Functional Requirements Analysis/Functional Allocation based on EUR for EU-APR

Sun Mi Choi*[a], Jin-Koo Kim[b]
[a]*KHNP Central Research Institute, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, Republic of Korea*
[b]*KEPCO E&C, Nuclear Dept., 269 Hyeoksin-ro, Gimcheon-si, Gyeongsanbuk-do*
sunmi.choi@khnp.co.kr

1. Introduction

The scope of Functional Requirements Analysis /Functional Allocation (FRA/FA) for reference plant (APR1400 of SKN 3&4) was sufficient to focus on critical safety function in accordance with NUREG-0711[1] which focus on human factor engineering.

In EU-APR, which is a modified design of the APR1400 to penetrate the European nuclear market, the FRA/FA which is based on European Utility Requirements (EUR)[2] and IEC 61513[3] is required to define the architecture and allocate MCR function and equipment. This report presents preliminary FRA/FA for EU-APR.

2. FRA/FA Methodology for Reference Plant

The scope of FRA/FA for reference plant included all of the functions needed to achieve plant safety and power production goals. The preferred success paths for 9 critical safety functions and critical power production functions were specified considering both safety class paths and non-safety class structures systems and components for emergency success paths and normal success paths respectively.

The functional requirements analysis was performed to:

- Define the critical functions that have to be accomplished to meet the plant's safety goals (critical safety functions) and the power production goals (critical power production functions).
- Define the preferred normal and emergency success paths that are used to maintain or restore the critical functions and delineate the hierarchical composition of the success paths through plant systems, processes, components, and control actions.
- Provide a framework for determining the roles and responsibilities of personnel and automation.

The functional allocation was performed to:

- Allocate the actions associated with each success path to a level of automation ranging from manual to fully automatic.

The FRA/FA was conducted using the structured top-down methodology in NPX80-IC-RR790-02, to:

1. Define functions that must be maintained to meet EU-APR safety goals and power production goals
2. Identify the success paths, including the success path control actions, needed to maintain or restore these functions for different plant condition
3. Allocate these control actions to a level of automation

3. Development of FRA/FA Methodology for EU-APR

3.1 Purpose of FRA/FA of EU-APR

The FRA/FA in EU-APR is required to define and ensure design rules and methods for the following issues which are required in the IEC and EUR[2]:

- I&C architecture, DiD levels and identification and defining of plant specific functions,
- Distribution of functions into different DiD and control/monitoring levels and distribution of tasks between manual and automatic functions,
- Classification and categorization of the automatic and manual I&C functions and equipment for control and monitoring,
- Boundaries, interfaces, isolation and separation rules between systems and equipment,
- V&V, qualification and suitability assessment processes of pre-existing and project specific I&C equipment as well as operating system and application software,
- Basis on task analysis in all operating stages and assessment of optimal tools to operating personnel including the optimal HMI.

3.2 Conceptual methodology of FRA/FA for EU-APR

The FRA/FA for EU-APR is hierarchically conducted using the structured top-down methodology to:

1. Identify a hierarchy of goals for the operation of the plant, covering all operational states and accident conditions. It takes into account all of the pre-conditions and pre-requisites given as General principles for I&C design
2. Define I&C functions that shall be maintained to meet EU-APR safety goals and power production goals
3. Allocate I&C functions considering the functional and performance requirements specification to I&C systems for each defense level and safety class.
4. Allocate control actions to a level of automation

4. Preliminary FRA/FA for EU-APR

4.1 Preliminary results of FRA/FA for EU-APR

The functions of control and monitoring for safety and process in EU-APR are assigned into I&C systems and the Human-Machine Interface (HMI) in the Main Control Room (MCR) based on the fulfilment of functional, performance and safety classification requirements. This FRA/FA also takes into account the guidance of defense levels in accordance with the WENRA RHWG's report[4], EUR[2], IEC 61513[3], IEC 61226[5], etc.

17 I&C functions for EU-APR are derived. And these functions are allocated to I&C systems. The representative I&C functions are as follows: reactor trip, ESFAS actuation, accident monitoring, managing design extension conditions, managing severe accident, etc.

4.2 I&C architecture of EU-APR

Based on the preliminary FRA/FA for EU-APR, I&C system architecture and individual I&C system are determined as shown in Figure 1.

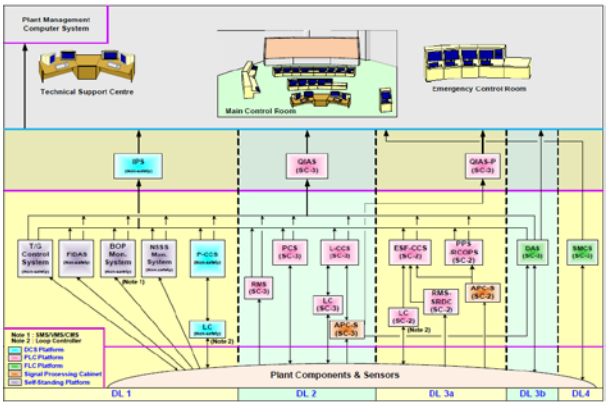

Figure 1 : Overall Configuration of the I&C System

To make I&C architecture, the major considerations are safety classification, independence, diversity, and defense-in-depth beside the FRF/FA. I&C system is segmented according to safety classification and functional assignment so that the failure influence of a controller can be minimized to the plant operation and safety. The I&C system has the interface with the systems to be operated, external systems and plant staffs through appropriate input and output devices, communication systems and HMI devices. These interfaces meet required separation, isolation and independence features. The implementation of I&C system is considered as an interface between the operators and the systems to be operated for manual and automated operation of the plant.

5. Conclusions

Based on the FRA/FA for reference plant, the preliminary FRA/FA of EU-APR is established and conduced. The result of preliminary FRA/FA which is required to cover all range of I&C design to comply with European requirements for EU-APR shows that I&C functions are divided into 17 functions. This result is utilized as the input of the designs for I&C architecture and system and analyses related to human factor engineering. As a result, I&C architecture is determined in accordance with WENRA RHWG's report[4], EUR[2], IEC 61513[3], IEC 61226[5] and FRA/FA results.

In the future, the FRA/FA and I&C architecture will be finalized by reflecting owner's requirements as the owner is determined.

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