# CPS-centered HFE V&V Results for Shin-Kori Units 5&6

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## 1. Introduction

The design of Shin-Kori units 5&6 human factors engineering was applied to overall HSI (Human-System Interface) design process in accordance with the Human Factors Engineering Program Plan (HFEPP) based on the NUREG-0711 Human Factors Engineering Program Review Model (HFEPRM).

In particular, HSIs installed and operated in the main control room, remote shutdown room, and safety-related local control station shall be complied with the detailed design principles of Human Factors Engineering Guideline (HFEG) and the verification and validation of design suitability are required.

The Human Factors Engineering Verification & Validation (HFE V&V) is an important activity for verifying and validating the HSI design, and the HFE V&V Plan is established in the early stages of the design to establish the evaluation direction of overall HFE design activities.

The Computerized Procedure System (CPS), one of the HSI subsystems in the main control room, shall verify and validate the design suitability in accordance with HFEPP and HFEG. The HFE V&V Plan for CPS should be established with a focus on the CPS-related HFE issues and validation plans for Shin-Kori units 5&6.

In this paper, the results of CPS-centered HFE V&V performed to address the issues related to CPS derived from the preliminary HFE V&V of Shin-Kori units 5 &6 were described.

## 2. CPS-centered HFE V&V for Shin-Kori Units 5&6

### *2.1 Evaluation Purpose*

CPS-centered HFE V&V for Shin-Kori units 5&6 was carried out in the APR main control room of the Central Research Institute (APR-MCR@CRI) to address outstanding CPS-related HFE issues in preliminary HFE V&V [1,2]. The configuration of CPS display for Shin-Kori units 5&6 is shown in Fig. 1.

### *2.2 Evaluation Method*

CPS-centered HFE V&V for Shin-Kori units 5&6 was conducted in terms of CPS operation, HFE design, and procedures based on accident scenarios with the participation of operators, HFE experts, operation expert, and design personnel.

- Operator Questionnaire: After carrying out the scenario, collect opinions on design improvement or problems through statistical analysis of whether the issue is closed or not through a survey of the operators and the user's opinion collection process.
- Expert observation: Experts observe the performance of the operator scenario and collect opinions on design improvement or problems through the design suitability assessment and the debriefing process with the operators.

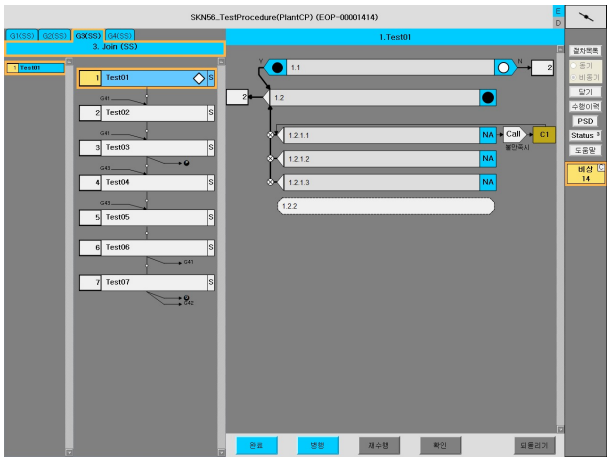


Fig. 1. Configuration of CPS Display for Shin-Kori units 5&6

### *2.3 Evaluation Facility and Schedule*

CPS-centered HFE V&V for Shin-Kori units 5&6 used in the APR main control room facilities installed at the Central Research Institute (APR-MCR@CRI). This facility is the same as the one used the preliminary HFE V&V of Shin-Kori units 5&6, but the CPS design changes were reflected to resolve pending issues related to CPS derived from the preliminary HFE V&V of Shin-Kori units 5&6 [1,2].

Table 1. Contents of CPS-centered HFE V&V

| Section | Contents | Participants |
|---|---|---|
| Pre-test | - Test of CPS and Simulator Running | HFE Expert<br>Operation Expert<br>CPS Designer |

| | | |
|---|---|---|
| 1st Evaluation | - Education for CPS Design Change<br>- Scenario-based HFE V&V | Operating Crew 1<br>HFE Expert<br>Operation Expert<br>CPS Designer |
| 2nd Evaluation | - Education for CPS Design Change<br>- Scenario-based HFE V&V | Operating Crew 2<br>HFE Expert<br>Operation Expert<br>CPS Designer |

### *2.4 Evaluation Scenarios*

Considering the model characteristics of the HFE V&V facilities, four scenarios were selected that reflect the procedures for verifying CPS issues as a result of preliminary HFE V&V of Shin-Kori units 5&6.

The scenario evaluated the CPS performance of operators including emergency operation situations such as Steam Generator Tube Rupture (SGTR) with CCF, Loss of Coolant Accident (LOCA), Loss of All Feedwater (LOAF), and Excess Steam Demand Event (ESDE) with CCF [2].

Table 2. Scenario Lists and CPS-related HFE Issues

| Scenarios | CPS-related HFE Issues |
|---|---|
| SGTR with CCF | 1. N/A Function<br>2. Auto Instruction with CCF |
| LOCA | 1. N/A Function<br>2. Auto Instruction<br>3. Binary Parent Instruction |
| LOAF | 1. N/A Function<br>2. Auto Instruction<br>3. Binary Parent Instruction<br>4. Case Instruction in AOP |
| ESDE with CCF | 1. N/A Function<br>2. Auto Instruction with CCF<br>3. Case Instruction in AOP |

## 3. The Results of CPS-centered HFE V&V

### *3.1 N/A Function*

The operator's survey on this issue found that the average value based on the 7-point rating scale was 4.52 (standard deviation 0.986) and that the use of the N/A option function was useful for performing the procedures in general by indicating a statistically significant value (p-value <0.05).

The expert observation and interview with the operator confirmed that the N/A function can be useful if it is necessary to pass a non-applicable step in the initial conditions verification procedure of the General Operating Procedure (GOP). For example, it was confirmed that N/A functions are necessary for verifying the combustible gas control safety functions of containment during the safety function status check of the Emergency Operating Procedure (EOP), since it is not possible to perform 'True' or 'False' processing under the conditions when the hydrogen monitor is not operating in the initial stage of the accident.

However, the addition of N/A functions may lead to the use of N/A by arbitrary judgement of the operator, for example, if N/A is used in the EOP continuously applied step, there is a possibility that the operator may omit continuous monitoring. Therefore, during the EOP continuously applied step, it is necessary to train not to use N/A function. In the CPS-centered HFE V&V, training on how to use N/A was conducted and no problems were found with the use of N/A by the operator [2].

### *3.2 Auto Instruction*

The results of the operator's questionnaire on this issue showed that the average value based on the 7-point rating scale was 5.03 (standard deviation 1.000) and that the use of the changed automatic instructions was useful for performing the procedures as a whole, indicating a significant value (p-value <0.05). In the case of automatic instructions, it did not apply to all procedures used in the HFE V&V, but only to the steps where automatic logic can be implemented among standard post trip actions and diagnostic actions procedures.

The results of the interview with the operator confirmed that the use of the automatic instructions is generally helpful to the operator's accident diagnosis and execution of the procedures. As a result of reflecting design changes that can select 'Logic Enable' and 'Logic Disable' functions to the CPS-centered HFE V&V, it was confirmed that the operator can properly cope with automatic logic failure by enabling the operator to disable the CPS auto logic [2].

### *3.3 Binary Parent Instruction*

The results of the operator's questionnaire on this issue showed that the average value based on the 7-point rating scale was 4.89 (standard deviation 0.809) and that the design changed binary parent instructions were found to be useful in carrying out the procedure in general, as well as indicating a statistically significant value (p-value <0.05).

This issue has been closed as expert observations confirm that there is no difficulty in carrying out the procedures. The results of the operator's interview showed that the binary auto instruction contained a letter 'A' (means Auto) on both sides, creating confusion as to which was treated as the final selection according to auto logic. To prevent this, a solution was proposed, such as leaving only the 'A' letter of the final

selection 'True' processed evaluation box in accordance with auto logic [2].

### *3.4 Case Instruction in AOP*

The results of the operator's questionnaire on this issue showed that the average value based on the 7-point rating scale was 5.18 (standard deviation 0.834) and that the use of the design changed case instruction in Abnormal Operating Procedure (AOP) was also helpful for performing the procedures by indicating a statistically significant value (p-value <0.05).

In the results of the interview with the operator, all the operators involved in the HFE V&V suggested that it is more effective to use the case instruction in AOP to select the appropriate gross step rather than the existing method [2].

### *3.5 Suitability of CPS in the event of CCF*

The results of the operator's questionnaire on this issue showed that the average value based on the 7-point rating scale was 4.44 (standard deviation 1.042), and that the use of the CPS was useful for performing the procedures in the event of Common Cause Failure (CCF) generally by indicating a statistically significant value (p-value <0.05).

The results of the interview with the operator indicated that in the accident situation accompanied by the CCF, the operator had the burden of carrying out both procedures simultaneously through a single CPS screen. It was also suggested that CCF procedure should be designated as crew procedure [2].

## 4. Conclusions

CPS-centered HFE V&V for Shin-Kori units 5&6 was carried out to address outstanding CPS-related HFE issues in preliminary HFE V&V. The operator questionnaire and interview data were obtained and expert observation was carried out through two groups of operating crew for assessing the pending issues.

The operator's survey assessment used a scale of 7-point rating, and it was required to check the number larger than 4 for convenience than the existing plant's CPS.

The operator's survey found that the average value based on the 7-point scale was 4.79 (standard deviation of 0.741), and that the CPS, which was modified in the design of Shin-Kori units 5&6, was suitable for overall use by indicating a statistically significant value [2].

## REFERENCES

[1] KHNP, Technical Memo, Shin-Kori Units 5&6 Computerized Procedure System centered HFE V&V Plan, 2018.

[2] KHNP, Technical Memo, Shin-Kori Units 5&6 Computerized Procedure System centered HFE V&V Report, 2018.