

The Safety Reviews on Human Factors Engineering of Shin-Ulchin 1 and 2 Nuclear Power Plants for Construction Permits

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1. Introduction

Based on current regulatory requirements, the staff of Korea Institute of Nuclear Safety (KINS) reviewed Chapter 18, "Human Factors Engineering (HFE)," of Preliminary Safety Analysis Report (PSAR) Shin-Ulchin 1 and 2 nuclear power plants (SUN 1&2) submitted for attaining Construction Permits [1]. The staff's review was based on implementation process plan proposed by the applicant that describes the HFE program required to develop the detailed design. Generally, for this purpose, NUREG-0800 Chapter 18 and NUREG-0711 were used to conduct the reviews of applicant submissions [2]. The objective of this paper is to present the safety review results on HFE of SUN 1&2 for Construction Permit.

2. Review Activities and Results

2.1 Documents

The applicant submitted Chapter 18, "Human Factors Engineering," of PSAR for attaining Construction Permits. In section 18.1, the applicant described an overview of the general HFE activities including the following 10 HFE program elements such as HFE program management, task analysis, human reliability analysis (HRA), human-system interface (HSI) design, HF Verification & Validation (HF V&V), etc. The section 18.2 explained an overview of the HSI in main control room with the detailed method and the section 18.3 described the design process of remote shutdown room. The applicant also submitted implementation plans and topical reports for providing detail information relating to HFE design such as HFE program plan, task analysis plan, HSI design integration plan, HSI design guide, HF V&V plan, etc.

2.2 Activities

The staff issued about 90 HFE-related requests for additional information (RAIs), the majority of which were of a clarifying nature and were satisfactorily addressed by the applicant. Some representative contents of the RAIs for HFE program review elements are as follows;

HFE Program management

- Application scope of HFE program
- HFE activities for the design of local control panel

- HFE team, organization, & responsibility
- HFE design of emergency response facilities
- HFE process management tool
- Integration with HFE and plant design activities
- Interrelationship of HFE activities for designing HSIs
- HFE design activities of subcontractors
- Management of HFE issues tracking system, etc.

Task Analysis

- Methodology of task analysis
- Scope and milestone of task analysis
- Input data and material for task analysis
- Task considerations in task analysis, etc.

Human Reliability Analysis

- Scope and milestone of human reliability analysis
- Interrelationships with the activities of other HFE program elements
- Feedback of HRA results to Shin-Kori 3 and 4 units
- HRA activities in accordance with NUREG-1792
- Operational philosophy in case that operator consoles are failed, etc.

Human-System Interface Design

- Activities of HSIs evaluation
- Style guides for detailed HSIs design
- Integration plan of HSIs design
- Design strategies for preventing human errors
- Design of safety console and minimum inventory
- Design of information display
- Design of environmental conditions and communication systems in remote shutdown room, etc.

Human Factors Verification and Validation

- Scope and milestone of HF V&V
- Availability and fidelity of validation test-beds
- Composition of V&V team
- Development of accident/event scenarios
- Determination of performance measures
- Experiment design (including Methodology of data analysis and interpretation)
- Management of human engineering discrepancies (HEDs), etc.

Review Interface of PSAR Chapter 7

- Crediting manual operator actions, especially for safety-related operator actions, as backup functions in diversity and defense-in-depth (D3) in digital computer-based instrumentation and control systems

2.3 Results

According to RAIs process, the staff had identified and resolved several issues for PSAR Chapter 18. In this paper, only some important and representative issues are provided.

Relating to the HFE program element “HFE program management”, an important concern was the scope of HFE program application; that is, in early review process, the applicant did not address of the HFE program for emergency operating facility, technical support center, and local control panel. For this issue, the applicant proposed that the scope of HFE application during the construction phase will include all areas (i.e., MCR, RSR, EOF, TSC, & LCP). In here, the HFE design applications of local control panes will be focus on the safety-related panels.

Relating to the HFE program element “HRA”, an important concern was the scope and milestone and feedback of HRA results to SKN 3&4. During the safety review of SKN 3&4 Construction Permits, relating to the HRA, the several safety concerns were issued as; (1) identification of the inter-relationship between the HRA and other HFE activities, (2) development of Performance Shaping Factors (PSFs) to be applied to the HRA, (3) identification of human error patterns and mechanisms (i.e., human error analysis), (4) development of HRA-based event scenarios for integrated system validation, and (5) integration of HRA results to PSA effectively (i.e., human error probabilities). For these issues, the applicant had developed the detail implementation plan [3], including specific approaches, methodologies, and resources. And, the safety review will be performed continuously as long-term plan till the Operating Licenses of SUN 1&2.

During the RAIs process of SUN 1&2 Construction Permits in chapter 18, the most important concern was the “analysis and validity for manual operator actions in D3 analysis” in the safety review of chapter 7, appendix 7A. According to Branch Technical Position (BTP) 7-19 of the US NRC “Guidance for Evaluation of Diversity and Defense-in-Depth in Digital Computer - Based Instrumentation and Control Systems”, the applicant should demonstrate by a suitable HFE analysis and validation that manual operator actions (i.e., safety-related and required operator actions) that can be performed inside the control room are reliable and acceptable as the automated backup functions in digital computer-based instrumentation and control systems. In this regard, Interim Staff Guidance (ISG) – 05 “Highly-Integrated Control Rooms—Human Factors Issues” are positioned as follows [4];

To credit operator actions, an acceptable method would be to demonstrate that the manual actions in response to a BTP 7-19 software CCF are both feasible and reliable, given the time available, and that the ability of operators to perform credited actions reliably will be maintained for as long as the manual actions are necessary to satisfy the D3 analysis. ---. Credited manual operator actions and their associated interfaces (controls, displays, and

alarms) must be specifically addressed in the applicant’s HFE Program. The applicant should commit, in the D3 submittal, to include the proposed D3 coping actions in a HFE Program consistent with that described in NUREG-0711.

In these regards, according to the acceptance criteria of NUREG-0711 and the details of PSAR section 7.8 and appendix 7A, the several safety concerns were issued by the staff for crediting manual operator actions as backup functions in D3 in digital computer-based instrumentation and control systems [5]. The issues can be classified into the following pinpoints; (1) clarification of safety-related and required operator actions, (2) application of ANSI/ANS 58.8 to determine the time response for safety-related operator actions, (3) analysis on HFE for determining time response of manual operator actions, (4) satisfaction of ANSI/ANS 58.8 section 3.1.5 that all safety-related operator actions to be performed in 30 minutes or less after Design Bases Events (DBEs) shall be capable of being performed in the control room, (5) satisfaction of ANSI/ANS 58.8 section 3.2.2 relating to safety-related operator actions that are required to be performed in the locations outside the control room, and (6) simulator fidelity which will be used in the integrated system validation and the validation results considering the accident scenarios in PSAR appendix 7A. For these issues, the applicant will develop the detail plan and the safety review will be performed continuously as long-term plan till the Operating Licenses of SUN 1&2.

3. Conclusions

This paper has provided the safety review results of PSAR chapter 18 “human factors engineering” in the design of SUN 1&2. During the review process, the staff had identified several issues for PSAR Chapter 18 and resolved these HFE issues. In this paper, some representative concerns and issues are provided with the post actions by the applicant. Actually these issues will be finally resolved after the Construction Permits (i.e., Operating License phase). Therefore, the staff’s review will be performed continuously during the construction phase and will perform audits that verify the application of the methodology and its results.

REFERENCES

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- [4] NRC, Highly-Integrated Control Rooms—Human Factors Issues, DI&C ISG-05, 2008.
- [5] American Nuclear Society (ANS), Time Response Design Criteria for Safety-Related Operator Actions, ANSI/ANS 58.8, 1994.