

## The Results of ISV for BNPP Computerized Procedure System

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### 1. Introduction

CPS(Computerized Procedure System) is being applied in the BNPP(Barakah Nuclear Power Plant) as the operation support system of the digital main control room. CPS HFE(Human factors Engineering) V&V(Verification & Validation) has to be performed according to the HFE regulatory requirement. Therefore, recently we had performed Integrated System Validation (ISV) as HFE V&V for CPS. ISV is an evaluation using performance-based test to determine whether an integrated system design (i.e., hardware, software, and personnel elements) meets performance requirements and supports the plant's safe operation. Because CPS is included in a part of the MMIS, CPS was also tested in the BNPP simulator with the other MMIS to verify whether or not CPS related issues are resolved and there are other issues. This paper introduces the ISV result for BNPP CPS.

### 2. ISV Methods and Results

ISV was conducted using BNPP simulator in Barakah NPP site. It took a week for a pilot test. Also, Main test was conducted for about 2 months. Three operation crews (5 people per crew) participated in this experiment. Details are indicated in Table 1 below.

Table1 Schedule for UAE CPS Usability Validation

Evaluation	Date	Performance details	Participants
Pilot test	' 15.07.16 ~' 15.07.20	<ul style="list-style-type: none"> <li>○ Conduct ISV scenario</li> <li>○ Check ISV facility (Simulator)</li> </ul>	<ul style="list-style-type: none"> <li>○ Operation crew</li> <li>○ CPS designer</li> <li>○ Simulator developer</li> <li>○ HFE specialist</li> <li>○ Process expert</li> </ul>
	' 15.11.26 ~' 15.11.30	<ul style="list-style-type: none"> <li>○ Conduct ISV scenario</li> <li>○ Check ISV facility (Simulator)</li> </ul>	<ul style="list-style-type: none"> <li>○ Same as the first Pre-test</li> </ul>
Main test	1st ' 16.01.14 ~' 16.01.21	<ul style="list-style-type: none"> <li>○ Conduct ISV scenario</li> <li>○ Conduct a survey</li> <li>○ Debriefing</li> </ul>	<ul style="list-style-type: none"> <li>○ Operation crew</li> <li>○ CPS designer</li> <li>○ Simulator developer</li> <li>○ HFE specialist</li> <li>○ Process expert</li> </ul>
	2nd ' 16.01.25 ~' 16.02.05	<ul style="list-style-type: none"> <li>○ Same as the first main test</li> </ul>	<ul style="list-style-type: none"> <li>○ Same as the first main test</li> </ul>
	3rd ' 16.02.19 ~' 16.02.27	<ul style="list-style-type: none"> <li>○ Same as the first main test</li> </ul>	<ul style="list-style-type: none"> <li>○ Same as the first main test</li> </ul>

#### 2.1 Method

KEPCO E&C A/E led the ISV test according to the ISV scenarios and KHNP CRI verified whether or not CPS related issues are remained in view of the CPS. HFE specialists participated in the Integrated System Validation for Barakah NPP. The HFE specialist observed ISV test and conducted a survey. After the surveys, he conducted debriefing with operation crew. HFE specialists have a great understanding of HFE, cognitive engineering for operation support system, and digital Main Control Room (MCR) including CPS. The HFE specialist drew the items to be solved and improved by collecting the result of observation and interview, and evaluated importance considering opinions from participated HFE specialists.

#### 2.2 Scenario used for evaluation

Evaluation scenarios for ISV were applied to comprehensively test MMIS including CPS. Details of the scenarios such as malfunction injection by time, evaluation point of the scenarios are indicated in the BNPP 1&2 HFE V&V Scenarios. AOP, ARP, EOP, and GOP are provided as computerized procedure and the other procedure (SOP etc.) are provided as backup hardcopy procedure. CPS Fail event is injected depending on the scenario. Backup hardcopy procedure is used in this case as computerized procedures are not available.

#### 2.3 Evaluation Facility

The facility used for ISV is BNPP simulator, established in the Barakah NPP site. This facility was used for operator training of BNPP Units 1&2. Computerized Procedure can be displayed in the Information FPDs of each operator's console in the BNPP simulator. The CPS used in this evaluation is same as that of BNPP Units 1&2. The CP(Computerized Procedure)s used in this evaluation is same as those of Barakah NPP.



Fig.1. UAE BNPP Simulator

## 2.4 Evaluation Result

CPS and CP related issues can be verified through the ISV. CPS related issues correspond to the system platform such as CPS display frame and CPS function. CP related issues correspond to the contents of CP such as use of positive sentence and arrangement of instruction within one step. CP related issues can be modified by procedure writers.

CPS related issues were not detected in this ISV. This is because CPS issues have been filtered through the SKN 3&4 construction phase. But, CP related issues were detected in this ISV as shown in Table2. This issues could be recovered through the procedure writer's guide or operator training. Korean operators who are preparing for dispatch to UAE and startup operation participated in the evaluation for the ISV. They all communicated in English during the evaluation. The questionnaire is written in English, and operators answered in Korean after reading the questionnaire. Debriefing was conducted in Korean. Although Korean operators communicating in English, because Korean operators had been trained by operation protocol (OSSA training) and communication experience of BNPP, there were no particular problems in executing English CPS. Although operator crews executes complex scenarios with the CPS, the time had little delayed for operators to understand the meaning of sentences, and operators spent almost same time in executing the scenario compared to the execution of the CPS in Korean. It took a long time for operators to perform the operation by one scenario, because the scenario itself is complex and has multiple events. CP issues such as emphasis of conditional terms(Less Than or Greater Than) and accurate use of action verbs, etc., was resolved and already reflected in the sentences of computerized procedure of BNPP. Table 8 shows resolution of the remained main issues from the last CPS centered V&V.

Table2 summary of main CP issues and resolution

	Remained Issues	Resolution
1	Insufficient emphasis of conditional terms	It is observed that an operator went to accurate step through the emphasis of conditional terms, that is, bold type of conditional terms is consistently applied. There is no case to go wrong step in the ISV scenarios. Average value of related issue's evaluation(Questionnaire No.6) from operator's survey marks 4.93.
2	No protocol for supporting communication in English	Although non-native English speakers communicate in English, the communicated messages were more clear among operators than before test. Because Korean operators had been trained according to operation protocol(through OSSA training) and communication experience of BNPP(It seems that there was no communication problem due to the normal practice of English), there were no particular problems in operating and executing English CPS. Communication problem does not happen under even a time-critical situation like EOP operation. Some reason to judge that there are no particular problems is as follows.

		○ There was consistency in the sentence expressions of Shift Supervisor's order within the operator crew. This is because operators had been trained according to the simulator training. Also, operator crews had consistent pattern to read numbers.
3	Inaccurate definitions of Action verbs used in EOP	Consistent Action verbs were used in the procedures. Operators acknowledged exact meaning of Action verbs.
4	Inconsistent use of sentences and words of SFSC	The same contents of SFSC (Safety Function Status Check) were written in same words and sentence expressions in each EOP. STA could perform procedure according to SFSC without problem.
5	Lack of operators' recognition about concurrent/in dependent verification step	All of operators could perform concurrent/independent verification step according to the procedure without missing. Average value of related issue's evaluation(Questionnaire No.7) from operator's survey marks 4.86.
6	Incongruent sentence structure of instructions	If conditional sentence is written in procedure, Conditional terms(such as IF, THEN, AND etc) is emphasized with thick character and underline is added in case of "IF or THEN". This rule is consistently applied in all of the procedure. We didn't find out the case that operators misunderstand procedure contents including conditional sentence. Average value of related issue's evaluation(Questionnaire No.1) from operator's survey marks 4.93.
7	Incongruent 'Key Step' design	Operators could easily recognize the Key Step through the training. We observed that operators frequently perform similar activity like 'Key Step' in the meanwhile of operation.

## 3. Conclusions

CPS has been tested many times from the APR1400 R&D phase to BNPP construction phase through SKN 3&4 construction phase. BNPP ISV evaluation was conducted and successfully tested with various scenario including events, and it has been verified that the CPS has no problems operating procedures in view of system as well as procedure. Operators successfully performed the operation including accident with CPS and MMI resources such as alarms and display.

## REFERENCES

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