

Operators' Recovery Behaviors from Noncompliance under a Simulated Emergency

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1. Introduction

The purpose of this paper is to examine operational behaviors such as an operator's noncompliance and recovery behaviors in conducting emergency operating procedures (EOPs) under a simulated emergency. 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, engineered safety feature set points, or other established limits [1]. For this reason, EOPs should be developed to reduce an operator's cognitive burden and to enhance an operator performance related to an EOP operation.

However, it has been reported that an EOP requires an operator's cognitive efforts in coping with off-normal events. Some research has shown that it can be caused by a mismatch between a static model (i.e., prescribed tasks in EOPs) and a dynamic process (i.e., the nature of an on-going situation) [2]-[3]. We also observed an operator's noncompliance through an analysis of the emergency training records collected from a full scope simulator of a Westinghouse 3-loop pressurized water reactor (PWR) [4]. We also provided suggestions for improvement in EOPs to reduce the likelihood of operator noncompliance with EOPs based on the evidence of mismatches from the operator behavior analysis of a simulated emergency [5].

In this paper, we focused on an operator's recovery actions observed through the operator behavior analysis of a simulated emergency. Operators recover from their own noncompliance, or that of other operators, variously during an EOP operation.

2. Methods and Results

2.1 Data Collection and Analysis

The simulated scenario for this study is a main steam line break (MSLB) and nearly coincident steam generator tube rupture (SGTR). We collected data on nine simulated emergency operation training cases for the scenario at a Westinghouse 3-loop PWR. Video recordings of the simulated operation, process parameter trend data, operation log file, and human machine interface (HMI) lists were collected. The participating operators use EOPs developed by the Westinghouse Owners Group [6].

Figure 1 shows the normative operation process with an EOP on the SGTR immediately following MSLB.

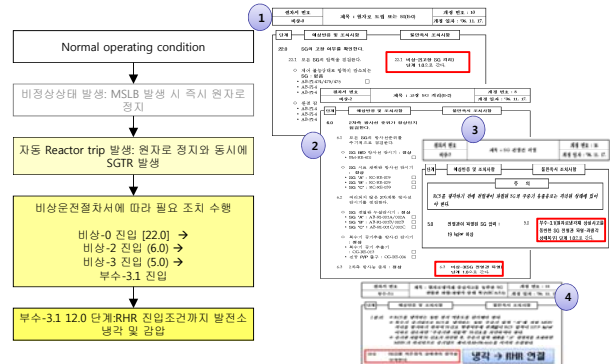


Figure 1 Normative EOP Operation Process on MSLB + SGTR

We developed transcripts based on the video recordings of the simulated emergency operation. For each transcript, we identified line by line the related EOP and step number. Based on the consolidated transcripts on the simulated emergency operation, we developed a checklist to observe how appropriately operators are conducting the related steps of EOPs. In this regard, we developed two kinds of checklist, one for shift supervisors (SSs) and the other for board operators (BOs). 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).

2.2 Results

We observed that there are common operational behaviors such as noncompliance in conducting EOPs, which may result in an excessive cognitive burden. In addition, some operator recovery behaviors are observed. The observed recovery behaviors and related noncompliance are shown in Table 1. Various operator noncompliance was observed in addition to the content of Table 1, but not all kinds of operator noncompliance were recovered. We categorized the operator noncompliance recovered by operators into omission and inappropriate operation. We determined that it is hard for an operator who has an omission to detect his/her own mistake. In most cases, the omission is perceived by another operator and recovered. However,

in the case of an inappropriate operation by a BO, the operator sometimes discovers his/her own mistake during component manipulation or reporting their action to the SSs. They can also realize the inappropriate operations of others since the distance between BOs is not too far.

3. Conclusions

In this paper, we observed operational behaviors such as operator noncompliance and recovery behaviors in conducting EOPs under a simulated emergency. We focused on an operator's recovery actions observed through an operator behavior analysis of a simulated emergency. Operators recover their own noncompliance or that of other operators during an EOP operation.

In the case of an omission, it is detected by another operator, since it is hard for the operator who had the omission to realize the mistake. In the case of an inappropriate operation by BOs, operators sometimes discover their own mistake during component manipulation or when reporting their action to the SSs. They can also realize the inappropriate operations of other operators. From the results, we have insights showing that recovery behaviors can occur when operators realize the omissions of others, or when operators detect their own inappropriate operations or those of other operators, while operator noncompliance occurs more diversely. Therefore, training and communication between the SS and BO are important to increase the number of recovery actions.

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Table1 Operators' Noncompliance & Recovery Behaviors

| Category | Operator Group | Noncompliance Behaviors | Recovery Behaviors |
|--------------------------------------|----------------|--|---|
| Omission (The whole/portion of step) | SS | <ul style="list-style-type: none"> • They sometimes omitted an entire step. • When a step consists of too many sub-steps or complicated syntaxes, operators are likely to omit a portion of sub-steps. | <ul style="list-style-type: none"> • In spite of SSs' overlooking, BOs realize a step was omitted, and thus they manipulate/ monitor the related component parameter to conduct the missed step and report their recovery action to the SSs. |
| | BO | <ul style="list-style-type: none"> • Though SSs instructed an entire step including sub-steps clearly, BOs sometimes omit a portion of them while conducting the step. | |
| Inappropriate operation | BO | <ul style="list-style-type: none"> • Though SSs instruct a step precisely, BOs conduct work irrelevant to the step (monitoring different parameter/ manipulating different component). | <ul style="list-style-type: none"> • When one of the BOs performs an operation irrelevant to the step, another BO corrects the inappropriate operation. • Sometimes the one who performs an inappropriate operation corrects the mistake. |