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Integrated System Validation of Barakah Nuclear Power Plant in UAE for The Human Factor Engineering

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1. Introduction

The Korea Hydro & Nuclear Power Co., Ltd(KHNP) have development APR1400 and now constructing this type six units in the KOREA and in the UAE. Simultaneously, APR1400 simulator has been developed based on the state-of-the-art object-oriented simulation technology of TH(Thermo-Hydraulic) and Reactor Core model, which is applied for the first time in the our country and for the exportation, to well simulate characteristics of APR1400. Barakah unit 1,2 simulator are constructed and supplied with this type simulator model[1]. Integrated system validation was performed using a simulator to verify the HFE(Human Factor Engineering) design of the MCR(Maim Control Room) for instrumentation and control system validation of the UAE nuclear power plant.

2. Barakah Nuclear Power Plant Simulator

APR1400 for the Barakah unit 1,2 has many specific features such as digital I&C, and digitalized main control room (MCR) design. The new human machine interface system (HMI) design concepts of APR1400 have following features [2].

- The interaction with the new control principle called “soft control” via compact workstations.
- Large amounts of data may be integrated and made available for the operators via large displays(LDPs)
- Hierarchical and access to process information is sequential.
- Operator aids increase including improved alarm management, computerized procedures, computerized operator support systems. This digital-based neo-concept main control room design needs comprehensive verification and validation process to get the license for construction.

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3. Integrated System Validation

The purpose of Integrated System Validation is to ensure the HFE design stability verification of the APR1400 plant MCR. Integrated system validation testing was carried out repeatedly by performing various scenarios using specially selected by HFE experts, operation professionals and operators objectively.

The operator was changed with every test and performed the same scenario to evaluate the weight of the derived error and objectivity of the test.

3.1 Simulator for an integrated system validation

Nuclear power plant simulator is used to test a nuclear power plant operator training and licensing. One of the features of the simulator is its application capable of simulated functionalities such as run, freeze, snapshot, backtrack and others required by ANSI/ANS-3.5[3]. The integrated system for validation should meet the requirements of “Nuclear Power Plant Simulators for Use in Operator Training and Examination”[4].

Throughout developing the simulator, for self test and verification, simulator followed criteria of ANSI/ANS 3.5 as developing standards. In order to simulate the entire range of plant, specially designed simulator has been successfully delivered to the ENEC which is plant operation company with faithful in the design criteria and developmenting to meet the requirements of the standard ANSI/ANS3.5.

The simulator design, It meets the various parts of criteria such as the interface integrity fidelity, physical & functional fidelity, environmental fidelity, data information fidelity and dynamic data fidelity of each system.

3.2 Human Factor Engineering deficiencies selection criteria

The simulator developed by KHNP(Korea Nuclear Hydro Power Co.) to purpose of education and training for operators and delivered to the ENEC was tested with various lists on site acceptance test and pre-checks carried out on the simulator during development period. Through the test, it was recognized for compliance with the performing human engineering verification test. Human Engineering Discrepancy(HED) selection criteria for deriving the HFE deficiencies are largely divided into three categories. Each priority items are divided into “Priority 1,2,3” as a significance.

The most preferred evaluation standard (Priority 1) is as follows.

A. Details on the safety affecting straightly or

indirectly(potential)
- The facts of Human faults affecting the human performance by reducing the power plant safety margins to under the acceptable levels

B. Operator safety-related HFE deficiencies or differences comparing to job requirements for operator duties.

3.3 Scenario proceedings

Scenario consists of Surveillance test, Normal operation and General operation, Abnormal operation and Emergency operation, after the Recovery operation and final shut down and so on. Totally 15 scenarios simulated operation course with qualified operators were carried out verification using the BNPP simulator under the supervision of sectoral HFE experts. The scenario procedding is presented table 1 and Fig. 1 showsIntegrated system validation was successfully completed.

Table I: Scenario proceedings

No	Procedures	Time (min)
1	Initial condition set-up of simulator Recording equipments(Video/Audio, toally 6) & communication equipents(Page phone/ telephone) installation	-
2	Pre briefing : Taking over(Plant initial condition & others)	15
3	Test start : Surveillance test, Normal and General operation → Abnormal operation → Emergency operation → Recovery operation and shut down operation.	120 ~ 180
4	Debriefing : Operator questionnaire, Q&A(Inspector & Operator) Data acquisition of scenarios Listing of Human Engineering Discrepancy(HED)	30 ~ 60

Fig. 1. Verification perform(LT), Data acquisition(RT)
FANR inspection (LB), De-briefing (RB)

3.4 ISV results & De-briefing

The ISV evaluation for BNPP was conducted and successfully tested with various scenario including events. However, various opinions & suggestions have been derived for the fidelity during the test.
For example, It has been found that the right side of QIAS-N MMI display was blanked. It can cause the incorrect understanding of system. Also, there were some problematic issues on the visual presentation of textual information in terms of display elements, such as font size and type, line space, background color, etc. After test the ENEC had requested to provide the all of source code to maintain the simulation system. This issue will be resolved by consultation with each other. In case of CPS, it has been verified that the CPS has no problems in view of system as well as procedure.

4. Conclusions

From January 2016 to February, during six weeks, the tests carried out three times repeatedly and the various proposals for ergonomical satisfactation were derived.
However, the HFE errors that cause significant change of validation target for APR1400 MCR design safety fidelity wasn't found. This has resulted in the conclusion to prove the stability of the basic design of APR1400 MCR. In the future, using the simulator derives the HFE requirements of the MCR systems and continually improve the simulator will be built in close to real high-fidelity power plant. These Integrated system validations are likely to be a great help in operating safety and preventing human errors by operators.
Therefore successful completion of the Integrated System Validation for BNPP simulation will be effective to promotion the distinction of our simulator and APR1400 NPP.
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