Lessons Learned from Wolsong NPP for Improvement of Seismic Monitoring System

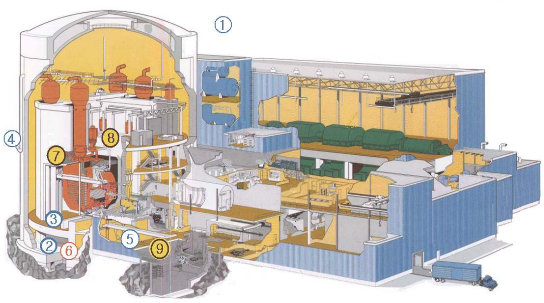
[*a] Se-Moon Park, [a] Chong-Hak Kim , [b] Seong-Keun Cho, [c] Jong-Sam Choi
[a] *Nuclear Engineering Technology Institute, Korea Hydro & Nuclear Power Co.,*
508 Keumbyong-ro, Yuseong, Daejeon, Korea 305-343
[b] *Shin-Wolsong NPP and* [c] *Wolsong NPP, Korea Hydro & Nuclear Power Co.,*
[*]Corresponding author: smpark365@khnp.co.kr

1. Introduction

The seismic monitoring system (SMS) in Wolsong NPP, Korea Hydro & Nuclear Power Co. (KHNP) has been improved in terms of enhancement of maintenance and replacement of aged parts and systems, which caused frequent inappropriate annunciation. Despite that there were no occurrences of earthquakes, alarms were triggered 27 times by pseudo-earthquakes or system malfunction during the five year period from 2001. To avoid this problem and to derive better seismic response data from the system, and so as to meet requirements of the regulatory body, software and hardware specifications have been upgraded. The seismic triggers have also been reformed with respect to logic and reduced in number. All the system modifications are described herein, and the results verifying their effectiveness are presented.

2. Methods and Results

In this section the upgraded software and hardware system of the seismic monitoring facility in Wolsong NPP are described. The improvements made to seismic trigger switches are also described. Figure 1 shows the location of the seismic monitoring sensors (accelerometers) in Wolsong NPP.



Time History Accelerometer
1. Free field (EL 100.0)
2. Reactor Building Basement (EL 93.9)
3. Reactor Support Floor (EL 100.0)
4. Reactor Building Wall (EL 111.62)
5. Auxiliary Building Basement (EL 93.9)

Seismic Switch
6. Reactor Building Basement (EL 93.9)

Peak Accelerometer
7. Emergency Core Cooling Water Pipe (EL 112.5)
8. Upper Deck of Reactor (EL 117.45)
9. Emergency Water Pipe (EL 93.9)

Fig. 1 Location of Seismic Monitoring Sensors

2.1 Software System (GeoDAS)

The seismic analysis software, GeoDAS has been developed to meet all requirements with respect to almost every possible application. The program has an open architecture for multiple local recorders connection protocol with even via internet (TCP/IP). Additionally GeoDAS provides powerful data analysis methods, which have been developed mainly for civil engineering purposes and preliminary seismic analysis of recorded data. Furthermore it has also several special features, which are required for particular applications or can be activated in some special cases only. It is a noteworthy point that a response spectrum analyzer shall remain the function at all times to provide full automatic retrieval of acceleration and evaluation of the Operation Basis Earthquake (OBE) condition using the peak acceleration or the response spectrum check and cumulative absolute velocity (CAV), immediately after event.

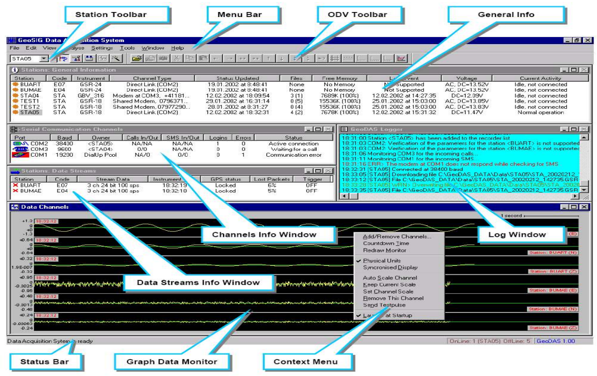


Fig. 2 Upgraded software, GeoDAS

2.2 Hardware System

Before After (frontal and back views)

Fig. 3 Improvement of Panel of Seismic Monitoring System

The SMS cabinet in MCR is comprised of nine layers, annunciation, seismic switch, alarm control device, playback unit (display, industrial PC & keyboard), seismic recorders, UPS and graphic printer, as seen in Fig. 3. The new cabinet is considerably more sophisticated than the former cabinet. The distinction is that the seismic switch in the SMS cabinet receives only the signal from accelerometer sensors located in the reactor structure and generates switching actions with its circuitry logic instead of being applied as the old seismic switch block in the radioactive reactor building structure. This new system can ensure ease of management, ALARA and safety for operators.

2.3 Seismic Trigger

US-NRC in Reg. Guide 1.12 states that one or more seismic triggers must be set at a location where an actual earthquake can be monitored. However, in Wolsong unit 1 & 2, all five accelerometer channels were set to activate as the seismic triggers, which increased the spurious triggering by pseudo earthquake from structural background vibration under normal operation behavior in the plant. The new seismic recorders were designed to include accelerometer-based trigger which is software based digital threshold algorithm. It included a voting scheme using any combination of the "AND", "OR", "NOT" logic. The voting scheme also has a built-in capability to assign a selectable weight factor to each trigger channel. This consideration could be given to avoid unnecessary triggering. The first step taken was therefore to reduce the number of trigger channels to two instead of five (see Fig. 4) with the triggering voting scheme. Second, to declare the real seismic events, additional triggering algorithms based on threshold level, STA/LTA or CAV are used by GeoDAS. This new feature has a function of filtering pseudo-quakes. However, it still provides seismic recording from five sensors as done in the previous system.

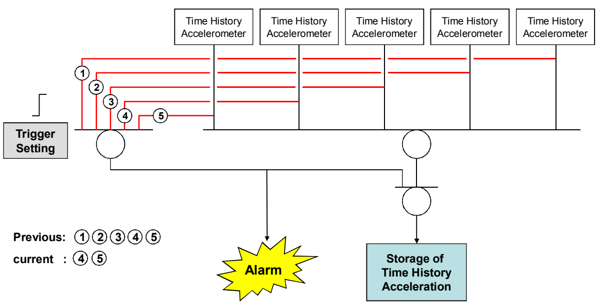


Fig. 4 Reformation of Seismic Trigger

2.4 Results

After the occurrence of the Fukuoka Earthquake on Mar. 20, 2005, it was determined that the practical reformation of the SMS was necessary to reduce unnecessary triggers. Most of false triggering was caused by machinery operational quakes, lightning surges and power transmission system fault around. However since the SMS has been reformed, no more false triggering has occurred except human errors such as cleaner's kicking. There is no doubt about that the reformation has increased management efficiency for the seismic monitoring facility. The new system cut the cost of maintenance and workers through less false triggering and more accessible seismic switches. The function of exchangeability was also added for data exchange among the facilities such as those of Shin-Wolsong and Shin-Kori NPPs.

Table 1 shows the differences between the old and the new systems. The digits of the recorder (digitizer) processor were upgraded from 12 bits to 18 bits. Analysis software was reformed from the DOS base to Windows XP. The analysis process is fully automated for seismic monitoring, alarming, response spectrum analysis and reporting. To obtain more accurate data, dynamic and frequency ranges were expanded. The dynamic Range was substantially expanded from 1000:1 to 100,000: 1.

Table 1. Comparison of System Specifications

Classification	Before		After	Reg.1.12 ANSI/ ANS
	Unit 1	Unit 2	Units 1&2	
Supplier	Sig SA	TERRA TECH. GeoTECH	Geo-SIG	-
Play Back PC	386DX => Pentium	486(laptop)	Pentium4 /ACE-925C	-
O.S.	DOS => Windows 98	MS-DOS 7.0	Windows XP	-
Digitizer	12 bits	12 bits	18 bits	-
Rec.Media / Capacity	CMOS SRAM / 25min	RAM / 30min	Flash Mem /512min	Archival / 25 min
Sample Rate	250SPS	250SPS	250SPS	200 SPS
Dynamic Range	72dB	72dB	108dB	60dB
Frequency Range	0.2 to 50Hz	0.2 to 50Hz	DC to 50Hz	0.2 to 50Hz
GPS Synchronizatio n equipment	yes	no	yes	-
Printer	Dot	Dot	Laser Jet	-

3. Conclusions

Reformation of the SMS in Wolsong NPP will save the management cost and analysis time for evaluation of seismic safety. In particular, it can prevent unnecessary shutdown of the reactor by pseudo-quakes. Through full automation analysis system, possible human error can also be avoided. The improved SMS ensured enhanced seismic safety of the NPP and provides a good example for other NPPs experiencing similar problems to those Wolsong NPP previously faced.

REFERENCES

[1] Regulatory Guide 1.12 "Instrumentation for Earthquakes (Rev. 1)", 1974
[2] Regulatory Guide 1.12 "Instrumentation for Earthquakes (Rev. 2)" March, 1997
[3] Korea Wolsong #1&2 FSAR