# Periodic Surveillance Testing Improvement Approach for the Digital Plant Protection System

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## 1. Introduction

Periodic Surveillance Testing (PST) Improvement Project is being performed by Korea Power Eng. Company, Inc. (KOPEC) as a contractor of Korea Hydro and Nuclear Power Co. Ltd (KHNP) together with Westinghouse Electric Company LLC (WEC) as a subcontractor. Plant Protection System (PPS) is not required during normal operation. Thus, the integrity of the PPS shall be confirmed via the periodic tests. However, the testing of Digital Plant Protection System (DPPS) takes too long time compared to that of the analog PPS. The excessive testing time imposes too much burden on the plant operator and could be a cause of human error. Thus, the test improvement for DPPS is needed to reduce the testing time. The improvement approach for the DPPS PST provides the recommended surveillance improvement to make the testing time shorten.

## 2. Methods and Results

In this section the approach and basis for the test improvement are described.

### *2.1 Improvement Approach*

The improvement approach takes credit for self-testing diagnostics which is provided with system, requires the system hardware to be tested periodically, but does not require the software to be periodically tested. Credit is taken for software operability based on the verification and validation testing that was previously-performed along with the continuous monitoring embedded and live CRC software codes.

Almost all hardware errors and inadvertent changes to the software are detected and alarmed in the control room via the DPPS channel system trouble alarm. The checks verify that the software has not changed and there are no alarms. The improved tests demonstrate that hardware beyond the scope of the embedded diagnostics shall be tested periodically. The improved surveillance does not alter the DPPS design, including test features, in any way. Some redundant tests are eliminated; others are assigned to an 18-month Surveillance Test Interval (STI) rather than the present 31-day STI. However, the basic design and testing philosophy remains unchanged. As such, compliance to the test standards [2, 3] is maintained. Figure 1 shows the UCN 5&6 DPPS/DESFAS-AC Testing Overlap. This figure provides an overview of manual and manually-initiated automatic testing, including software and hardware. The testing performed by the Automatic Bistable and Local Coincidence Logics Testing is not required in the improved approach because the software does not change and the combination of manual testing and the embedded self-testing diagnostics can identify the any errors these tests would identify.

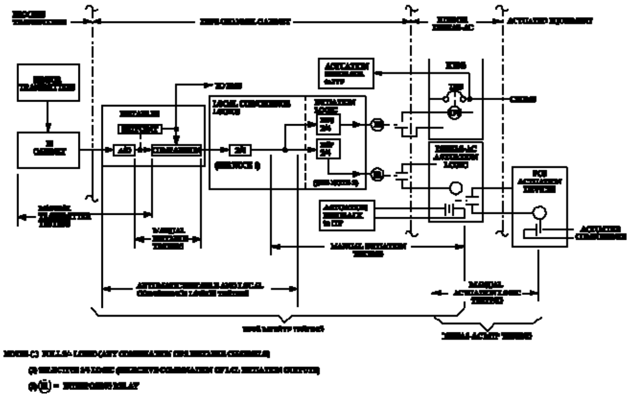

Fig. 1. DPPS and DESFAS-AC Testing Overlap

### *2.2 Basis*

The improved AC160-based DPPS Channel Function Test (CFT) takes an approach similar to that used for the AC 160-based Common Q Core Protection Calculator System (CPCS) that is used at Palo Verde and approved by the United States Nuclear Regulatory Commission (USNRC). BTP HICB-17 [2] indicates that digital computer-based instrumentation and control systems are prone to different kinds of failures than are traditional analog systems. BTP HICB-17 requires that surveillance testing, taken together with automatic self-testing, should provide a mechanism for detecting all detectable failures.

The AC160 performs diagnostic and supervisory functions to continuously monitor the whole system for correct operation; each type of AC160 module has its own diagnostic functions. The AC160 monitors the system, as a whole, by collecting all the diagnostic information and checking the consistency of the hardware configuration and the application software.

Application automatic self-testing can also be continuously performed at the MTP referred to as "Normal Testing" which provides the on-line surveillance comparison for the parameter Setpoint values. In addition, Normal Testing monitors the process values and each channel performs a Cross Channel Comparison value check.

Operating experience in Table 1 indicates that all system failures which occurred were successfully detected via the continuous, self-testing diagnostics provisions, for any given 18-month interval.

Table 1. Operating History for DPPS/DESFAS-AC

| System & Unit | Equipment Name | Failure Mode/Maintenance Method | Method of Detection | Operating Time (day) |
|---|---|---|---|---|
| DESFAS-AC 6 | Opto-Coupler (CH A) | Intermittent malfunction occurred / replaced | Actuation Alarm | 236 |
| DESFAS-AC 6 | Fiber Optic Receiver (Ch A) | Internally short circuit / replaced | Normal Test | 473 |
| DPPS 5 | MTP Display | Power supply fail / replaced | N/A | 875 |
| DPPS 5 | PM646A (CH A) | LCL 1 processor fail (Code: 0A) / replaced | Self-diagnostics | 69 |
| DPPS 6 | Bypass Switch | Human error / NA | NA | 69 |

UCN 5&6 : Total 76 ea AC 160 Module
Commercial Operation : Unit 5 : From 2004.07.29, Unit 6 : From 2005.04.22

### *2.3 Improved Surveillance Test*

The DPPS provides an extensive and continuous automatic diagnostic suite including Normal Testing that is capable of detecting the majority of hardware and software failures. As such, additional software tests are not required to be performed during the 31-day frequency CFT.

However, digital input and output contacts used for alarms, trips and nuisance alarm are not tested by self-testing diagnostics since doing so would cause a channel trip, actuation or nuisance alarm. Therefore, the 31-day frequency CFT should test all hardware that performs a safety function or indication. It identifies the failure of a component identifying loss of function (e.g., DPPS trouble) by manual testing and verification that the continuous diagnostics are operating correctly with no errors detected. This test requires operation of the trip-actuating device, or other digital contact, and verification of the channel operability. This test is applied to the reactor trip breakers, DO module contacts, initiation logic circuitry, initiation relays, Under Voltage (UV) relays, Shunt Trip relays, operating bypass switches and manual variable setpoint reset control switches. Tests include the entire signal path including actuation of the end devices.

The basis for the 18-month frequency is that the DPPS performs a continuous, self-monitoring function. This eliminates the need to perform all CFT at a 31-day frequency. This 18-month frequency CFT essentially validates the self-monitoring function; it checks for a small set of failure modes that are undetectable by the self-monitoring function.

## 3. Conclusions

The integrity of hardware and software will be confirmed by Self-diagnostics running continuously as background operations and the Normal Test. The software will be checked automatically by CRC function. The improvement approach is that hardware beyond the scope of the embedded diagnostics be tested periodically; e.g., 31-day intervals for hardware that performs a safety function and 18-month intervals for hardware that does not perform a safety function.

## ACKNOWLEDGEMENT

This study is in progress under the project, “Periodic Surveillance Testing Improvement for UCN 5&6 Digital Plant Protection System” sponsored by Korea Hydro and Nuclear Power Co. Ltd (KHNP). WEC as a subcontractor has been providing the technical report [1] for the recommended tests.

## REFERENCES

[1] Robert L. Rescorl, Joseph E. Burns, James W, Pfeifer “Periodic Surveillance Testing Evaluation Improvement Report for UCN 5&6 Digital Plant Protection System”, Westinghouse Electric Company LLC, Pittsburgh, PA, 2007.
[2] Branch Technical Position HICB-17(Rev.4), “Guidance on Self-Test and Surveillance Test Provisions”.
[3] IEEE338-1987, “IEEE Standard Criteria for the Periodic Testing of Nuclear Power Generating Station Safety Systems”.