

A Study on the Human Factor Engineering Program for Verifying the staffing of i-SMR

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1. Introduction

KHNP (Korea Hydro & Nuclear Power co.) is developing i-SMR (innovative Small Modular Reactor) that can not only improve safety but also increase economic feasibility, and standard design is currently underway. i-SMR introduced a new operation method in the form of controlling four reactor modules in one Main Control Room (MCR). i-SMR first assumed a three-person operation by reflecting innovative design characteristics such as system simplification and integration, safety system passive design, and maximization of operation support level [2]. For the Standard Design Approval(SDA) application of i-SMR, Human Factor Engineering analysis and suitability evaluation of the initially assumed staffing are essential.

In this paper, it is intended to describe the planning and analysis method of a Human Factor Engineering program [3] based on multi-module control operation.

2. Human Factor Engineering activities

As mentioned in the previous section, in order to obtain i-SMR SDA, it is essential to verify the suitability of the staffing. To do this, it is necessary to develop a HFEPP to perform Human Factor Engineering analysis and suitability verification of operator staffing of i-SMR.

Appropriate management standards and systems for Human Factor Engineering activities should be established by specifying Human Factor Engineering program application targets, restrictions, and program activities. According to NUREG-0711[1], the Human Factor Engineering program consists of 12 activity elements. We would like to review the overall management plan for Human Factor Engineering program activities for i-SMR Staffing Plan Verification & Validation (SPV) and especially explain the following six Human Factor Engineering activity elements.

- Operating Experience Review (OER)
- Functional Requirements Analysis and Function Allocation (FRA & FA)
- Task Analysis (TA)
- Staffing and Qualifications(S&Q)
- Treatment of Important Human Actions (TIHA)
- Staffing Plan Verification & Validation (SPV)

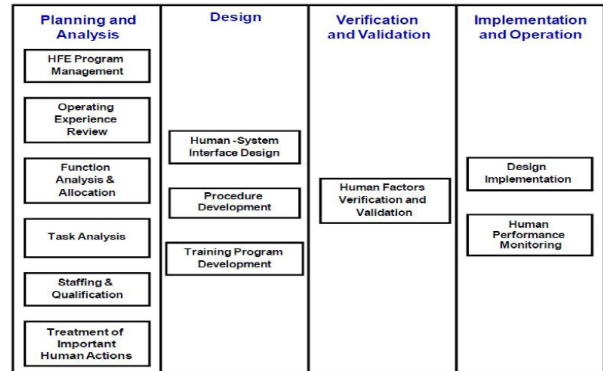


Fig. 1. Elements of the HFE program's review model [1]

The SPV of the staffing presented in the i-SMR operating concept is carried out as part of the staffing and S&Q analysis among the Human Factor Engineering program activities presented in NUREG-0711, and will be finally verified and validated through ISV later.

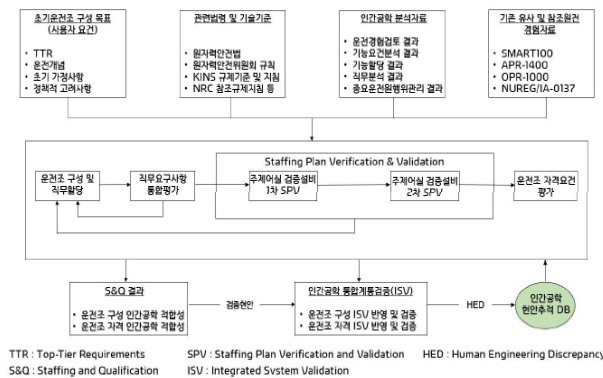


Fig. 2. Verification and Validation process for staffing plan

Verification and validation of the staffing plan is performed through the process shown in Figure 2.

2.1 Operating Experience Review (OER)

OER is performed to identify and analyze problems and current issues related to Human Factor Engineering that occurred in similar designs of i-SMR so that they can be reflected in i-SMR design. The scope of OER is as follows.

Similar plant and system / industrial ergonomics issues/concerned HMI technology / criteria / critical human activities identified in the reference design.

2.2 Functional Requirements Analysis and Function Allocation (FRA & FA)

The FRA & FA of i-SMR is performed by identifying safety and power generation functions, as well as identifying information flow and process requirements.

The purpose of this element is to verify that the applicant defined those functions that must be carried out to satisfy the plant's safety goals and that the assignment of responsibilities for those functions (function allocation) to personnel and automation in a way that takes advantage of human strengths and avoids human limitations. The scope of FRA & FA is as follows.

Safety function / Power generation function that may affect the safety function

2.3 Task Analysis (TA)

TA can confirm that performance requirements do not exceed human capabilities and specify requirements for information display, alarm, and control necessary for task performance. The scope of the TA is as follows.

Conceptual Design Task Data / Basic Design Task Data / Detailed Design Task Data / Operational and Maintenance Task Data

2.4 Staffing and Qualifications(S&Q)

The S&Q of i-SMR analyzes the initially assumed operator staffing and qualification based on the task requirements according to the TA results and performs it repeatedly throughout the entire design stage. The scope of the S&Q is as follows.

Initial operator position configuration objectives/ Human Factor Engineering Analysis/Regulation and Criterion/operator task allocation/operator composition evaluation / Human performance suitability evaluation/operator staffing qualification evaluation

2.5 Treatment of Important Human Actions (TIHA)

Important human action management is to manage important operator action that can degrade safety. Important human action management is an essential element to achieve the human factor engineering design goal of minimizing the possibility of operator error and providing interaction between the operator and the HMI facility with error monitoring and recovery capability. The scope of the TIHA is as follows.

probabilistic Important Human Actions/deterministic Important Human Actions

2.6 Staffing Plan Verification & Validation (SPV)

ISV to verify the suitability of i-SMR's three-person operator configuration plan is to evaluate the suitability of operating the power plant safely and efficiently through human performance-based evaluation of iMCR (i-SMR MCR) operator configuration. The scope of the SPV is as follows.

Operator group job assignment evaluation / operator staffing level evaluation / operator staffing human performance suitability evaluation / operator group qualification evaluation

3. Conclusion

i-SMR is currently under standard design, and there are plans to apply for SDA in 2026. Activities under the Human Factor Engineering Program will be carried out for the submission of documents in the Human Factor Engineering field of SDA. As Human Factor Engineering analysis and the suitability assessment of staffing are required, operating strategies and accident response strategies are being developed for the composition of the three-person staffing. And Human Factor Engineering program planning and analysis methods based on multi-module control operation should also be established.

According to the HFE plan of this paper, the Human Factor Engineering program activities will be carried out, and it is expected that the results will be applied to SDA to contribute to SDA obtainment.

REFERENCES

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