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Insights on Operator Behavior Analysis Based on Simulations in Digital MCR

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1. Introduction

The necessity for the HRA (Human Reliability Analysis) database based on real event data or simulator data has been increased since the HEP (Human Error Probability) quantification reflecting the real world became important. In this situation, KAERI (Korea Atomic Energy Research Institute) developed a systematic framework called HuREX (Human Reliability data Extraction) for HRA data collection and analysis to produce an HEP from diverse sources such as simulator recordings and LERs (Licensee Event Reports) [1-3].

Based on the HuREX framework, we successfully extracted a set of HEPs for 21 generic task types from audio-visual records that were collected from full-scope training simulators equipped with conventional MCRs (Main Control Rooms) [4].

Recently, a new issue has been raised in the extraction of HRA data because the use of up-to-date digital technologies is typical in the development of MCRs in NPPs (Nuclear Power Plants). Therefore, a research project to develop HEPs and extract HRA data using a simulator at an APR 1400 (Advanced Power Reactor 1400MWe) which has a digitalized MCR was launched in 2016. To this end, we investigated HuREX framework and newly derived HRA data items that can reflect the digitalized environment since the project has been performed based on HuREX framework. And then we collected and analyzed simulation recordings for emergency and abnormal scenarios from an APR1400 simulator to extract UAs (Unsafe Acts). We defined that an UA is an inappropriate human behavior that may affect a safety operation of NPPs. From this concern, all kinds of deviations from 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 purpose of this paper is to describe insights on operator behavior characteristics of digital environment based on operator behavior analysis with simulation data. We investigate the related procedures to understand the relation between UAs and the contents or structure of procedure. From the insights, we propose some modification of procedure or CPS (Computer-based Procedure System) to reduce the number of UAs.

2. Analysis and Results

The scenario and the number of simulations for this research are described in Table 1. In this research, the scope for UA analysis and data collection period are limited to the SBO (Station Black Out), SGTR (Steam Generator Tube Rupture), and SBLOCA (Small Break Loss Of Coolant Accident) for the first half year of 2017. Table 1 shows the summary of data for this research.

Table 1. Selected Simulation Scenarios and Related Procedure (Data collection period: The first half year of 2017)

Scenario	The Number of Simulations	Related Procedure
SBO	6	SPTA-DA-E7
SGTR	7	SPTA-DA-E3
SBLOCA	8	SPTA-DA-E2
SPTA: Standard Post Trip Action, DA: Diagnostic Action E: Emergency procedure		

In this paper, we investigate the relation between UAs and procedural information. From reviewing DA (Diagnosis Action) procedure, all UAs occurred during DA operation are identified as related to the contents of the procedure. That is, among thirty-six instructions for a diagnosis process, twenty-two instructions are in a double conditional sentence structure and five are in negative form. In particular, in the instructions of the double condition statements, some conditional statements are in the form of negative sentences and some conditional statements are composed of compound sentence. They can confuse an operator's diagnosis.

In addition, one of the cautions described earlier in the DA procedure states that immediate response to an accident may reduce or eliminate symptoms contained in the accident diagnosis and should not ignore the initial process parameters for the diagnosis. However, the location of the cautions in the procedure tend to be overlooked by operators. This is because the cautions appear before the page of the main diagnosis process in the procedure.

For some operator's omissions of component manipulation step during a procedure operation, we review the related procedures. For some component manipulations that are not easy to operate, the procedure states only to operate a device, and for details, see attached at the end of the procedure or refer to other procedures. The examples of the manipulations is 'open all A components and load all B components'. This type of instructional statement prevents operators from performing the manipulation of the device completely.

3. Conclusions

In this paper, we described insights on operator behavior characteristics of digital environment based on UA analysis with simulation data. To this end, we collected and analyzed simulation recordings for SBO, SGTR, and SBLOCA scenarios for the first half year of 2017 from an APR1400 simulator. To identify the relation between the UAs and the related procedures, we investigated the contents or structure of procedures which are related to the selected scenarios. Based on the results, some UAs have been found to be related to the structure or contents of the procedures.

To reduce those kinds of the UA occurrences, we propose some modifications of the related procedure in this paper. Firstly, it is necessary to convert the double conditional sentence and the negative structures directive into two single conditional and positive statements respectively in the DA procedure. Secondly, important cautions that are easy to be overlooked at the beginning of a procedure, but must be performed, are need to be designed to appear in the relevant instructions. And thirdly, it is suggested that the details of critical component manipulation attached at the end of the procedure are changed so that operators can view them on the same page of the procedure or that a CPS is designed so that operators can go directly to the related procedure in case that the details are described in an another procedure.

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