

# HFE V&V Results of Computerized Procedure System for APR+

Yongsoo Kim\*, Yeonsub Jung

KHNP CRI, 70, 1312beon-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, Korea

\*Corresponding author: bryankim@khnp.co.kr

## 1. Introduction

Since the CPS (computerized procedure system) has applied to SKN3&4 units at first, operators suggested many design change items and operating experience derived from user experience.

Though the logic composition of CPS was very good to use, there were opinions that the esthetic design of CPS MMI display was insufficient. So many operators proposed an improvement of CPS MMI display such as the frame of display and the shape of button etc.

According to this operating experience, KHNP CRI accomplished the system design of CPS and the cooperative company realized the esthetic design.

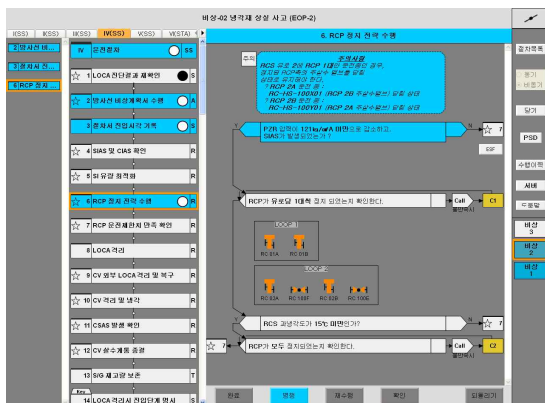
In this paper, the design changes compared to predecessor and HFE V&V results of CPS for APR+ are presented to enhance the safety and application through design optimization.

## 2. Major Design Characteristics of CPS for APR+

In this section, major design characteristics of CPS are described. The following displays are suggested by KHNP CRI, the system designer of CPS, for esthetic design. The design changes of CPS for APR+ compared to predecessor are as follows [1,2].

### 2.1 The Elimination of Monitoring Pane

The monitoring pane is eliminated to use the CPS MMI display efficiently. In spite of this limitation, monitoring steps such as CAS and postponed step are showed in the overview pane prominently.



[ Before ]



[ After ]

Fig. 1. Elimination of Monitoring Pane

### 2.2 The Change of Contingency Actions Display

The contingency actions display is presented with symbol 'C'. The child instruction is folded to save the space of step pane. If the parent instruction is not satisfied, the contingency actions display is extended to the downward. That is, there are no Call-Return interface and transfer of CPS MMI display in conventional CPS. The contingency actions are presented with anticipated response and actions at the same display.

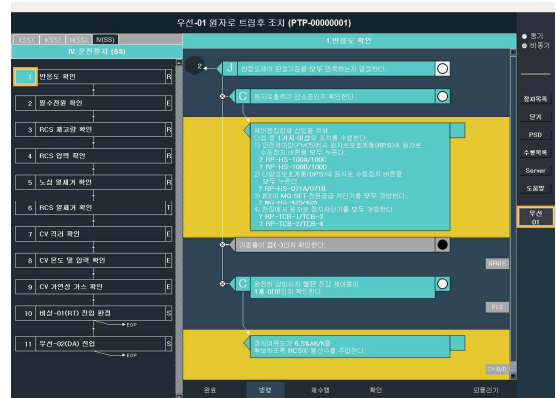


Fig. 2. Change of Contingency Actions Display

### 2.3 The Use of Joint Instruction Symbol 'J' and Contingency Actions Symbol 'C'

The symbol 'J' is used to indicate that there is a child instruction and the symbol 'C' is used to indicate the contingency actions.

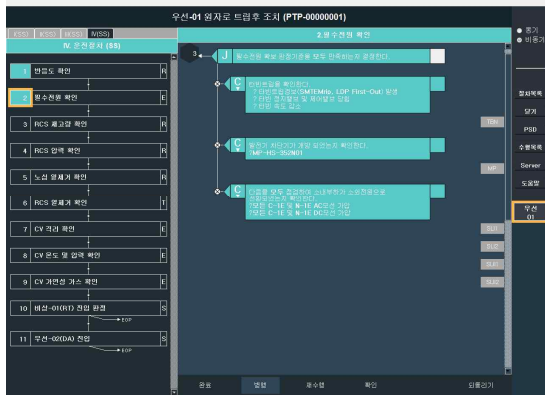


Fig. 3. Use of Symbol 'J' and 'C'

#### 2.4 The Addition of Instruction Evaluation Value

All instructions have one evaluation value among Null, True, False and N/A (not applicable). N/A is selected by clicking the right mouse button according to the plant status and the evaluation value is interpreted to 'True'.

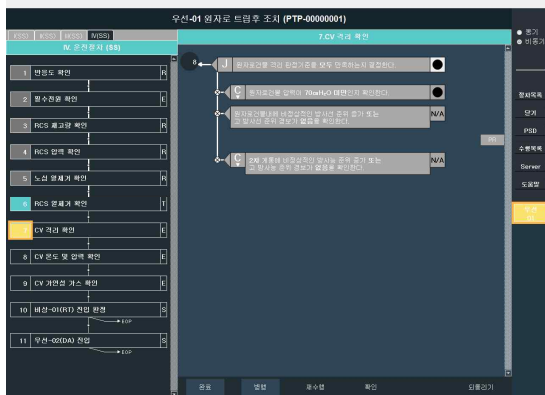


Fig. 4. Addition of Instruction Evaluation Value

### 3. HFE V&V Results of CPS for APR+

It is requested to perform the HFE V&V in relation to CPS development through an independent review team in compliance with NUREG/CR-6634. According to this requirement, we performed the HFE V&V of CPS for APR+ by external HFE experts.

#### 3.1 Major Subjects of HFE V&V

- The evaluation of HFE suitability about the elimination of monitoring pane
- The evaluation of HFE suitability about the change of contingency actions display
- The evaluation of HFE suitability about the use of joint instruction symbol 'J' and contingency actions symbol 'C'

- The evaluation of HFE suitability about the addition of instruction value
- The evaluation of HFE suitability about the design such as Flowlogic Diagram and definition of terminology etc.

#### 3.2 HFE V&V Results of CPS

The external HFE experts took part in HFE V&V to investigate the anticipated problems and design changes about CPS for APR+ and submitted a final report to KHNP CRI. The major comments of HFE experts derived from HFE V&V are as follows.[3]

- If the function of existing monitoring pane is maintained, the elimination of monitoring pane has no problem.
- When the flashing function of monitoring pane is showed in overview pane, it is possible to disappear at the overview pane because of scrolling the display.
- It is easy to recognize the procedure step instruction because of expanding the width of overview pane.
- The design of showing contingency actions at the same display is more intuitional compared to conventional design and more identical to the actual operation practice.
- The place-keeping problem derived from transferring the display is solved between anticipated response and actions and contingency actions.
- The use of symbol 'J' and 'C' to indicate the joint instruction and contingency actions is not a problem in HFE. But the specific reason of using the symbol is needed to prevent the unnecessary design.
- The selection of N/A should be limited except for essential situation. Especially, the use of N/A in development stage of EOG has no consideration for emergency operation concept and operator action.
- It is need to distinguish button area from background further.
- White letter in gray and cyan background is not good for readability.
- Italic font to emphasize the caution instruction should be avoided to comply with the requirement of NUREG-0700.

### 4. Conclusions

In this paper, the major design changes and HFE V&V results of CPS for APR+ were introduced to

increase the practical use of CPS. The design changes of CPS for APR+ were performed to improve the operator usability based on the proven APR1400 design. In addition to the design changes of CPS described above, the followings should be investigated closely for APR+ to get into the global nuclear industry.

- Though the monitoring pane is eliminated because of many limitations, the research about the potential function of monitoring pane should be continued.
- The development direction of CPS is anticipated to the intelligence and automation. The monitoring function, such as entry condition, termination condition and CAS logic, is a key technology to realize the intelligence and automation.
- The reflection of HFE V&V results and the detailed design of CPS for APR+
- The consecutive effort to improve the operation convenience and suitability of CPS
- Licensing issues derived from the APR+ development project

Through the design optimization of CPS for APR+, such as the design validation and the operating experience review, it is expected to improve the technical completeness and application.

Also the APR+ design developed based on the proven APR1400 design is anticipated to contribute to enhance the license feasibility and the readiness of project implementation.

## **ACKNOWLEDGEMENTS**

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## **REFERENCES**

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