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Design Improvement of NSSS Integrity Monitoring System for SKN1&2

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1. Introduction

All OPR1000 plants have been operated 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). For the Shin-Kori Nuclear Power Plant (SKN) 1&2, many System Design (SD) and Component Design (CD) improvements for the NIMS have been accomplished by KOPEC and by WEC, respectively. This paper briefly describes the SD and the CD improvements for the SKN1&2 NIMS.

2. Design Improvements

2.1 System Platform

Considering more than 40-years of the plant life time, standard H/W platform and proven OS are preferred. A system with some PCs and Graphic User Interface (GUI) functions has become a widely-used model [1].

The NIMS has been evolved into a network of industrial PCs, built primarily using the LabVIEW development S/W and compatible PCI I/O cards. Remote control of Alarm Unit (AU) computers has been provided using a commercially available Windows desk top application and the Ethernet LAN technology.

For SKN1&2, all NIMS subsystems have their own historical archive functions and historical analysis tools that include logging, trending and reports. The previous NIMS store about one month of data online, and store archive data on tapes holding about one month of data. Now each SKN1&2 NIMS subsystem locally stores its data online for at least one or two full fuel cycles, and can store and access datasets on DVDs.

2.2 Acoustic Leak Monitoring System

The ALMS can attain a high sensitivity for leak detection, depending on the number of sensors for each monitoring region [2]. Up to UCN 5&6, there has been only one ALMS sensor on the Reactor Vessel (RV) lower head. One ALMS channel is added for the monitoring of the RV lower head of SKN1&2. Having an additional sensor on the RV lower head also allows continued monitoring of the RV lower head in case of one sensor failure until the failed sensor is replaced.

Previous to SKN1&2, a vendor-unique platform for the ALMS Alarm Unit (ALMS-AU) was used. For the SKN1&2, the ALMS-AU consists of an industrial PC with Windows XP, running LabVIEW application S/W. The ALMS-AU for SKN1&2 utilizes new 8-channel PCI cards for the signal acquisition and processing. The new ALMS-AU utilizes Ethernet LAN instead of IEEE-488 data links. Therefore, a simple communication structure is now established.

For SKN1&2, each ALMS preamplifier is designed to use single coaxial cable (for power input, test input, and sensor output signals) instead of two coaxial cables for the UCN5&6 ALMS preamplifier. Therefore, the cables and containment penetrations necessary for the ALMS have been reduced in the SKN1&2 project.

2.3 Internals Vibration Monitoring System

The IVMS monitors the vibration of RV internals, including Core Support Barrel (CSB), based on ASME OM-S/G, Part 5 [3]. For the vibration monitoring of the CSB, twelve signals from the Ex-core Neutron Flux Monitoring System (ENFMS) are provided through fiber-optic isolators to the IVMS.

The design of the SKN1&2 IVMS is based on WEC's four channel Core Barrel Vibration Monitoring System (CBVMS). The system is expanded to support all twelve ENFMS subchannels, and now provides an operator-convenient MMI that continuously shows the status and signal levels of all channels.

Up to the UCN5&6 IVMS, the IVMS signal processing and analysis functions have been implemented at the NIMS Analysis Computer (NIMS-AC). The major improvement of the SKN1&2 IVMS over the UCN5&6 IVMS is that a dedicated computer, the IVMS computer, is now used to continuously monitor the vibration of RV internals, and provides an alarm if the vibration levels have changed without need for operator analysis and evaluation.

The IVMS for SKN1&2 has been implemented with the standard NIMS platform, an industrial PC running Windows and LabVIEW-based application S/W. The IVMS computer is also used as a centralized NIMS Operating Station (NOS). Because of this dual purpose of the IVMS computer, the unit is called as the NOS/IVMS computer.

[Note 1] WEC Approval Doc. No.: WAAP-6410

2.4 Loose Parts Monitoring System

The LPMS has been designed to meet the intents of ASME OM-S/G, Part 12 [4]. The two (2) Minutes Storage Device (2MSD) computers for the UCN5&6 LPMS were renamed as the Data Acquisition Device (DAD) for the SKN1&2 LPMS. The analysis functions of the DAD have been enhanced with LabVIEW technology. The DAD tools are operable on large datasets, stored locally at the PC, providing better timing and spectral resolution. The NIMS-AC has changed such that it is used only for the LPMS. It has been renamed as the LPMS-AC for SKN1&2.

2.5 RCP Vibration Monitoring System

Since UCN3&4 up to UCN 5&6, the RCPVMS have been equipped with three proximity probe channels and three accelerometer channels per RCP. All of these six channels of sensors are installed on the pump side of RCP, and no sensors are installed on the motor side.

Per ASME OM-S/G, Part 14 [5], the RCPVMS for SKN1&2 has been designed to equip sensors on both the pump and motor sides. No accelerometer needs to be installed on the pump side per the ASME OM guide [5]. Considering the RCP characteristics of OPR1000, each SKN1&2 RCP has one accelerometer mounted at the pump thrust bearing assembly in the axial direction. Figure 1 shows that three accelerometers per the RCP motor are newly installed for the vibration monitoring of upper and lower motor bearings for SKN1&2.

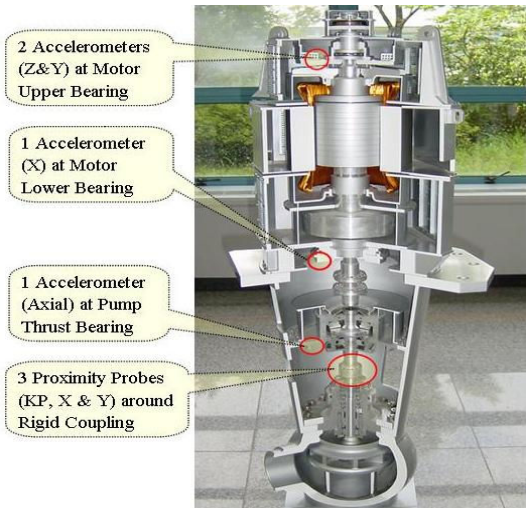

Figure 1. RCPVMS sensor locations for SKN1&2

2.6 Overall NIMS H/W & S/W

Up to UCN5&6 project the NIMS had been supplied to sites without the time synchronization facility. The SKN1&2 NIMS design includes time synchronization function such that the NIMS is designed to receive the plant standard time synchronization signals from the PMAS time server through an Ethernet network.

During the SKN1&2 NIMS design process, most of NIMS computers (except LPMS-AU & LPMS-AC) are designed to utilize the industrial PC and Windows OS.

The data logging and analysis functions for the ALMS, IVMS and RCPVMS have moved from NIMS-AC to subsystem computers (i.e., ALMS-AU, NOS/ IVMS computer and RCPVMS-AU, respectively). However, the NIMS Operating Station (NOS) function enables a NIMS engineer, who is seated in computer room, to remotely access and analyze the NIMS subsystem data through the Ethernet network. The NOS/ IVMS computer can be used as a main display of NOS functions. The NOS shows a NIMS status display, which shows alarm and communication status of overall NIMS as shown in Figure 2.

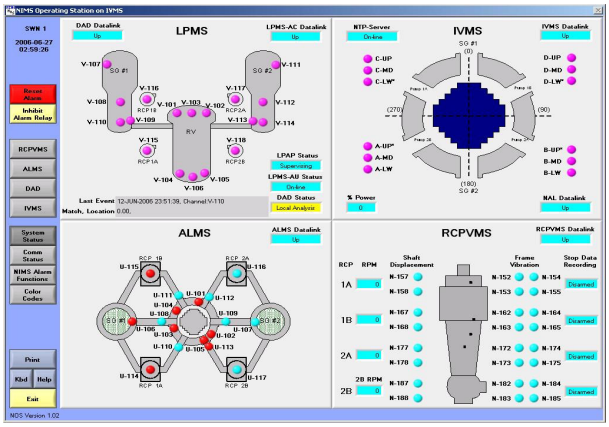

Figure 2. NIMS Status Display for SKN1&2

3. Conclusion

As the NIMS has been evolved from YGN 3&4, UCN 3&4, YGN/UCN 5&6 and now SKN/SWN 1&2, many design improvements have been made. Advanced design features, including new GUI, will be confirmed once the system goes into full operation at the SKN/SWN 1&2 sites. We expect that even more benefits of the utility will be identified as the site operators gain experiences utilizing the new NIMS design features.

In the future we will make efforts to develop the SKN3&4 NIMS with the same design objectives as before. Besides attaining the required functionality, we are striving to minimize obsolescence and life-cycle costs. We plan that the future systems will be even easier to operate and maintain than previous systems.

REFERENCES

[1] J-H Park et al., "Development of an Enhanced LPMS", Transaction of KNS 2005 Autumn Meeting, Sections 2.1 - 2.3.
[2] CEI/IEC 1250: 1994, "Nuclear reactors – Detection of leakage in coolant systems", Section 6.6.
[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.