Development of a Validation Tool for the SPADES of SKN 1&2

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1. Introduction

Plant Monitoring and Annunciator System(PMAS) of Shin-Kori(SKN) 1&2 is a newly developed system based on the outputs of Korea Standard Nuclear Plant Plus(KSNP+) project. Throughout the development processes, the quality of the PMAS has been tightly monitored per the specialized quality control program which has been applied to the first of kind products. However, in the cases of the legacy Plant Monitoring Systems(PMS) from YGN 3&4 to UCN 5&6, significant amounts of site services were provided to resolve the functional and design flaws which had been found during the first 3 years operation after commissioning. Because the software packages of the monitoring system are very large and complex, it is well known that all functional flaws could not be found by the unit tests and integration tests.

To increase the quality of the monitoring system during the implementation stage, and to perform enough dynamic tests which are similar or equivalent to the field adaption tests, a validation tool for the monitoring system has been developed to provide input signals similar to the actual plant operation modes. To develop the validation tool, a sample sub-system, Safety Parameter Display and Evaluation System(SPADES) was selected as test target. Because the SPADES of SKN 1&2 project has been developed from the scratch, most of the system functions have been newly developed by the dedicated Task Force Team for SKN 1&2 project which means the SPADES was the suitable system to be the test target. This paper summarizes the contents of the validation tool development and its application result.

2. Selection Background of SPADES

2.1 SPADES Design Change of SKN 1&2

As a sub-system of PMAS, the SPADES is designed for the monitoring of the normal and abnormal operations to support the post accident operations of the plant. Because the Critical Function Monitoring System(CFMS), which is the legacy system of SPADES, has some design mismatches compared with the Emergency Operation Procedures(EOP), it was decided to develop a new critical function monitoring system from the scratch in SKN 1&2 construction project.

2.2 Reason for the Selection as a Test Target

The developed SPADES(Figure 1) is a big scale system which consists of more than 200 display pages and a server program. After development, new SPADES come out about 10 times bigger than its legacy system, the CFMS. Due to the complexity of the functions and scale of the system, many efforts for the Verification and Validation(V&V) tests had been performed to achieve the quality goal. However, considering that the most functions of the SPADES are used only when an emergency operational status, the possibility of the detection of the functional defects is very low during the plant life time. Also, it is not realistic to perform an emergency operation tests for the validation purpose of the SPADES in the actual plant. Therefore, it will be very helpful to enhance the completeness of the system if a validation tool is provided which can supply the plant data of emergency operations. With above reasons, the SPADES was selected as the best test objective among sub-systems of the PMAS.
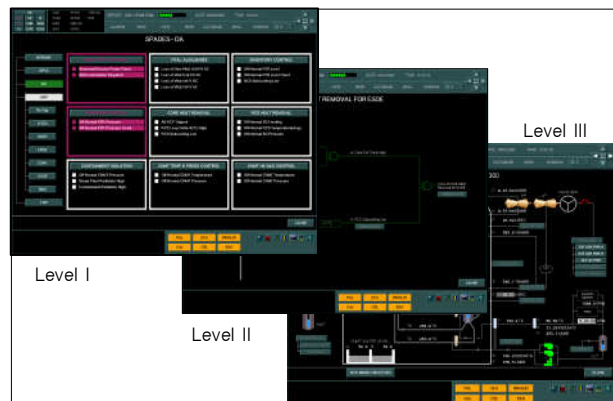

Figure 1. SPADES Operational Displays

3. Development of Validation Tool

3.1 Virtual Plant

A simulator, called Window based Nuclear Plant Analyzer(Win-NPA), has been modified to take the role of the virtual plant. The Win-NPA is an interactive, high fidelity, real-time engineering simulator for nuclear power plants. The Win-NPA consists of the process model simulating the plant behavior, graphical user interface (GUI), and simulation executive for enhanced user interface. Its simulation capability

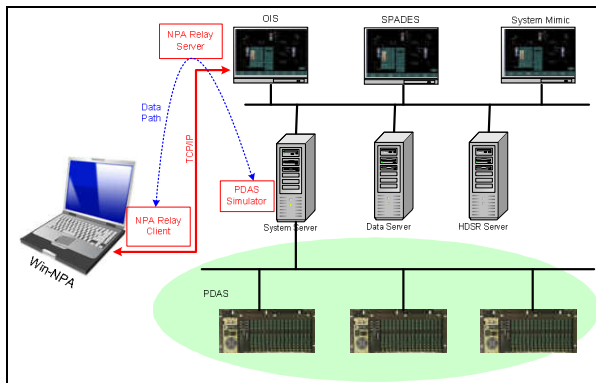covers a wide range of nuclear power plant operations including normal, abnormal, and accident conditions.

Figure 2. Configuration of Validation Test

3.2 Validation Methodology

The new monitoring algorithms of SKN 1&2 SPADES had been designed and verified with the NPA which is the SUN/Solaris version of Win-NPA. This means that if the implemented SPADES is tested with connection to Win-NPA in on-line fashion, the test results can be used to judge the correctness of system functions. Figure 2 shows the configuration of validation test which was developed based on this idea.

3.3 Signal Interface

The number of inputs of SPADES, necessary for the validation test, was identified as many as around 300 variables. To reduce costs and labors for the hardwiring, it was decided to connect the signals via Ethernet TCP/IP communication. The module NpaRelay is a software package for the relay of signals from Win-NPA to the database of PMAS. The NpaRelay client is installed in a Operator Interface Displays(OISs) and NpaRelay server module is installed in Win-NPA side. Figure 2 shows the configuration for the signal interfaces between PMAS and Win-NPA.

To supply the SPADES input signals from the Win-NPA, the list of pairs for the Point ID(PID) of the PMAS and the variable of Win-NPA was generated for 221 points. An engineering unit conversion program was developed for these to match the units. In case of discrete signals, inversion function was included for the consistency of the physical meanings of states.

4. Tests and Results

4.1 Test Event

The SPADES consists of 10 operational modes supporting the corresponding emergency operation procedures (Figure 1). The tests were performed to verify that the simulation input signals are transmitted correctly to the SPADES depending on the specific

event via NpaRelay Module. Also the response time was necessary to verify that the test inputs signals (221 points) could be transmitted in real-time(once in every second). The Steam Generator Tube Rupture(SGTR) accident was simulated by the Malfunction Generator of Win-NPA to verify these.

4.2 Test Result

After executing Win-NPA, SGTR event of one-tube with amount of 21 kg/sec was simulated with the Malfunction Generator tool. The supplied 221 signals were recorded in Win-NPA Trend Viewer and PMAS HDSR program. The data received by the PMAS was analyzed to be same to the generated data by the Win-NPA. The validation test results for the SGTR mode of the SPADES operation was acceptable with respect to appropriate acceptance criteria. Figure 3 shows that simulated signals of Win-NPA and PMAS are coincident to each other in additional test.
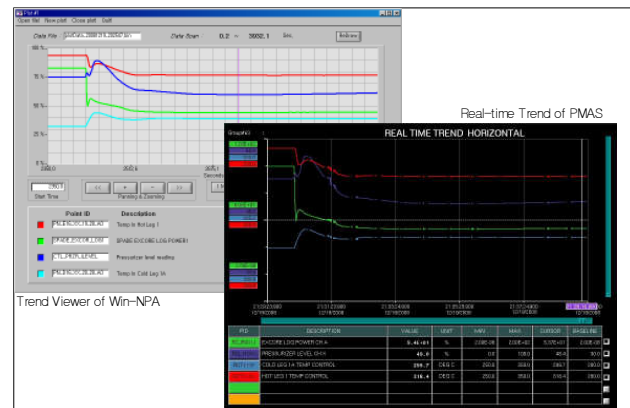

Figure 3. Simulation Results of Reactor Trip Event

5. Conclusion

A validation tool for the SPADES of SKN 1&2 has been developed for the tests of emergency modes of operations. A test for the SGTR event was performed and the result was acceptable. It is concluded that the developed validation tool is effective methodology for the tests of the SPADES.

Because the Success Path Monitoring(SPM) is added to the SPADES of SKN 3&4 and the system platform will be changed in Shin Ulchin 1&2, this test tool can be applied to enhance the completeness of the SPADES.

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