

Development Status of Safety Console for APR+

Yongsoo Kim*, Yeonsub Jung

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

*Corresponding author: bryankim@khnp.co.kr

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 after Post-Fukushima accident. So HSI (Human System Interface) design for reinforcing safety was accomplished in previous APR+ development stage. In this paper, the development status of safety console for APR+ is presented to enhance the design safety through performance validation.

2. Optimized Design of Safety Console

In this section, major development status of safety console is described such as operation concept of channelized soft control design. The detailed design status of safety console based on APR+ performance validation project is as follows [1,2].

2.1 Functions of Safety Console

Advanced digital MCR (Main Control Room) is composed of LDP (Large Display Panel), operator console and safety console. The safety console is a backup facility used in case of operator console unavailability.

- Power decrease and shutdown operation
- Maintaining of HSB (Hot Standby) state
- Performing of HSD (Hot Shutdown) and CSD (Cold Shutdown) operation
- Supporting of surveillance test during normal operation
- Accident mitigation and maintaining of safe state during emergency operation
- Providing of system-level hardwired switch to perform safety function

- Providing of DIS (Diverse Indication System) and DMA (Diverse Manual Actuation) switch to maintain safe state in case of CCF (Common Cause Failure)

2.2 Necessities of Development

Safety console of APR+ standard design was proceeded to the conceptual design stage using down-sized and touch-screen method compared to APR1400.

- Performing of optimized design of safety console reflecting operating experience to improve convenience and safety
- Improving of design completeness to maximize MCR task effectivity and operation convenience by performing of detailed design
- Validation of design suitability and operator performance for down-sized and touch-screen safety console
- Ensuring of licensing correspondence data of potential issues for first-of-a-kind engineering

2.3 Optimized and Detailed Design of Safety Console

According to the first year plan, the licensing requirements and the case study of overseas nuclear power plants are reviewed. Since Shin-Kori Units 5&6, the revision 4 of RG 1.97 applies to the newly constructed nuclear power plants to select the accident monitoring instrumentation.

The concept of minimum inventory was firstly used at SECY 92-053 and it means fixed alarms, displays and controls to perform the important human actions derived from emergency operations and PSA (Probabilistic Safety Assessment).

The equipment list of safety console is selected through task analysis, PSA etc. and HSI arrangement drawing is prepared including minimum inventory and ESF (Engineered Safety Feature) actuation switch.

The detailed arrangement and optimized dimension design of safety console through task analysis were performed considering predecessor design change and HFE (Human Factors Engineering) validation results. The HSI arrangement drawing of Shin-Kori Units 5&6 is shown in Fig. 1. So the conventional type DMA switches are added to improve operational convenience and cope with CCF.

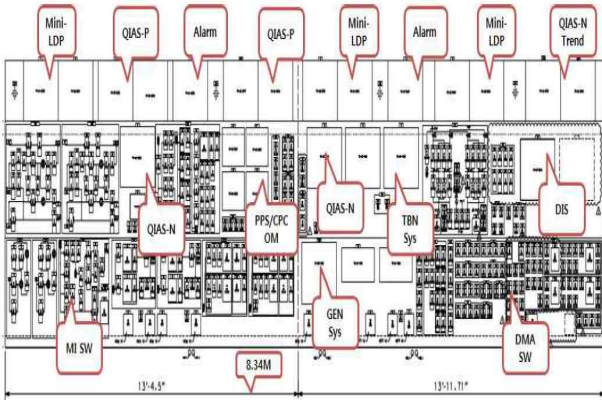


Fig. 1. HSI Arrangement Drawing of Safety Console for Shin-Kori Units 5&6

Consequently, the dimension of safety console is increased compare to predecessor and then effectivity of MCR space is degraded at Shin-Kori Units 5&6 projects.

In case of operator console unavailability, operators use conventional type controls at the safety console and the operational effectivity is decreased.

In this paper, the safety console for APR+ is developed to reduce the dimension and ensure the design flexibility by replacing the conventional type switches with FPD (Flat Panel Display). That is, hardwired switches have only control function of system level and most of safety class minimum inventory switches are designed to channelized soft controls conducting monitoring and control. The HSI arrangement drawing of APR+ is shown in Fig. 2 [1,2].

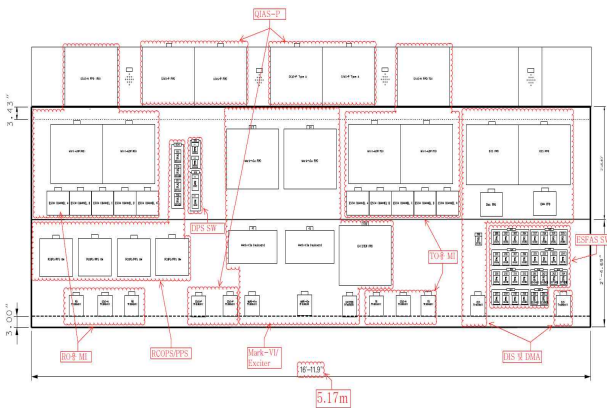


Fig. 2. HSI Arrangement Drawing of Safety Console for APR+ Optimized and Detailed Design

So the APR+ design adopted the universal ESCM (Engineered Safety Feature Soft Control Module) into the operator console and the channelized ESCM into the safety console. The design status of ESCM soft control, adopted to APR1400, APR1400 DC and APR+ respectively, is presented in Table I [3].

Table I: Design Status of ESCM Soft Control

Item	APR1400	APR1400 DC	APR+
Safety Console	Universal ESCM	Channelized ESCM	Channelized ESCM
Operator Console	Universal ESCM	Channelized ESCM	Universal ESCM

2.4 Operation Concept of Channelized Safety Console

The design realization and operation concept of channelized soft control are derived from the review of home and abroad design status and licensing requirements.

The operation method of channelized safety console is composed of main operation method and backup operation method. Firstly, the main operation method, shown in Fig. 3, uses channelized soft control interfaced with Mini-LDP. That is, the equipment to control is selected in Mini-LDP and then the control command is performed in channelized soft control display.

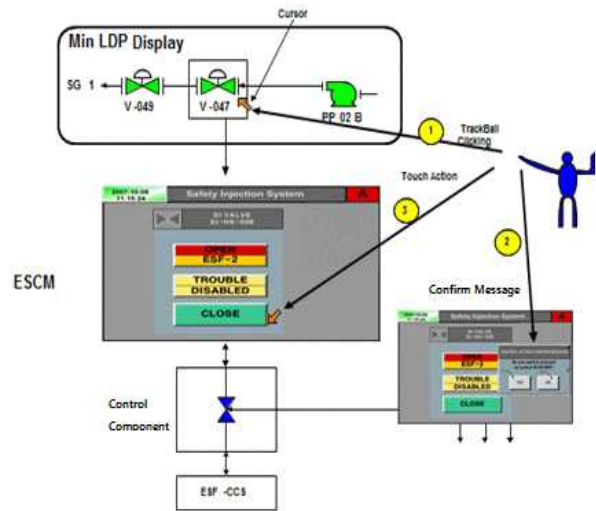


Fig. 3. Main Operation Method of Channelized Safety Console

Secondly, the backup operation method, shown in Fig. 4, uses only channelized soft control display. The channelized soft control display is provided to select the control equipment in case of Mini-LDP unavailability.

All operators use the common HSI displays and minimum inventory and DMA switches are replaced with channelized display controls [1,2].

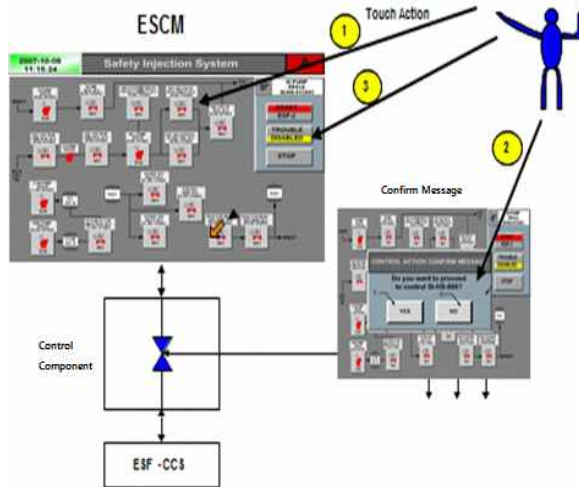


Fig. 4. Backup Operation Method of Channelized Safety Console

2.5 HFE Validation of Design Suitability and Operation Convenience

The safety console for APR+ is designed to reinforce the independence between channels by adopting the channelized soft control display. It is a design change to improve the channel independence and separation compared to APR1400 design. So the design suitability and operation convenience of the safety console using touch-screen method will be validated through manufacturing the safety console at this development project.

3. Conclusions and Further Study

In this paper, the major development status of safety console for APR+ was introduced to increase the safety of HSI system design. In addition to the design characteristics of safety console described above, the followings should be closely investigated to get into the global nuclear industry.

- HFE V&V (Verification and Validation) of the design suitability and operation convenience of touch-screen method applied to safety console
- HFE V&V of channelized ESCM applied to safety console
- Signal independence between safety channels and interface with non-safety system
- Licensing issues derived from the previous APR+ development project

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.

REFERENCES

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