An Operator's Conventional Behaviors Related to Unsafe Acts from Simulator Training Record Analysis

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1. Introduction

A framework called the HuREX (Human Reliability data Extraction) system was developed for data collection and analysis to produce HEP (Human Error Probability), as shown in Fig. 1 [1]. A standardized guideline to specify how to gather HRA data from simulator training records was developed, and IGTs (Information Gathering Templates) used to collect HRA data were designed. We also defined inappropriate human behavior (or UA; Unsafe Act) for HRA data collection and showed case study to identify UAs with simulator training record [2].

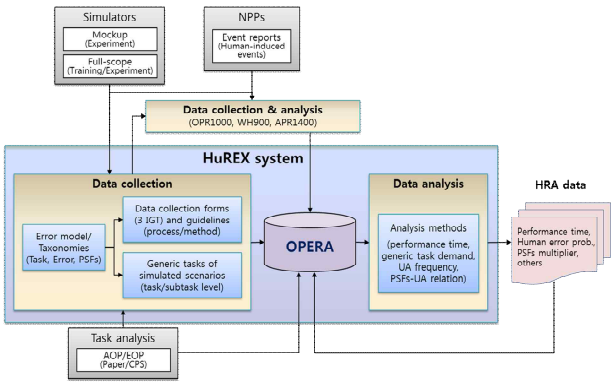

Fig. 1. HuREX Framework

Before this work, we had analyzed the operational behaviors in following EOPs (Emergency Operation Procedure) under a simulated emergency to share the evidence of a mismatch between a static model (i.e., prescribed tasks in EOPs) and a dynamic process (i.e., what actually occurs in an ongoing situation) that may result in an excessive cognitive burden in conducting EOPs [3]. In spite of the small amount of data, some common operational behaviors were observed during the EOP operations. And the observations in the study showed features similar to the results of an existing study [4].

The purpose of this paper is to describe operators' behaviors leading to UAs under ISLOCA (Interfacing System Loss of Coolant Accident) scenario for a Westinghouse 3-loop plant. For this study, we analyzed UAs identified from ten cases of ISLOCA simulator training records. From the result, an adequate plan will be in pace to reduce UAs.

2. Methods and Results

2.1 UA Analysis through Case Study

We defined that an UA is an inappropriate human behavior that has a potential for leading the safety of NPPs to a negative direction. From this concern, all kinds of deviations from the following operating procedures can be regarded as UA candidates, because these operating procedures contain many tasks to be done by operating personnel, which are very important to reduce the consequences of accident sequences. After UA candidates are selected, UAs leading to the consequences mentioned above are identified among the UA candidates. The consequences of a UA are defined as follows:

- Inappropriate procedure progression (EOO, EOC)
  - Inappropriate procedure selection
  - Inappropriate step selection
- Inappropriate execution (EOO, EOC)
  - Inappropriate manipulation
  - Inappropriate notification

We summarized UAs by UA type classification which considers a cognitive activity under a procedure driven operation, a task type, and an error mode in Table 1[2].

Table 1. UAs Identified from Ten Cases of ISLOCA Trainings

Process of Procedure Driven Operation	UA Type	# of UAs
Instruction for Information gathering	RP-information (EOO)	3
	RP-information (EOC)	4
Information gathering and reporting	IG-comparison (EOC)	3
	IG-trend (EOC)	6
Situation interpreting		
Instruction for execution or procedure progression	RP-manipulation (EOO)	5
	RP-manipulation (EOC)	2
	RP-notification (EOO)	2
	RP-procedure UA (EOO)	1
	RP-step (EOO)	4
Execution	OT-manipulation	2

- RP: Response planning and instruction
- IG: Information gathering and reporting
- OT: Other
- EOO: Error of Omission
- EOC: Error of Commission

Based on the results, we found out that SSs (Shift Supervisor) conduct omissions of instruction more frequently than inappropriate instruction, since the number of 'Response planning and instruction (EOO)' is 15 (47%) and that the number of 'Information gathering and reporting (EOC)' by BO (Board Operator) is nine (28%).

2.2 Operators' Conventional Behaviors Related to UAs

In the previous research in an operator's behavior, we summarized operational behaviors in conducting EOPs, which may result from a mismatch between the static model ('snap-shot' description in EOPs) and the dynamic process (the nature of the ongoing status). Among those results, we screened four kinds of operator behaviors in this study. They are related to some UAs from the case study.

Parameter check at a fixed time

BOs sometimes check a parameter at a fixed time only when they enter the relevant step that requires the parameter checking during an EOP operation. The real status of a plant, however, changes in any way at any moment.

From the case study, two BOs reported each pressure of three SGs (Steam Generator) were stable, even though those were gradually decreasing. These behaviors caused UAs, since SS did not perform a step transferring which should be done based on the BOs' reporting. Figure 1 shows the SGs' pressure trend at the moment.

Fig. 2. Trend of SGs' pressure related to an UA

Decision by information previously obtained

Once BOs check a parameter and report its value to SSs, SSs sometimes assume that it will not be changed at the following steps, which require checking the same parameter so that they tend to skip the repetitive action. For example, a task for checking a CV (Containment Vessel) pressure is required three times during E-0 operation by ISLOCA. SSs tended to omit the second and/or third instruction after they verified the first instruction to confirm the CV pressure. However the parameter might increase or decrease rapidly after the initial check or SS might make a mistake by confusing description in a procedure.

And also SSs tended to omit instructions for information gathering when they recognized that alarms in the instructions were activated automatically by ESFAS (Engineered Safety Features Related System) signal. From the case study, SSs often omitted verifying AFW (Auxiliary Feed Water) pumps running and/or SI (Safety Injection) pumps running after they recognized an ESFAS signal was actuated.

Due to this SSs' operational behavior, we evaluated all kinds of SSs' instruction omission due to 'Decision by information previously obtained' to examine the portion of the conventional behavior. Table 2 shows the frequency of omissions for information gathering by SS. From Table 2, SSs omitted performing sub steps for information gathering at an average 41% under ISLOCA scenario. In particular, they omitted sub steps for information gathering at an average 45% during E-0 operation, which is a procedure for a reactor trip or safety injection and should be directly performed under emergency situation.

Table 2. Frequency of omission for performing information gathering sub-steps by emergency procedure

Crew ID	Number of sub-steps for information gathering		Number of sub-steps omitted		Frequency of omission for performing information gathering sub-steps	
	E-0	E-1	E-0	E-1	E-0	E-1
1	73	38	27	16	0.37	0.42
2	73	38	24	8	0.33	0.21
3	73	36	36	13	0.49	0.36
4	73	38	19	7	0.26	0.18
5	73	38	34	18	0.47	0.47
6	73	-	48	-	0.66	-
7	73	38	41	8	0.56	0.21
8	73	36	42	11	0.58	0.31
9	73	38	19	15	0.26	0.39
10	73	36	37	6	0.51	0.17

Among the omissions in Table 2, three omissions were selected as UAs. Two were caused by confusing description. That is, SSs performed Step 4.0 (Check secondary radiation) of E-1 and they realized that it was normal by BO's report in the case of ISLOCA. After the step, two SSs omitted Step 11.2 (Check auxiliary building radiation) of E-1. Based on instructors' opinion, SSs can be confused Step 11.2 with Step 4.0, since the two steps look the same instruction. Consequently the two SSs did not perform an RNO (Response Not Obtained) part to go to ECA (Emergency Contingency Action) 1-2 even though a radiation in the auxiliary building was not normal. The other one omission also

was caused by skipping verifying RCS (Reactor Coolant System) pressure previously obtained. The SS did not catch the abnormality status of the containment vessel changed from normal to abnormal.

Operation by operator's knowledge

Operators conventionally conduct an action that is not specified in an EOP based on their knowledge. From the case study, one BO stopped RHR (Residual Heat Remove) pumps during E-0 and the related SS did not instruct the manipulation based on the procedure. The condition for RHR pumps are that an RCS pressure is above a set point and its trend is stable or increasing. However, the BO stopped the RHR pumps under just one condition was satisfied. That is, the RCS pressure met the set point, but the trend was decreasing.

Notes and Cautions

Notes contain information to support operator actions, and cautions contain information about potential hazards to equipment and/or operating personnel. Despite their importance, SSs seem to overlook these notes and cautions.

From the case study, two SSs omitted the first caution of E-1 to issue an emergency alerts. Those actions were linked directly to UAs.

3. Conclusions

In this paper, we evaluated UAs which may be caused by common operational behaviors to observe whether a UA can occur by an operator's conventional behavior. With ten cases of ISLOCA training records, we identified 32 UAs and evaluated some UAs were resulted in operators' conventional behaviors which are 'parameter check at a fixed time', 'decision by information previously obtained', 'operation by operator's knowledge', and 'notes and cautions'.

With these results, we expect that some UAs can be reduced by controlling the common operational behaviors through training. In an advanced MCR (Main Control Room) using CPS (Computerized Procedure System), some operational behaviors mentioned in this paper can be hard to occur, since an SS should make a mark to confirm a step completion. For a future works, we are to analyze operators' conventional behaviors in a CPS environment.

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