

## Performance Test for Shinkori Units 5&6 Simulator

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### 1. Introduction

KHNP CRI is working on a project to develop a simulator for Shinkori Units 5&6(SKN5&6). The Shinkori Units 5&6 simulator simulates the dynamic behavior of APR1400 nuclear power plants and human machine interface (HMI) that can monitor and control them. The Shinkori Units 5&6 simulator is being developed in several improved directions based on the development experience of the existing APR1400 simulator such as Shinkori Units 3&4 and Shinhanul Units 1&2. And Performance tests for performance verification of newly developed Shinkori units 5&6 simulator is carried out twice.

In this paper, we want to explain the features and performance test of Shinkori units 5&6 simulator.

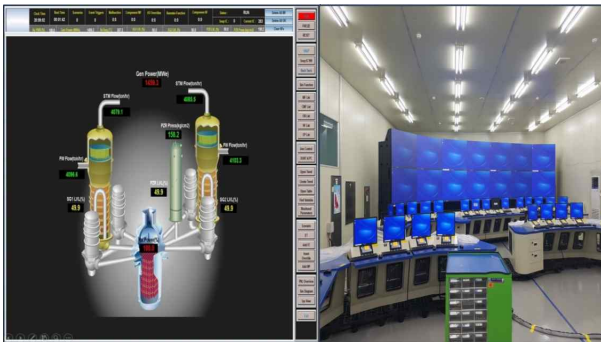


Fig. 1. SKN5&6 development screen and integrated site

### 2. Shinkori units 5&6 features

There are several main features of the Shinkori Units 5&6 simulator. These features will improve utilization of the simulator compared to previous simulators.

First of all, The HMI screen development of the safety system and the non-safety system is developed in an emulation method using one tool for easy maintenance. The sim-diagram screen of the instructor control panel is expanded to a screen can be modeling so that instructors can simulate various plant conditions. Compared to conventional simulators, we have expanded the modeling of valves, pumps, tanks, etc., improving the fidelity of the simulator.

Secondly, one of the follow-up measures to Fukushima was to be reflected in the Shinkori units 5&6 simulator. It is developing an interface to operate a severe accident module developed with MAAP5 code (severe accident analysis code) in conjunction with a

simulator and to facilitate smooth implementation from normal state to severe accident.

Thirdly, three-dimensional graphics implementation was made possible to enhance visual effects for education and training of serious accidents.

Fourthly, due to accidents such as SBO, power loss for control of instruments such as safety control panels and operation valves is implemented and developed to be the same as actual behavior of the plant during the simulation training.

Finally, it will improve the fidelity of the simulator by reflecting the design changes issued by the reference plant after the completion of the acceptance test and reflecting the parts not reflected after the design data freeze date.

### 3. Simulator Performance Tests

#### 3.1 Overview of Performance Tests

The performance test selected 106 test items in accordance with the requirements for the simulator International Standard Performance Test (ANSI/ANS3.5-2009) specified by the American Standards Association.

As mentioned earlier, this performance test will be carried out twice. The first is the factory acceptance test(FAT), where hardware and software are integrated into the hardware manufacturing plant, and the second is the site acceptance test(SAT), where the facility is transported to the Shinkori units 5&6 simulator site.

Each test procedure is prepared, approved, and performed. If a problem occurs in a performance test, a Discrepancy Report (DR) is issued, and when the DR is modified, a retest is performed to verify the performance of the simulator. Some procedures were carried out three or four times to resolve discrepancies.

#### 3.2 FAT (Factory Acceptance Test)

It will be developed for about 48 months from April 2018 to March 2022 for the Shinkori Units 5&6 simulator. The new hardware and software developed are integrated to perform performance acquisition tests of FAT and SAT. The FAT conducted 106 tests for about three months from August to November 2020, and the test items were as follows. 9 common test including hardware I/O test, 15 normal tests including power operation from 100% to 75%, 66 abnormal tests including loss of off site power, 4 Steady State tests

including 100% power steady state operation test, 11 transient tests including RX manual trip and 24hr operate tests were conducted. The FAT was attended by MCR operation expert and operators of Shinkori Units 3&4 and simulator expert of CRI.

#### 4. Results

The test results table shows how many tests that the KHNP conducted to meet the requirements. Each test took about few hours to maximum of two days needed to be spent. The FAT results were all satisfactory. The completed tests were attached by a signed procedure and a graph of the results. During the FAT performance test, about 700 discrepancies were issued and almost solved before SAT.

Table. 1. FAT Test Result

Test Type	Q'ty	Tested		Completion rate(%)
		pass	fail	
Common	9	9	0	100.0
Normal	15	15	0	100.0
Abnormal	66	66	0	100.0
Transient	11	11	0	100.0
Steadystate	4	4	0	100.0
24hr operation	1	1	0	100.0
<b>Total</b>	<b>106</b>	<b>106</b>	<b>0</b>	<b>100.0</b>

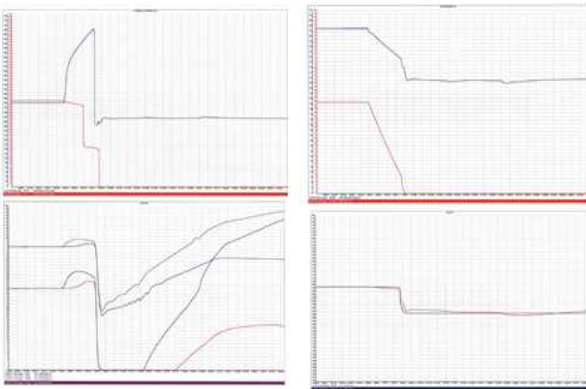


Fig. 2. Examples of SKN5&6 FAT result graphs such as letdown flow, PZR Press, SG level, and T-average.

#### 5. Conclusions

The FAT was successful since the troubles were corrected and retests were confirmed by the operator. KHNP learned the frequent troubles that occur while testing the simulators. After resolving the DRs from the FAT, the shinkori units 5&6 simulator (including H/W and S/W) was transported to shinkori units 5&6 sites.

Now SAT of the simulator is ongoing. After the SAT, ISV (Integrated System Validation) for verifying the design of the main control room is scheduled for Shinkori units 5&6 in the simulator.

The Shinkori Units 5&6 simulator will be used to secure licenses for operators and train the main control room personnel regularly.

#### REFERENCES

- [1] ANSI/ANS-3.5-2009, "Nuclear Power Plant Simulators for Use in Operator Training and Examination," American Nuclear Society, La Grange Park, IL, September 2009
- [2] U.S. Nuclear Regulatory Commission, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examination, and Applicant Experience Requirements", Regulatory Guide 1.149 Revision 4, May 2010