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Occurrence Process of Unsafe Act and Recovery in conducting EOP under a Simulated Emergency

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1. Introduction

"Emergency operating procedures (EOPs) are plant procedures that direct operator actions necessary to mitigate the consequences of transients and accidents that have caused plant parameters to exceed reactor protection system set points or engineered safety feature set points, or other established limits [1]." Therefore an EOP operation according to the EOP instruction is critical to a plant's safety after accidents. For this reason, EOPs should be developed to reduce operators' cognitive burden and to enhance operators' performance related to the EOP operation. In spite of many kinds of efforts to reduce operators' cognitive burden, it has been reported that EOPs also require operators' cognitive efforts in coping with off-normal events [2].

In Korea, we have analyzed an operator's behaviors such as error of omission (EOO) and error of commission (EOC) by noncompliance with emergency training records collected from a full scope simulator of a Westinghouse 3-loop pressurized water reactor (PWR). The simulated scenario for this study is a steam generator tube rupture immediately following a main steam line break [3].

The purpose of this paper is to classify the occurrence process of an unsafe act by a performer and a recovery behavior observed under a simulated emergency. This result will be applied to the development of HRA (Human Reliability Analysis) data handbook and the improvement the existing HRA methodology.

2. Methods and Results

2.1 Operators' Missions during EOP Operation

During EOP operation, main control room operators should maintain a rigid operation configuration and follow the EOP instruction. An instruction–response between the shift supervisors (SSs) group and board operators (BOs) should be maintained to perform EOP operation during an abnormal situation. The SS group consists of a senior reactor operator (SRO) and shift technical advisor (STA), and the BO group consists of a reactor operator (RO), turbine operator (TO), and electrical operator (EO). To recover or restore the off-normal status of a plant to a safe condition, an SS should select an appropriate EOP for the emergency, instruct each step specified in the EOP, determine an appropriate route for the next step in the left-hand side of an EOP or a response not obtained (RNO) in the right one on each step, and confirm the BOs' component manipulation work while the BOs should follow the SRO's instruction and manipulate a plant control after reporting to the SRO.

2.2 Occurrence Process of Unsafe Act

According to the data analysis, an unsafe act occurs during SSs' instruction, BOs' response, or both. These occurrences explain operators' missions as mentioned in the previous section. Figure 1 shows the occurrence process of an unsafe act under an EOP operation circumstance by identifying a subject of the behaviors and the related occurrence path.

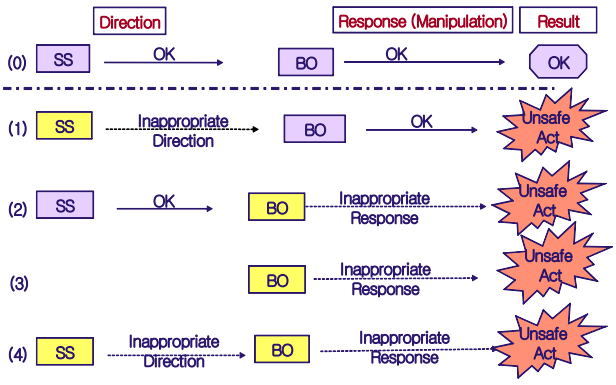

Figure 1. Unsafe Act Occurrence Process under an EOP Operation

In the Fig.1, the case (0) shows the ideal case that has no human error during an EOP operation. During conducting a step of an EOP, noncompliance by an SS occurs when he/she instruct the step, while that by a BO occurs when he/she manipulate a component to comply with the SS's instruction.

Table 1 shows the explanation of four kinds of unsafe acts by human error definitions.

Table 1. Classification of Four Types of Unsafe Acts

Case No.	Performer	EOO or EOC	Mistake or Slip
1	SS	EOO or EOC	Mistake or slip
2	BO	EOO or EOC	Slip
3	BO	EOC	Mistake
4	SS & BO	EOO(SS) + EOC(BO) EOC(SS) + EOC(BO)	Slip(SS) + Slip(BO)

According to Reason's classification of human error, errors by SSs (case (1) & (4)) include mistakes or slips while errors by BOs after listening to an instruction by SSs (case (2) & (4)) are slips. The case (3), errors by BOs which can be caused by BO's inappropriate interventions without any SSs' instruction during an EOP operation, are mistakes [4]. The case (1), (2), and (4) resulted in an EOO or EOC, while the case (3) always resulted in an EOC.

An EOC by BO following an EOO by SS in the case (4) is different from the case (3) because the BO's action in the former is not an inappropriate intervention, but rather a timely action according to the order of a step of an EOP. It can be a kind of a fail to recover.

2.3 Occurrence Process of Recovery

A recovery is an operator's action to prevent deviant conditions from producing unwanted effects. Figure 2 shows the occurrence process of a recovery by categorizing the operator noncompliance recovered into an EOO and EOC and by a detector.

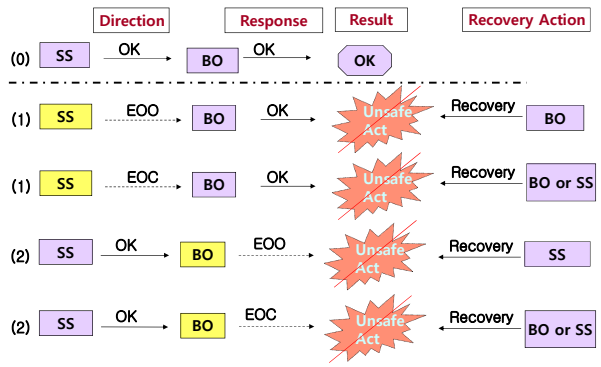

Figure 2. Recovery Occurrence Process under an EOP Operation

We observed that it is hard for an operator who conducts an EOO to detect his/her own mistake. In most cases, the omission is perceived by another operator and recovered. However, in the case of an EOC, the operator sometimes discovers his/her own mistake during component manipulation or reporting their action to the SSs for a BO or during confirming a step for a SS. Between BOs, they can also realize an EOC by others since their physical distance is not too far. A recovery from an EOC by a BO without any SSs' instruction (case (3)), however, can hardly occurs.

3. Conclusions

In this paper, we observed operational behaviors such as operator noncompliance and recovery in conducting EOPs under a simulated emergency to investigate their occurrence processes. We classified the occurrence process of an unsafe act under an EOP operation circumstance by identifying a subject of the behaviors and the related occurrence path. And also we categorized the occurrence process of a recovery by the operator noncompliance recovered and by a detector. This result will be applied to the development of HRA data handbook and the improvement the existing HRA methodology.

ACKNOWLEGEMENT

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