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The Fifth (5th) Design Improvement of NSSS Integrity Monitoring System

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1. Introduction

All OPR1000 and APR1400 plants have been designed with the NSSS Integrity Monitoring System (NIMS), which generally includes four subsystems, i.e., Acoustic Leak Monitoring System (ALMS), Internals Vibration Monitoring System (IVMS), Loose Parts Monitoring System (LPMS) and RCP Vibration Monitoring System (RCPVMS). The NIMS design has been continuously improved in both System Design (SD) and Component Design (CD) aspects by KOPEC and WEC, respectively. As the NIMS evolved from YGN3&4, UCN3&4, YGN/UCN5&6, SKN/SWN1&2, and now SKN3&4, a total five times of major improvement have been implemented. The fifth (5th) design changes have been made for Shin-Kori Nuclear Power Plant Units 3 and 4 (SKN3&4), which are under construction as the first plant of APR1400. This paper briefly describes the SD and CD improvements for SKN 3&4 NIMS in order to provide public understanding.

2. Design Improvement Features

2.1 System Platform

Considering the nuclear power plant lifetime, a standard H/W platforms and a proven Operating Systems (OS) is preferred. A system with industrial PC's, Windows OS, and Graphic User Interface (GUI) functions has nearly become an industry standard [1].

For Shin-Kori Units 1 and 2 (SKN1&2) and Shin-Wolsong Units 1 and 2 (SWN1&2), which are the last constructing plants of OPR1000 in Korea, all of the NIMS subsystems, except for the LPMS, had reached the goal of standardization. The SKN1&2 and SWN 1&2 LPMS computers consists of several different H/W platforms (i.e., PC, AlphaServer, and STD Bus) and OS's (i.e., MS-DOS, Win-98, Win-XP, OpenVMS) for its four computers.

For SKN3&4, all NIMS subsystems, including the LPMS, are designed using same Windows-based industrial PC and all employ National Instrument's LabVIEW™ software platform.

In SKN1&2 and SWN1&2, because of the mix of OS's, all of the LPMS computers could not be remotely controlled from the NIMS Operating Station (NOS) PC. Because of the mix of programming languages, and all of the NIMS computers could not pass their data over the Ethernet LAN, so several serial datalinks were employed. For SKN3&4, the use of LabVIEW on Windows PC's for all sub- systems, including the LPMS, has allowed four Alarm Unit (AU) computers (one for each subsystem), to be connected to the NIMS LAN. Each subsystem alarm unit can be remotely controlled from the NOS computers through the LAN.

For SKN3&4, the NIMS equipment configuration is much simplified compared with the previous plants. The SKN1&2 NIMS consist of two cabinets, one in MCR, and the other in Computer Room. However, for SKN3&4, only one cabinet, Alarm Unit Cabinet (AUC), will be provided in the I&C equipment room.

For SKN3&4, a NOS computer, a printer, and some network equipment will be installed in the Computer Room. See below Figure 1.

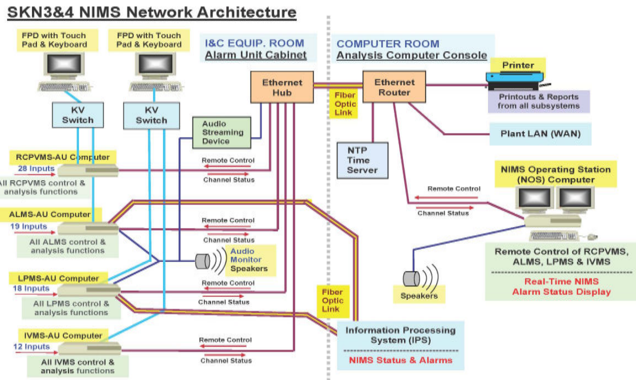

Fig. 1. NIMS Network Architecture for SKN3&4

2.2 Loose Parts Monitoring System (LPMS)

The LPMS has been designed to meet the intents of ASME OM-S/G-2000, Part 12 [4]. For SKN3&4, the LPMS design has been changed to incorporate WEC's Digital Metal Impact Monitoring System - DX (DMIMS -DX™) technology. With the incorporation of DMIMS -DX™, the LPMS configuration has been simplified to use only one PC. In comparison, the SKN1&2 LPMS uses four computers. The SKN3&4 LPMS will differ from the SKN1&2 and SWN1&2 LPMS as follows:

- high-speed data capture with 100 kHz sampling
- records every impact above recording thresholds
- wide frequency band (minimum 0.5 to 15 kHz)
- simplified system operating procedures
- remote data transfer capability via internet
- patented false alarm detection algorithm

2.3 Acoustic Leak Monitoring System (ALMS)

The Acoustic Emission (AE) method permits the identification of general, if not exact, location of a leak.

* [Note 1] WEC Approval Doc. No.: WAAP-6675

Therefore, the AE method is able to monitor critical components [2]. Before SKN3&4, there has been no ALMS sensor on the pressurizer (PZR) lower head, so one (1) ALMS channel has been added for the monitoring of the PZR lower head. Having an ALMS sensor on the PZR lower head allows the monitoring of leak events at the welding points.

In addition, the ALMS for SKN3&4 does not include the Pressurizer Safety Valve (PSV) monitoring channels, because the PSV for OPR1000 is replaced with the Pilot Operated Safety Relief Valve (POSRV) for APR1400, and the leakage monitoring through the POSRV will be done by another monitoring system.

2.4 Internals Vibration Monitoring System (IVMS)

The IVMS monitors the vibration of RV internals, including Core Support Barrel (CSB), based on ASME OM-S/G-2000, Part 5 [3].

Since SKN1&2, the IVMS software design has been based on WEC's Core Barrel Vibration Monitoring System (CBVMS). Automatic alarming has been implemented to detect shifts of primary in-phase and out-of-phase frequency signals, which are indicators of major mechanical changes to the system. Monitoring, detecting, and alarming on changes are the primary purposes of the IVMS.

2.5 RCP Vibration Monitoring System (RCPVMS)

Per ASME OM-S/G-2000 Part 14 [5], the RCPVMS for SKN1&2 and SWN1&2 has been designed to equip sensors on both pump and motor sides. Considering the RCP characteristics of APR1400, each RCP has two (2) accelerometers mounted at pump thrust bearing assembly in axial (Z) and radial (X) directions, two (2) accelerometers mounted at motor upper bearing assembly in radial (X&Y) directions, and three (3) proximity probes around the rigid coupling in radial (X &Y) directions, plus a keyphaser, as shown in Fig. 2.

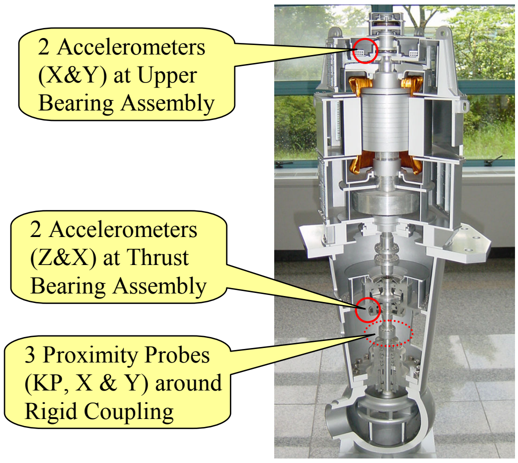

Fig. 2. RCPVMS Sensor Locations for SKN3&4

The LPMS deals with impact event signals with wide range of magnitude up to 100 g, whereas the RCPVMS deals with very low level of continuous vibration signals (i.e., typically less than 1 g). Therefore, the SKN3&4 RCPVMS accelerometers have been changed to increase their sensitivity ten times (i.e., from 10 pC/g to 100 pC/g) higher than legacy RCPVMS. In addition, the RCPVMS S/W has been changed to improve its capability for event analysis, and the unit display of 'mil' will be changed to 'micrometer'.

2.6 Overall NIMS H/W & S/W

In addition, for SKN3&4, the system has been simplified such that only one pair of fiber optic cables, for the Network, are required between the NIMS AUC in I&C Equipment Room and the Analysis Computer Console (ACC) in Computer room for control and operation of NIMS. Two additional pairs of fiber optic datalinks are installed between the ACC and the Information Processing System (IPS). For SKN3&4, all data logging, and analysis functions for the ALMS, LPMS, IVMS and RCPVMS alarm units have been moved to the I&C equipment room. However, for daily operation, the NOS function allows a NIMS operator, who is seated in the Computer Room, to remotely access and analyze all NIMS subsystem data through the Ethernet network.

3. Conclusion

Since the YongGwang Units 3 and 4 (YGN3&4), the NIMS has been evolved, and now the fifth major design improvement have been implemented for SKN3&4.

The most significant changes of the SKN3&4 NIMS compared with the SKN1&2 NIMS is the application of DMIMS-DX™ technology to the legacy LPMS. Based on this LPMS design change, a uniform type of industrial PC, Windows OS and software development platform has been adopted for the whole system.

The second significant changes for the SKN3&4 NIMS is the full remote control capability of all subsystems through the LAN. By implementing security provisions, the NIMS can be connected to the Internet, if remote access is required for analysis, maintenance or software changes.

In the future, we expect that the SKN3&4 NIMS construction and operation will be more convenient than previous plants, because of its remote access and control capability, and improved GUI functions. In addition, the system maintenance and obsolescence problems are expected to be diminished because of its uniform hardware platform and OS application.

REFERENCES

[1] Y.G. Oh et al., "Design Improvement of NIMS for SKN 1&2", KNS '06 Autumn Meeting Transaction, Section 5-J.
[2] USNRC Reg. Guide 1.45, Rev. 1, Guidance on Monitoring and Responding to RCS Leakage, Section B (May 2008)
[3] ASME OM-S/G-2000, Part 5 (Guide), "Inservice Monitoring of CSB Axial Preload in PWR", Section 2
[4] ASME OM-S/G-2000, Part 12 (Standard), "Loose Part Monitoring in LWR Power Plants", Section 4.2.4.
[5] ASME OM-S/G-2000, Part 14 (Guide), "Vibration Monitoring of Rotating Equipment in NPP", Table 5.