Monitoring Re-execution Condition of Continuous Action Step in Computerized Procedure System

Yun Goo Kim, Sungjin Lee

MMIS Team, Nuclear Engineering and Technology Institute, KHNP Co.,Ltd,
25-1 Jang-dong, Yuseong-gu, Daejeon, Korea, 305-343
goodguy@khnp.co.kr, sungjinlee@khnp.co.kr

1. Introduction

The APR1400 digital main control room (MCR) has many advanced features of computerized control room. One of the most important improvements is the Computerized Procedure System (CPS). Emergency operating procedure (EOP) in the Nuclear Power Plant (NPP) provides a series of instructions to MCR operators to cope with design base events. Computerized EOP supports the operator in terms of plant monitoring, decision making, and control access.

Continuous Action Step (CAS) in EOP should be monitored through the entire procedure execution when plant processes are disturbed under emergency conditions. CPS can monitor CAS re-execution condition during EOP execution. CPS has functions to monitor CAS re-execution condition.

2. Design of Monitoring Continuous Action Steps

2.1 Characteristic of CAS in paper-based procedure

In a paper-based EOP, most steps must be monitored continuously as a CAS. Shin-Kori Unit 1&2 EOP for a LOCA (Loss of Coolant Accident) has 81 steps, and 73 of them are CAS. The operator should simultaneously monitor the CAS condition while executing steps in sequence. It has been studied that CAS increases the mental workload of MCR operators [1]. Also, it takes time before operators re-execute CAS because operator has to execute steps in sequence to detect the CAS re-execution condition. This is important because the CAS that needs to be executed usually has higher priority than the step being executed.

2.2 Design approach for monitoring CAS in CPS.

In the APR1400 advanced digital MCR, plant process information is provided through DCS (Distributed Control System). CPS, which is a part of DCS, can access DCS information. CPS provides procedure instructions in flow chart format as well as plant process information that is needed in current instruction. CPS can monitor the condition for CAS re-execution based on logics defined by the procedure writer. When the condition is met, CPS informs the monitoring result to the operator.
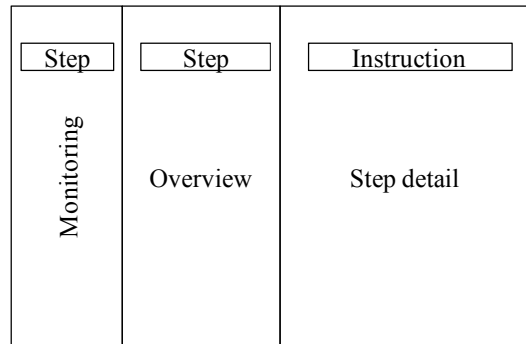

Fig.1. CPS Display

Monitoring pane is designed to inform monitoring result. When CPS detects that CAS re-execution condition is met, then that step is registered in monitoring pane to notify monitoring result and to provide the operator with navigation path to access that CAS.

2.3 Selection and designing of monitoring logic for CAS

A procedure writer can define a certain step as a CAS when CAS re-execution condition can be clearly defined as a measurable and deterministic condition. When a CAS re-execution condition cannot be defined as logic, it is monitored by the operator during procedure execution.

2.4 Operation concept with automatically monitored CAS

The NPP operator executes steps according to procedure execution flow in sequential order. During this procedure execution, operators execute each step of the procedure in sequence by performing what can be done to complete the step, Once all steps are covered, operators repeat from the beginning of the procedure. If a CAS with monitoring logic is completed, CPS starts monitoring the CAS re-execution logic until that step becomes incomplete. When CPS detects that the CAS re-execution conditions is met, CPS informs the operator and support the operator to navigates to the CAS through monitoring pane and re-executes the CAS. For the CAS without logic, the monitoring for re-execution condition is operator's responsibility. Operator needs to navigate to the CAS without logic and re-executes according to his decision. After completion of the CAS with or without logic, the operator goes back to the normal (i.e. sequential execution) process.
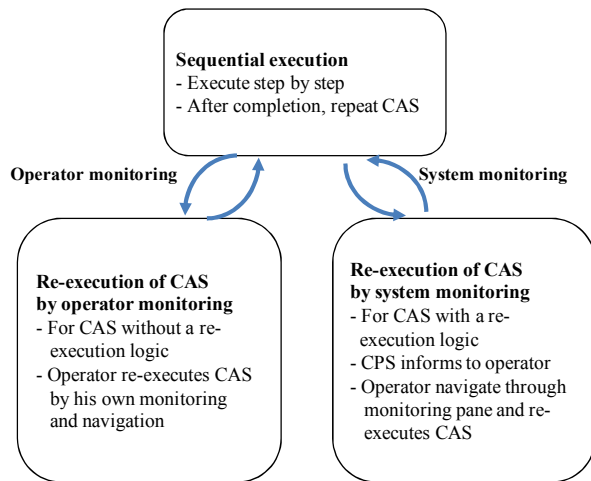
Fig.2. CAS re-execution flow

3. Conclusions

APR1400 approach for automatic monitoring the Continuous Action Step (CAS) in Computerized Procedure System (CPS) is presented. CPS supports an MCR operator in monitoring the CAS re-execution logic during the Emergency Operation Procedure (EOP). The monitoring of CAS decreases the workload of the operator, and the operator can therefore pay more attention to his/her current step instead of monitoring the CAS re-execution logic. Moreover, because the system informs the operator when the CAS re-execution logic is met, the operator reaction time for the CAS is shortened and it improves NPP safety. A human factor engineering verification and validation (HFE V&V) is planned to evaluate the effect of the monitoring of the CAS in CPS.

REFERENCES

[1] Park J., Jung W., Ha J. , Development of the step complexity measure for emergency operating procedures using entropy concepts, (2001) Reliability Engineering and System Safety, 71 (2), pp. 115-130.
[2] John M. O'Hara, James C. Higgins, William S. Brown, Human Factors Considerations with Respect to Emerging Technology in Nuclear Power Plants, BNL Tech Report No. 79947-2008
[3] Integrating Digital and Conventional Human-System Interfaces: Lesson Learned from a Control Room Modernization Program, NUREG/CR-6749
[4] System Specification for Computerized Procedure System (DDS1) KHNP Document No. : 9-797-K-464-001
[5] John M. O'Hara, James C. Higgins, Computer-based Procedure Systems: Technical Basis and Human Factors Review Guidance (NUREG/CR-6634)
[6] Jung Y. Seong P. Kim M. A model for computerized procedures based on flowcharts and success logic trees. (2004) Reliability Engineering and System Safety, 83 (3), pp. 351-3