A Shaking Table Test for an Evaluation of Functional Failure of 480V MCC

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1. Introduction

For the evaluation of a failure mode for Motor Control Centers (MCCs), a shaking table test was performed. For the shaking table tests, two kinds of seismic input motions were used which were a US NRC Reg. guide 1.60 design spectrum and a UHS spectrum. Especially, the UHS input motion was selected for an evaluation of high frequency seismic effect. PGA levels for shaking table test were scheduled by 0.2g to 5.0g but the test was stopped at about the 2.5g level because of the chattering of the relay systems. Through this test, several kinds of functional failure modes can be found and the chattering effect of several relays in the MCCs can be certified.

2. 480V MCC Cabinet

A 480V MCC Cabinet is one of major equipment system in Nuclear Power Plant. For the shaking table test, a real MCC cabinet was rented from the manufacturing company. A figure and drawing are shown in Figure 1. The descriptions of the MCC are summarized in Table 1.

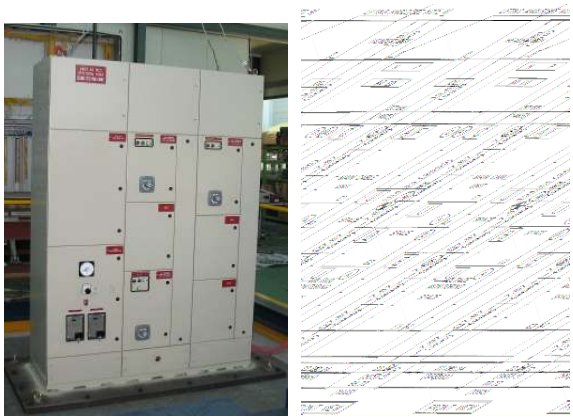


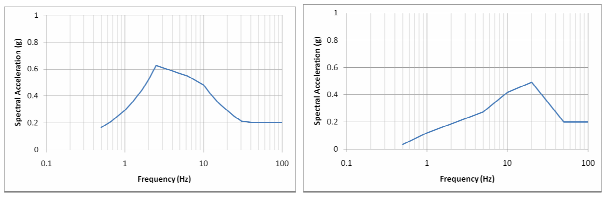
Figure 1. An Overview of MCC

Table 1. Description of MCC Cabinet

Dimension(mm)	Width	1,695
	Depth	550
	Height	2,650
Weight (kg)	Transportation	1,350

3. Shaking Table Test

For the shaking table test, two kinds of seismic input motions were used. One is an artificial seismic input motion based on the NRC Reg. guide 1.60 design spectrum and the other is also an artificial seismic motion based on the Korean Nuclear Power Plant site specific Uniform Hazard Spectrum (UHS). The UHS motion was selected for an evaluation of a High frequency effect of the electric equipment in a NPP. The target input spectrums are shown in Figure 2.



(a) (b)

Figure 2. Seismic Motion for Shaking Table Test; (a) US NRC Design Spectrum (b) Uniform Hazard Spectrum

The shaking table tests were scheduled as shown in Table 2. As shown in Table 2, the shaking table tests were performed with a one dimensional shaking which was a front to back direction (horizontal) and a vertical direction. Same schedule was applied to the two kinds of seismic input motions.

Table 2. A Schedule for Shaking Table Test

	PGA(g)	Remarks
1		Frequency Check (x, y, z)
2-3	0.2	1-D input (F-B, Vertical)
4-5	0.4	1-D input (F-B, Vertical)
6-7	0.8	1-D input (F-B, Vertical)
8-9	1.2	1-D input (F-B, Vertical)
10		Frequency Check (x, y, z)
11-12	1.8	1-D input (F-B, Vertical)
13-14	3.0	1-D input (F-B, Vertical)
15-16	4.0	1-D input (F-B, Vertical)
17 -18	5.0	1-D input (F-B, Vertical)
19		Frequency Check

For the evaluation of a relay chattering, the electric signal was measured at several points. There are two kinds of ground fault relays, and thermal relays are installed in the MCC. It is impossible to measure the electric signal of all relays, only some of the relays and electric equipments were considered. In the case of the US NRC spectrum, 480V AC power was supplied so it can measure the signals of the equipments related to a power system like a power transformer. But in case of UHS spectrum, 480V

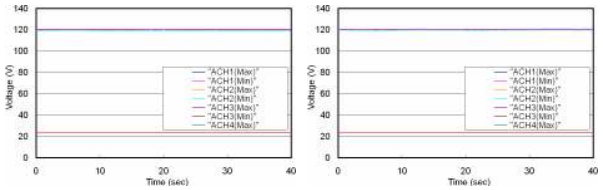
AC power wasn't supplied because of the safety of experiment. Therefore, only the signals from the relays were measured. For the measurement of a relay system, an arbitrary input power was supplied to the MCC. The measurement items for each experiment are summarized in Table 3.

Table 3. Measurement of Electric Signals

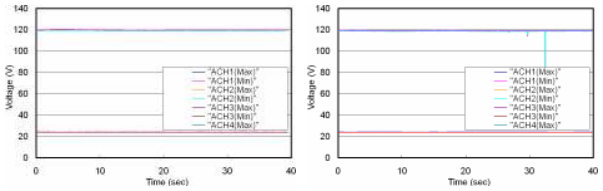
	Shaking Table Test	
	1st Test (NRC)	2nd Test (UHS)
CH1	Power Transformer	Fuse
CH2	TR 2nd Power	Fuse 2A
CH3	Fuse	Overload Relay
CH4	Fuse 2A	Ground Fault Relay
CH5	Relay	Relay
CH6	Relay	-

4. Test Results

The shaking table test was scheduled as 0.2g to 5.0g but a severe chattering signal was observed in the 1.2g test so the functional test according to the NRC design spectrum was stopped. The electric signals measured from the shaking table test by the NRC design spectrum are shown in Figure 3. As shown in the Figure 3, in the case of the SSE level of an earthquake at 0.2g test, there are no chattering events observed, but in the case of the 1.2g shaking, a chattering is observed both in the horizontal and vertical direction. But in this case a chattering is not related to a relay but to a secondary power transformer system.



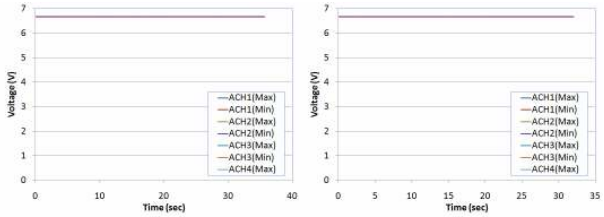
(a) 0.2g Horizontal (b) 0.2g Vertical



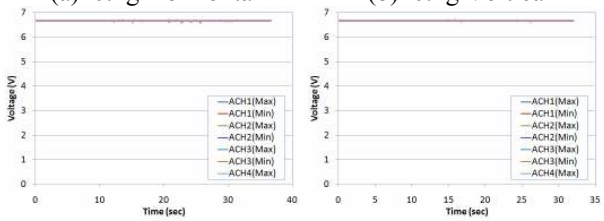
(c) 1.2g Horizontal (d)1.2g Vertical

Figure 3. Electric Signals from NRC Spectrum

In the case of the UHS spectrum, the shaking table test was performed at 0.2g to 3.0g. The measurement results are shown in Figure 4. As shown in Figure 4, measured voltage is about 6.6V. In case of UHS earthquake, 480V AC power was not supplied to the MCC but for the measurement of relay chattering 6.6V power was supplied to the relay system arbitrarily. As shown in Figure 4, there was no chattering happened in case of 0.2g shaking. But in case of 3.0g shaking it can be clearly observed chattering effects. In this case chattering happened both horizontal and vertical shaking.



(a) 0.2g Horizontal (b) 0.2g Vertical



(c) 3.0g Horizontal (d)3.0g Vertical

Figure 4. Electric Signals from UHS Spectrum

5. Conclusion

A shaking table test for the evaluation of a functional failure of electric cabinet systems in a NPP was implemented. The 480V MCC was selected for the shaking table test. A US NRC design response spectrum and a Uniform Hazard Spectrum were selected for the input seismic motion. As a result, it can be recognized that the 480V MCC has a sufficient seismicity as a SSE level earthquake. But in the case of a higher level earthquake motion, a chattering happened for both seismic motions, moreover both a horizontal and vertical shaking cause a relay chattering. More detail analyses are needed for an evaluation of a local seismic response effect, type of relay and seismic motion.

ACKNOWLEDGEMENT

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