Development of OSSA(Operation Service Support Agreement) Simulator and Site Acceptance Test

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1. Introduction

United Arab Emirates and South Korea has signed the construction contract to build nuclear power plants valued at about 20.4 billion. It was the first nuclear power plant that South Korea exports in the nuclear industry. Barakah Nuclear Power Plant's reference plant is Shin-Kori #3,4 and Unit 3 has connected to the grid since January[1].

Building the nuclear power plant is on the schedule, remaining question is who could operate the NPP after the construction is finished. OSSA is known as Operation Service Support Agreement, it is the contract between KHNP(Korea Hydro and Nuclear Power Co.,) and ENEC(Emirates Nuclear Energy Corporation) for United Arab Emirates Nuclear Power Plant operations support. The contract is mostly about the safety and reliability operations and as well as of the training of UAE operators to have better experiences. KHNP and ENEC have signed this contract about $880 million on 24th of July[1].

UAE operators needed to be trained and tested before they come to UAE for operate the NPP. The OSSA simulator was built because operator shall not make any mistakes even if the plant is not yet constructed. Simulator Training is a key for getting experiences without operating the actual plant, because the nuclear power plant never used as the test in real situations. Operators' requirement is to have more than 2 years at site experiences and also they have to be trained 5 to 8 months of the training. Operators also tested by the regulator for evaluations during the training.

Fig. 1. The Overview of OSSA simulator

2. Summary

In this section, summary of the test is described in Table 1.

Table I: Test Summary

Test Periods	Plan	Actual
	July 08 ~ July 31	July 08 ~ July 27
Place	OSSA Simulator MCR at Shin Kori	
Partici-pants	Operation Team(14) Education Team(14) Central Research Institute(2) Training Team(2) Regulator(3)	

As you can see from the above table, the test plan was from July 08 ~ July 31 of 2015. But actual periods got shorten since the test result came fast and many participants were involved and worked hard to meet the test requirements.

Table II: Test Results

Test Type	Q'ty	Tested		Completion rate(%)
		Pass	Fail	
Common	1	1	0	100.0
Normal	12	12	0	100.0
Transient	11	11	0	100.0
Total	24	24	0	100.0

The test results table shows how many tests that the KHNP conducted to meet the requirements. 1 common hardware test, 12 normal tests, and 11 transient tests were conducted. Each test took about few hours to maximum of two days needed to be spent. The test names are specifically written in Table 3.

Table III: Test Name

No.	Test Type	Operation Mode	Procedure Name
1	Common	-	Hardware Test
2	Normal	1	Power Operation from 100% to 75%
3	Normal	1	Power Operation from 75% to 50%
4	Normal	1	Power Operation from 50% to 2%
5	Normal	3	Power Operation from 2% to Hot Standby
6	Normal	3 → 4	Shutdown Operation from Hot Standby to Hot Shutdown
7	Normal	4 → 5	Shutdown Operation from Hot Shutdown to Cold Shutdown
8	Normal	5 → 4	Startup Operation from Cold Shutdown to Hot Shutdown
9	Normal	4 → 3	Startup Operation from Hot Shutdown to Hot Standby
10	Normal	3 → 1	Startup Operation from Hot Standby to 25%
11	Normal	1	Power Operation from 25% to 100%
12	Normal	5 → 6	RCS Drainage to Mid-Loop
13	Normal	5	RCS Filling and Vent
14	Transient	DBA	Inadvertent RX Manual Trip
15	Transient	DBA	Simultaneous Trip of All Feedwater Pumps
16	Transient	DBA	Simultaneous Closure of All Main Steam Isolation Valves
17	Transient	DBA	Simultaneous Trip of All Reactor Coolant Pumps
18	Transient	DBA	RCP Trip 1A,1B,2A,2B
19	Transient	DBA	Turbine Trip
20	Transient	DBA	Maximum Rate Power Ramp from 100% Down to 75% and Back Up to 100%
21	Transient	DBA	Maximum Size Reactor Coolant System Rupture Combined with Loss of All Offsite Power
22	Transient	DBA	Maximum Size Unisolable Main Steam line Rupture inside Containment
23	Transient	DBA	PZR POSRV Stuck Open
24	Transient	DBA	Maximum Design Load Rejection

OSSA simulator is copied version of UAE simulators. The site acceptance tests for UAE simulator that we conducted had more than 120 tests. KHNP and ENEC knew that the OSSA simulator is copied version of UAE, so we have decided to optimize the test on OSSA simulator. Even though we optimized the test we still covered as much as possible to applicable to ANSI/ANS-3.5(1998). The tests has the operation mode from 1 to 6 and has Design Based Accidents tests were included.

Fig. 2. Desktop Simulator

The desktop simulator was created and idea comes from ENEC operation team, it is helpful tool and uses various ways such as simulator verification, operator training, instructor tool, and etc. Fig 2 shows the desktop simulator.
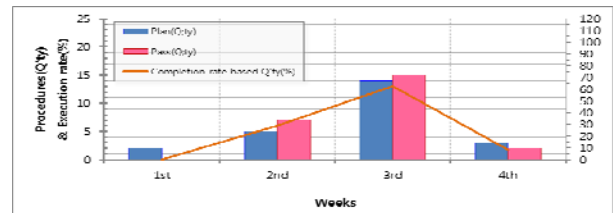

Fig. 3. Plan vs. Pass Rate, and Completion rate based on the quantity of the tests

The plan vs. pass, and completion rate based on the quantity of the tests shows in Fig 3. The first week started in July 08, the plan was to finish some tests but the test could not be finished. However 2 more tests compare to the plan was finished in the second week. Third week also 1 more tests compare to the plan was passed. Fourth week the plan was to finish 3 tests but only two tests were remained and remain tests were all passed.

3. Conclusions

The experience such as the site acceptance test will lead the future nuclear industry to meet the global standard and to lead the safety of the NPP. Under the OSSA agreement 400 KHNP experts will support the operations. Most of the operators were trained at the OSSA simulator which is most reliable simulator that can demonstrate satisfactory performance for the simulator.

REFERENCES

[1] World Nuclear News, Agreement assures Korean export support for UAE plant operations, World Nuclear News, 25 July 2016.
[2] Mun-Soo Kim, Jin-Hyuk Hong and Myeong-Soo Lee, Development of Simulator Model and Acceptance Test for BARAKAH Unit 1(APR1400 Simulator), ICAPP 2015, p.15251, 2015.