A Study on the Application of the CPS in OPR1000

Chanho Sung*, Kyungmin Kim, Jungho Kim, Jooyoul Lee
KHNP Central Research Institute, 70 1312-gill, Yuseung-daero, Yuseung-gu, Daejeon, Korea
*Corresponding author: chsung95@khnp.co.kr

1. Introduction

Computer-based procedures have been applied to nuclear power plants built since the 2000s worldwide. Computer-based procedures have been known to have various advantages over paper-based procedures [1], such as sharing procedural performance information, reducing the burden on operators such as remembering procedural stages, and reducing the possibility of human errors.

KHNP developed the CPS (Computerized Procedure System) in the early 2000s and has been applying it to APR1400 type nuclear power plants. The MCR (Main Control Room) of the APR1400 is composed of a fully digital environment, and the operators drive the power plant using CPS at each their workstation.

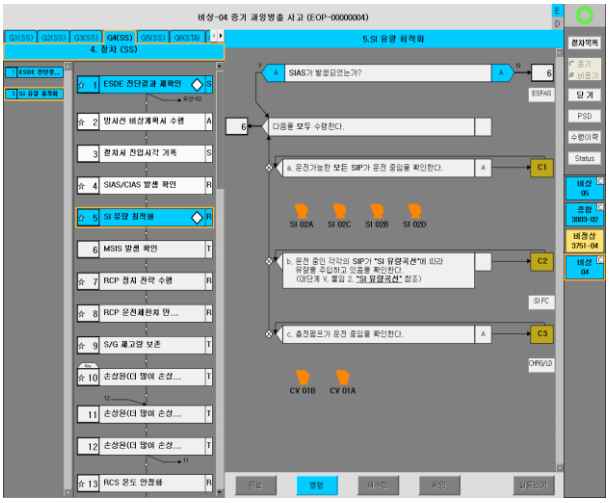

Fig. 1. User interface of the CPS for APR1400 [2]

Although the CPS of KHNP was originally developed for APR1400, the possibility was reviewed that it could be sufficiently applied to existing nuclear power plants other than APR1400. In applying CPS to existing nuclear power plants, it is advantageous to have a power plant type as close to APR1400 as possible for risk reduction and successful application. Therefore, the OPR1000 type, which is a nuclear power plant before APR1400 type, was decided to be applied.

This paper describes the study on how to apply CPS in the existing nuclear power plant, OPR 1000.

2. Applying the CPS to OPR1000

2.1 Advantages of CPS application to OPR1000

The ultimate purpose of applying CPS to OPR1000 is to maintain safer operation of nuclear power plants by reducing the possibility of human errors. One of the biggest features of CPS is that all operators in the main control room can share performance information in the ongoing procedure in real time, thereby reducing human errors due to mutual information supplementation.

In addition, the procedure controller can refer to operating support information (e.g., process variable values, device status information, etc.) appearing in the CPS in real time, thereby improving the convenience of performing the procedure.

2.2 Design Optimization of CPS for OPR1000

In order to apply the CPS of APR1400 to OPR1000, it is necessary to modify and optimize the design. For example, APR1400 CPS has a linkage function to call a soft controller, and also has a function of linking the system information screen related to the execution of the procedure. Since the soft controller is not used in the OPR1000, the soft controller linkage function should be removed from the CPS. However, an information screen connection related to performing the procedure may be necessary. In OPR1000, there are information screens related to major safety variables in PMAS (Plant Monitoring and Alarm System) [3], so it is necessary to consider linking this information.

2.3 Considerations when applying CPS

The OPR1000 main control room environment is different from the APR1400. Above all, in OPR1000, the operators perform monitoring, control, and procedures on the bench boards provided in the front and both sides of the main control room. In addition, they move the bench board as needed and perform such tasks. In other words, in OPR1000, operators do not sit on their own workstation and perform monitoring, control, and procedures like APR1400. Therefore, in the OPR1000, the operators should be able to operate the controllers of the bench board while watching the CPS. Another important consideration is that wireless communication is not permitted in the MCR. So, the use of devices such as tablet PCs using wireless communication for CPS operation is limited.

2.4 How to use CPS in OPR1000 MCR

When using CPS in APR1400, the operator generally needs two screens. That is, a screen (left) for performing CPS and an information support screen (right) for giving information associated with performing CPS. Monitoring and control in the main control room is mainly carried out by RO, TO, and EO, and SS controls the overall performance of the procedure. Accordingly, the SS may need not only a CPS screen but also an information support screen. However, since the operators (RO, TO, EO) in charge of actual monitoring and control can directly utilize the information on the bench board, the information support screen may be unnecessary.

Figure 2 and figure 3 show conceptual designs for using CPS in OPR1000 MCR. The layouts of the figures show examples of CPS application methods considering MCR environment in which wireless communication is not available.

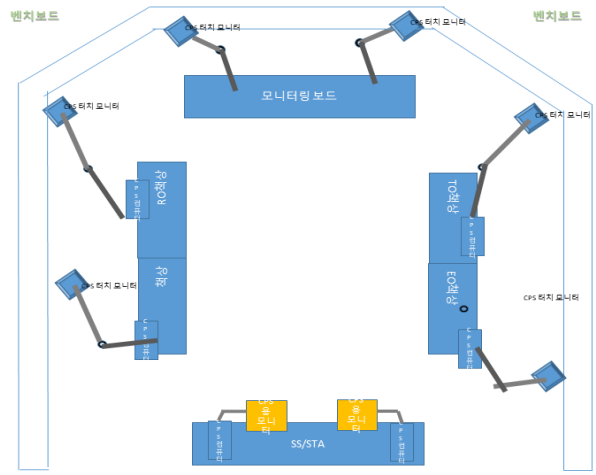

Fig. 2. A layout of the user screens for CPS using monitor arms in OPR1000 MCR

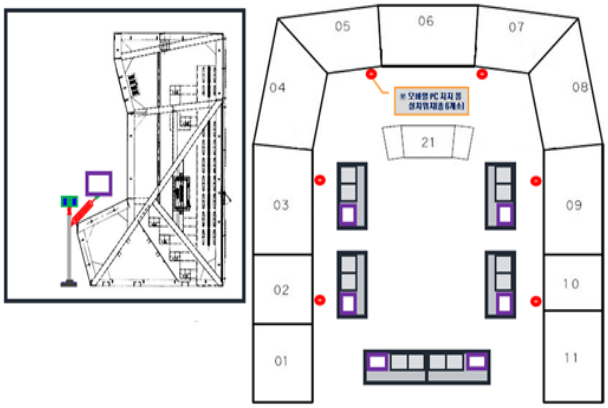

Fig. 3. A layout of the user screens for CPS using 6 poles in OPR1000 MCR.

2.5 Evaluation of usability of CPS

For the optimized CPS to be applied to OPR1000, usability evaluation is required. First of all, CPS will be built in OPR1000 simulator to evaluate usability. In addition, OPR1000 operators will be invited to receive CPS user training, and after that, scenario-based CPS usability evaluation will be conducted. The operating scenario for usability evaluation is configured to link normal, abnormal, and emergency situations [4], and not only evaluation of DBA (Design Basis Accident) but also D3 (Diversity and Defense in Depth) such as CCF(common cause failure) situation will be included in the scenarios. The usability evaluation results will be published as a report.

3. Conclusions

KHNP CRI is conducting research on applying CPS to OPR1000 nuclear power plants. As mentioned in this paper, it is judged that the CPS developed for APR1400 can be supplemented and applied to the OPR1000 nuclear power plant to contribute to the safe operation of the power plant. In order to apply CPS to OPR1000, various considerations are required in addition to those mentioned in this paper, and it will be optimized and applied through collaboration with operating experts, CPS designer, and HFE experts. It is expected to be the basis for exporting Korean CPS to nuclear power plants around the world in the future.

REFERENCES

[1] US NRC, Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance, NUREG/CR-6634, 2000
[2] KHNP, SKN5&6 CPS System Design Specification, Rev4, 2021
[3] KHNP, Plant Monitoring and Alarm System, 2015
[4] KHNP, SKN5&6 CPS Centered HFE V&V Plan, Rev 1, 2020