Design Characteristics of Soft Control for APR+

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1. Introduction

The design requirements of a nuclear power plant are dependent on the safety philosophy, which is closely related to the historical background of nuclear industry in each country, and operation strategy.

In the global nuclear industry, the design requirements have been largely divided into the US and the European ones. The APR+ design, based on the proven APR1400 design, was developed to fully comply with the US regulatory and utility requirements. It was also developed to improve the technical competitiveness and enlarge the export market share through design uniqueness and the improvement of safety.

The robust design of safety and its validation were requested Post-Fukushima accident. So MMIS design and validation for reinforcing safety were accomplished in APR+ development project. In this paper, the design characteristics of soft control for APR+ are presented to enhance the safety of MMIS design.

2. Major Design Characteristics of Soft Control

In this section, major design characteristics of soft control are described. The design characteristics of soft control based on APR+ project are as follows [1,2].

2.1 Configuration of Soft Control

The soft control is composed of Information FPD Soft Control and ESCM Soft Control in operator console and safety console. The configuration of soft control in safety console is presented in Fig. 1.

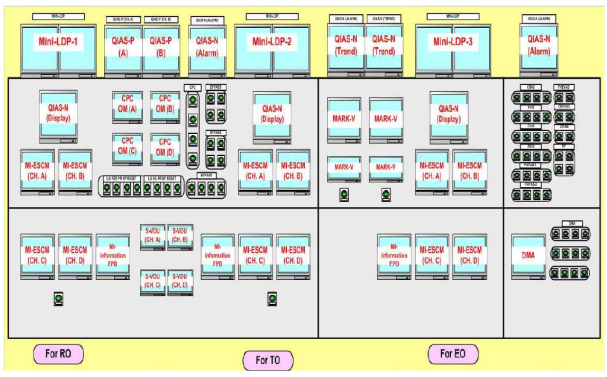

Fig. 1. Configuration of Soft Control in Safety Console

- Operator Console : Information FPD Soft Control, ESCM Soft Control
- Safety Console : MI-Information FPD Soft Control, MI-ESCM Soft Control

2.2 Design Criteria of Soft Control

- Maintain the electrical and physical independence between safety class (ESCM) and non-safety class (Information FPD) soft control
- Enable to make a component selection and control independently at the soft control for safety class
- Isolate the failure effect of soft control by making an independent design between fixed manual control and soft control at the safety console
- Design the soft control for safety class by multichannels and connect the safety channel one by one by confirming the channel
- Construct equally the operator console located in RSR and MCR

2.3 Design Status of ESCM Soft control

According to NRC's request, all ESCMs are designed to divisionalized ESCM in APR1400 DC project. Despite many advantages, such as the simplification of I&C system and a profitable licensing, the divisionalized ESCM is expected to increase the cognitive and physical load due to the shift of operator to control the component by channels [1].

Table 1. Design Status of ESCM Soft Control

Item	APR1400	APR1400 DC	APR+
Operator Console	Universal ESCM	Divisionalized ESCM	Universal ESCM
Safety Console	Universal ESCM	Divisionalized ESCM	Divisionalized ESCM
Control Command Switch	Channel Confirm Switch	-	Command Temporary Enable Switch
Control Sequence	1. IFPD 2. CCS 3. ESCM	1. IFPD 2. ESCM	1. IFPD 2. ESCM 3. CTE

So the APR+ design adopted the universal ESCM into the operator console and the divisionalized ESCM into the safety console. HFE V&V of divisionalized ESCM and touch-screen method applied to safety

console will be carried out additionally in the detailed design. The design status of ESCM soft control, adopted to APR1400, APR1400 DC and APR+ respectively, is presented in Table 1.

2.4 Signal Process of Soft Control

- The control signal of component from Information FPD and ESCM is connected to CDG(Command Division Gateway) through DCN(Data Communication Network) [3].
- CDG is opened temporarily only when confirming the CTE(Command Temporary Enable) switch and then closed after the control signal of component is transferred to ESF-CCS LC.
- The information signal of safety class component is transferred to ESCM through CDG by using the DCN and transferred to Information FPD through MTP by using the non-safety class network.
- ESCM and CDG are designed to meet the requirements of ISG-04 by composing the independent communication processor and function processor.
- ESCM and CDG are designed to prevent the data handshaking by using the dual-ported memory.

The signal process of soft control mentioned above is shown in Fig. 2.

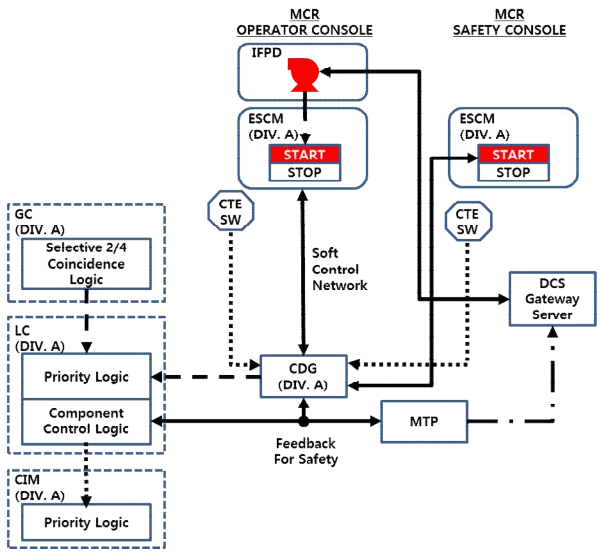

Fig. 2. Signal Process of Soft Control

2.5 Operation Concept of Soft Control

Soft control for APR+ is divided into safety class and non-safety class. Soft control for safety class, based on touch-screen method, is provided to operate the component of safety class at the ESCM. On the other hand, soft control for non-safety class component is provided at the Information FPD [1].

As shown in Fig. 3., if the operator wants to start a safety class pump, the operator clicks the relevant pump on the Information FPD and then the control window of selected component is displayed at the ESCM. When the operator touches the start button on the pop-up window, CTE switch is flashing and the start command is transferred to the pump temporarily only when manipulating the CTE switch.

As mentioned above, in case of safety class component, the logic is designed that the operator should press the confirm switch finally to prevent human error.

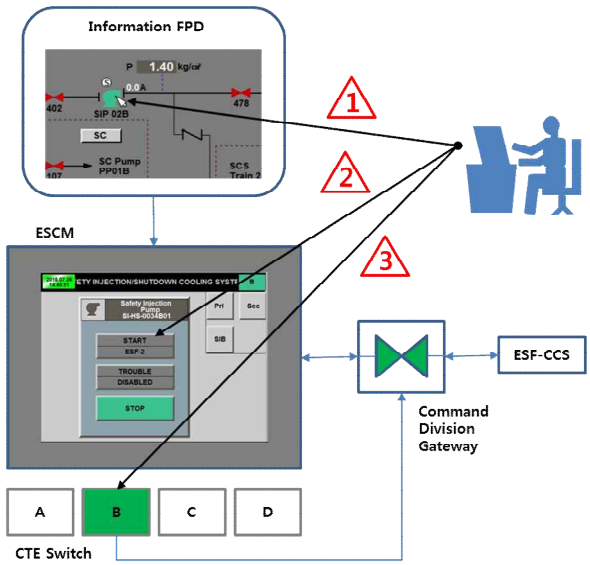

Fig. 3. Operation Concept of Soft Control

2.6 Design Change for Reinforcing Independence

The soft control for APR+ is designed to reinforce the independence between channels by adopting the confirm switch of control command. That is, the control command is delivered to the local component by pressing the CTE switch finally after manipulating the selected component on the Information FPD.

It is a design change to improve the channel independence and separation compared to APR1400 design. But the operation convenience and suitability of the continuous control such as set-point change should be considered sufficiently in the detailed design [1,3].

3. Conclusions

In this paper, the major design characteristics of soft control for APR+ were introduced to increase the safety of MMIS design. In addition to the design characteristics of soft control described above, the following should be investigated closely for APR+ to get into the global nuclear industry.

- HFE V&V of Divisionalized ESCM and touch-screen method applied to safety console
- The operation convenience and suitability of the continuous control
- Signal independence between safety channels and interface with non-safety system
- Licensing issues derived from the APR+ development project
- Lessons learned from Post-Fukushima accident

Through the optimization of the APR+ design including soft control, such as the design validation and the improvement of safety, it is expected to improve the technical completeness.

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 in the global nuclear industry.

ACKNOWLEDGEMENTS

This work was supported by the Technology Development for Safety Improvement of APR+ Design of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy.

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