# A Study on the Application of Control Room for SMR with Multiple Reactors

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## 1. Introduction

More than 80 SMRs (Small Modular Reactors), which are known to have various advantages (e.g., economic feasibility, safety, construction, …), have recently been developed around the world, and some of them are even in the commercial stage. However, despite the various advantages of SMR, experience in design, construction, licensing, and operation of SMR is very scarce worldwide compared to previous commercial nuclear power plants.

SMR development is underway in Korea under the names of 'SMART100' and 'i-SMR', and the basic design of i-SMR (innovative-SMR) has been completed (2023), and the standard design is currently in progress. The characteristic of i-SMR's operating point of view is that it aims to operate four reactor modules in one control room [1,2]. Existing commercial nuclear power plants and some SMR designs are based on one control room in one reactor, but recently, multiple reactor modules have been designed to be monitored and controlled in one control room based on safety and economy.

This paper describes the various problems or considerations expected for the SMR design consisting of one control room with multiple reactor modules, and proposes a design plan for the i-SMR control room considering these shortcomings.

## 2. Control Room for SMR with Multiple Reactors

### *2.1 Control room Circumstance for the SMR*

The SMR unlike the existing commercial nuclear power plants, which intends to operate multiple reactor modules in one control room, consists of a small number of operators. In other words, as for the main control room operator of a commercial nuclear power plant, 4 or 5 qualified operators monitor and control one nuclear power plant in one control room. On the other hand, SMR, which has been recently designed, performs monitoring and control of multiple reactor modules with 6 or less operators in one control room, so the roles of SMR operators in monitoring and controlling nuclear power plants may be changed compared to existing commercial nuclear power plants, and the task load may be increased accordingly. In addition, the roles of the control room operator, for example, work order control, and mutual collaboration with the power plant site, are required in performing incidental services such as periodic equipment testing to operate each module, fuel replacement, and overhauls. Therefore, when multiple reactor modules are operated, it is essential to consider these various cases because the operation status and maintenance timing of each module are not the same or cannot be performed simultaneously, which is a factor that should be reflected in the operation strategy at the beginning of the SMR design.

### *2.2 Considerations of Control Room Operation for the SMR*

The most important thing in the operation strategy of the control room of SMR is the safety of the power plant. In other words, one main purpose of the operation of the control room is to maintain the safety of the power plant and should not be disturbed in maintaining such safety. Operators should be able to maintain the safety of the power plant by always being able to cope with normal, abnormal and emergency situations of the power plant, so they should be able to concentrate on monitoring and control of the plant situation. In the case of SMR operating multiple reactor modules, the monitoring and control of multiple reactor modules are performed with a small number of operators, accordingly the operator's task load may increase and the concentration may decrease because the operating conditions (or operation mode) of each reactor module may be different. Therefore, to make up for these shortcomings, reinforcement of automation level and passive system design are being introduced for safe and efficient monitoring and control of SMR.

Also, in SMR, where multiple reactor modules are applied, the inevitable tasks for power plant maintenance (e.g., periodic equipment test, overhaul) can be performed at different times for each reactor module, and the role of the control room is also required, so the essential unique tasks of the control

room operators (monitoring and controlling nuclear power plants, and coping with situations) may be hindered when the tasks for power plant maintenance are carried out. As a result, they can affect safe operation of SMR with multiple reactors.

## 3. Proposal for the Application of i-SMR's Control Room

According to the basic design of i-SMR, i-SMR has one control room with 4 reactor modules. Therefore i-SMR also needs to consider the aforementioned considerations and we propose the control room for i-SMR as follows.

### *3.1 Integrated Control room and Reactor Module Control room*

The control room of i-SMR need to consist of integrated control room (ICR) and reactor module control room (RCR). The role of ICR is to monitor the status of total reactor modules, and to cope with an immediate response to any emergency situation such as abnormal which needs to be responded quickly. On the other hand, the role of RCR is to cope with tasks which require a relatively long time such as start-up, reactor output increase/decrease, fuel replacement, overhaul, periodic component test and emergency operating procedure. The number of RCR may be one or two, each of which is built independently of ICR. The RCR can monitor and control each reactor module, but one reactor module at a time.

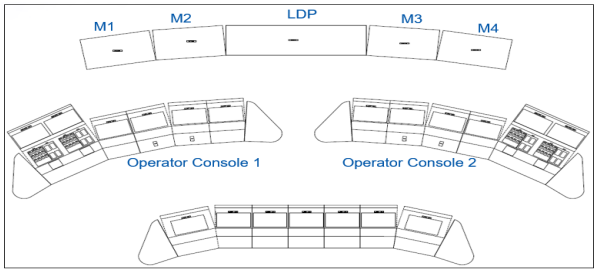


Fig. 1. Integrated Control Room (ICR) configuration

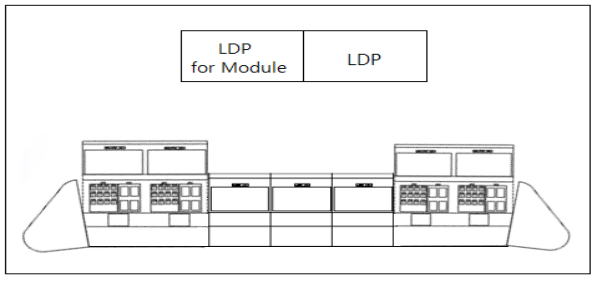


Fig. 2. Reactor module Control Room (RCR) configuration

### *3.2 Configuration of Reactor Module Control room*

Since RCR aims to monitor and control a specific reactor module to be targeted, no facility or amount of information of the same scale as ICR is required. Accordingly, the following facility configuration is required for monitoring and control of one specific reactor module.

- Large Display Panel: displays comprehensive information for all reactor modules and detailed information for target reactor module
- Operator's Console: consists of 3 display screens and switches for performing safety functions on the entire reactor modules
- Communication Facility: enables communication with ICR, TSC(Technical Support Center), OSC(Operation Support Center), and EOF(Emergency Operation Facility)
- Operators for emergency: consist of 1 SRO and 1 RO, and they do not always reside in the RCR and are put into RCR if necessary. Also, they need to be managed as separate organization different from the ICR operators.

### *3.3 Considerations for the Operation of Reactor Module Control room*

The most important thing to keep in mind in operating the RCR is the right to control over the target reactor. The right to control should be considered not only for the target reactor itself, but also for other reactors and the overall SMR affected by the control of the target reactor. Therefore, it is necessary to consider the followings.

- How to transfer control to RCR
- Scope of RCR control
- How to perform control that affects other reactor modules or the overall SMR
- How to restore control with ICR

## 4. Conclusions

In the paper, ICR (Integrated Control Room) and RCR (Reactor module Control Room) are presented considering the safety of control room operation side and the efficiency of SMR's operation side. More research is needed on the application of RCR from the perspective of operating strategies. In addition, research on the role division or role integration between RCR and RSR (Remote Shutdown Room) is considered necessary.

## REFERENCES

[1] KHNP, Plant Design Description for i-SMR, 2023
[2] KHNP, HFE Evaluation Plan for Control room Staffing of i-SMR, 2023