factors. The table 2 shows a part of analysis steps proposed above by an example the SBO accident of Kori unit 1.

Table 2. An analysis of the SBO accident of Kori unit 1

Accident sequence	Cause of accident	Hazard
Feb. 9. 2012. 19:30: Started protective relay test of GCB (Generator Circuit Breaker)	A worker ignored the direction of supervisor and arbitrarily operated the generator protection system	A mal-operation Occurred by worker's conceit. →Default of direction
20:34:30: Occurred LOOP, low voltage on the safety Bus-Opened automatically 345kV SWYD PCB 7100/7272	Even if EDG 'A' is in middle of a maintenance, EDG 'B' automatically operated without the confirmation of whether EDG 'B' work or not.	Don't check the confirmation of equipment. → Because of the carelessness
20:34:31~20:36: EDG B auto-start signal on MCR operator found EDG 'B' fail to start and Failed to manual EDG 'B' start	The startup failure of the EDG 'B' caused by functional degradation, i.e the mechanical damage on the solenoid valve of the startup air system of the EDG 'B'	After loss of component for solenoid valve cap, not properly took a action. → The worker made a misjudgment.

The third column on the table 2 is indicating the hazards including all errors such as a system and human error. As next stage, extracted hazards should be categorized according to the system, education and training, and operational (individual or team), since the response and procedure in the guideline suggesting this study are different depending on each of situation. A table 3 is showing the categorization of hazards. We ensure that factors indicated in table 3 are hazards that might be occurring during the accident, and crucial to the human errors. And we can know that factors generate the fatal accident when it combines with other environmental factors or conditions such that an earthquake and psychological panic state are coincided with factor in table 3, because the unexpected situation has the potential possibility that can lead to a more complex accident.

Table 3. Categorization of hazards about KORI unit 1 SBO accident

System hazard	Education and Training hazard	Operational (individual and team) hazard
No confirmation of operation after repaired equipment	Deficiency of duty experience	Lack of safety consciousness and carelessness
Incomplete countermeasure after loss of component	Job stress	Fulfillment deficiency of initial action procedure at emergency situation
Failure of redundancy	Failure of communication at emergency situation	Deficiency of initial action at emergency situation
Functional failure of emergency auxiliary power supply system	Deficiency of report system at emergency situation	Inaccurate communication
	Failure of corresponding training	Misjudgment

4. Discussions and Further Studies

In this paper we try to propose an approach to analyzing and extracting human error hazards for suggesting additional countermeasures to the human errors in unexpected situations. They might be utilized to develop contingency guidelines, especially for reducing the human error accident in NPPs. But the trial application in this study is currently limited since it is not easy to find accidents cases in detail enough to enumerate the proposed steps. Therefore, we will try to analyze as more cases as possible, and consider other environmental factors and human error conditions.

Next step of this study is to suggest countermeasures to respond to the human error hazards when individuals, team, organization, and system encounter the unexpected situations in NPPs. It is important to reduce the human errors in unexpected situations, and might be possible to cope with them through the preparations such as guidelines, and prior education and training programs for safety competence build-up.

ACKNOWLEMENT

This research was supported by the nuclear energy research and development project (Grant. 2012M2A8A-4004256) funded by the Ministry of Education, Science and Technology

REFERENCES

[1] INPO, ‘Lessons Learned from the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station’, INPO 11-005, August, 2012

[2] Korea Atomic Energy Research Institute, ‘Development of Human Error Countermeasures for Nuclear Safety’, Jan, 2015

[3] Nuclear Energy Institute, 'Diverse and Flexible Coping Strategies(FLEX) implementation guide, NEI 12-06, Draft rev.0, August, 2012

[4] International Atomic Energy Agency, 'Report of the EXPERT MISSION to review the Station Blackout Event that happened at Kori NPP on 9 February 2012', June, 2012