Conceptual Design of Operator Support System for Limiting Condition for Operation

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1. Introduction

A technical specification establishes requirements for items such as safety limits, limiting safety system settings, limiting control settings, Limiting Conditions for Operation (LCO), surveillance requirements, design features, and administrative controls [1]. The technical specification is one chapter of final safety analysis report and includes limiting condition for operation to ensure the plant safety.

LCO of technical specification is very important requirements to operate nuclear power plants. Therefore, the operator crew has to monitor LCO and if LCO is satisfied, the operator crew shall perform the related actions. But events related to LCO have been occurring occasionally, and the recent event of control rod withdrawal of Hanbit #1 unit is also related to LCO [2]. In normal situation, an operator crew does not miss the entry of LCO, but human errors to miss the entry of LCO may occur in the specific situation such as preventive maintenance that required many tasks.

This paper briefly describes the results of site investigation for technical specification and difficulties of technical specification monitoring, and suggests the conceptual design of operator support system for monitoring the LCO of technical specification to remove the human errors such as skill-based and knowledge-based to miss the entry of LCO in this process.

2. Prior investigation of existing systems for technical specification

The prior investigation was performed for existing systems and LCO of technical specification of OPR1000 nuclear power plant.

The first system is Technical Specification Annunciator System (TAS) which is implemented using PI system [3]. TAS can monitor the entry of some of LCOs but TAS cannot monitor full range of the entry of LCO. And Technical Specification Monitoring Program (TSMP) is also implemented using PI system but this program also cannot monitor the full range of the entry of LCO. These systems cannot prevent human error in advance such as rule based error and knowledge-based error. And these systems does not have any retrieval functions of technical specification, e.g., bases of logic condition, related systems and indications.

Therefore, the system to be developed have the retrieval functions and can prevent human errors in advance, and can monitor in full scope the entry of LCO.

3. Site investigations for Technical Specification

The site investigations were conducted for system development and task analysis. Even though the decision for the entry of LCO is responsible for main control room (MCR) operators, the investigations were conducted with all related operators because the LCO is related to other departments such as maintenance departments.

Table I shows the main results of investigations.

Table I: Site interview main results

Dep.	Main comments
OOD*	Ambiguities to the entry of LCO
	Analysis to pre-developed system for technical specification LCO
	Validation for logic conditions for LCO
OMD**	If the system to be developed will be added to the plant system, the difficulty for development is too high.
	The process of plant maintenance shall be considered.
OOD & OMD	The relevance to LCO should be systematically reviewed in high workload such as plant overhaul.

* OOD : operators in operation department
** OMD : operators in maintenance department

4. Conceptual design

4.1 Prevention human errors in advance

The failures of action, or unintentional actions, are classified as skill-based. This error type is categorized into slips of action and lapses of memory. And the failures in planning are referred to as mistakes. These are categorized as rule-based mistakes and knowledge-based mistakes [4].

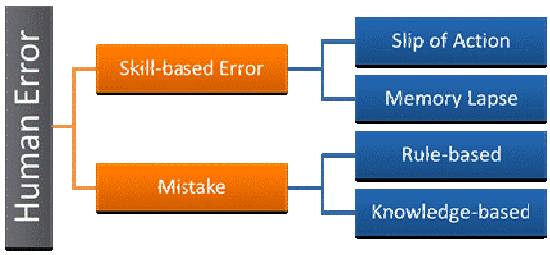

Fig. 1. Human error typology

The knowledge-based mistakes result from 'trial and error'. In these cases, insufficient knowledge about how to perform a task results in the development of a solution that is incorrectly expected to work. Fig. 2 describes the process of checking for relevance to LCO to remove this human error.

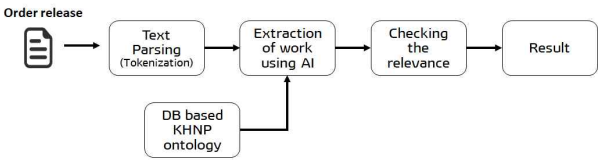

Fig. 2. The process of checking for relevance to LCO

This system checks the order of ERP and parses the order contents and extracts the scheduled work and checks the relevance to LCO. This function does not add any burden and prevent the knowledge-based human error.

And rule-based mistakes refer to situations where the use or disregard of a particular rule or set of rules results in an undesired outcome [4]. Fig. 3 describes the process of pre-testing for the work result to prevent this rule-based human error.

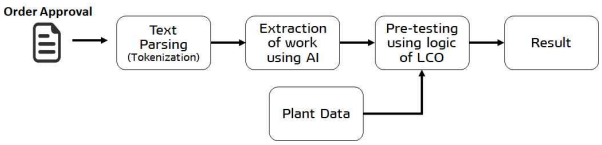

Fig. 3. The process of pre-testing for the work result

This function also provides the pre-test result of the scheduled work using real-time data after pre-processing the data similar to the previous function.

4.2 Full range of LCO monitoring

In order to the usability of the system, this system should monitor a full range of LCO. Fig. 4 shows the example of the logic diagram of the entry of LCO that is not in existing systems. The user can also check the basis of the logic on the logic diagram and can simulate the result of the logic changing the input variables.

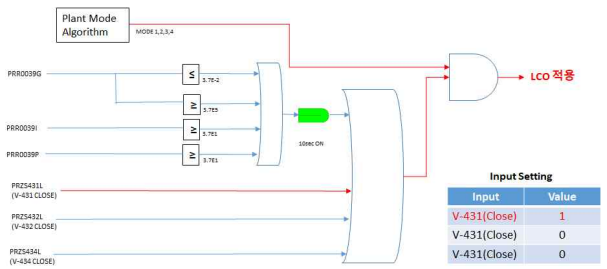

Fig. 4. The example of a logic diagram of the entry of LCO

5. Conclusions and further works

This paper suggests the conceptual design based on the user requirements after site investigation and prior investigation of exiting systems for technical specification. This conceptual design can prevent the human errors such as rule-based error and knowledge-based error. And also this system can monitor the full range of the entry of LCO using the real-time plant data.

For the monitoring of the complicated LCO, the artificial intelligent technique based decision methodology is being reviewed. And the ontology of technical specification is under development for checking the relevance to LCO. The proposed operator support system for LCO may reduce human errors related to LCO and increase plant safety.

ACKNOWLEDGEMENT

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REFERENCES

[1] "NRC glossary", Last Reviewed/Updated March 21, 2019, accessed March 18, 2020, https://www.nrc.gov/reading-rm/basic-ref/glossary/technical-specifications.html

[2] 2019-01 호(190510HB1) 원전 사고 고장 조사보고서 "한빛 1 호기 원자로 특성 시험중 부주의한 제어봉 인출에 따른 보조급수계통 작동 및 원자로 수동정지"

[3] Yong-Won Kim, Jae Jun Jeong. Development of a Technical Specification Monitoring System Using Real-time Operating Parameters in OPR1000. Transactions of the Korean Nuclear Society Autumn Meeting Goyang, Korea, October 24-25, 2019

[4] "Human Factors-Human error", accessed March 18, 2020, https://www.nopsema.gov.au/resources/human-factors/human-error/