

Assessment of the Seismic Performance of a 125V DC Battery Charger Using the Shaking Table Test

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1. Introduction

In this study, the shaking table test was conducted to assess the seismic performance of electric equipment, one of the main facilities in nuclear power plants. There are many electric facilities in nuclear power plants, and damage to these facilities may significantly affect the safety of the entire nuclear power plant, beyond the damage to the electric facilities themselves. The electric devices used in nuclear power plants are usually installed in cabinets, and the seismic performance of such cabinets is assessed using the shaking table test [1-2] and finite element analysis.

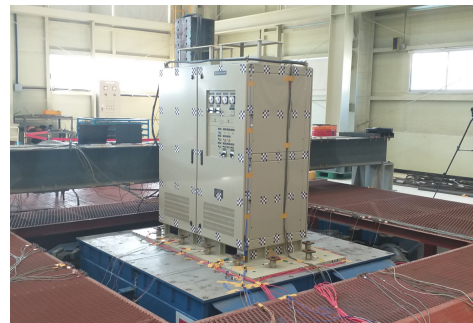
Nuclear power plants are designed considering the standard response spectrum of NRC Regulatory Guideline 1.60 (RG 1.60). RG 1.60 can be adjusted according to the peak ground acceleration (PGA) given to each seismic zone where nuclear power plants are located. Moreover, it was found that the uniform hazard spectrum (UHS) for the nuclear sites in South Korea exhibited low spectral acceleration values in the low-frequency region and was significantly amplified in the high-frequency region. Therefore, the need for seismic performance assessment considering the effect of high-frequency ground motions is increasing, and experimental studies on ground motions, including low- and high-frequency vibrations, are required [3]. In this study, the shaking table test was conducted on the DC 125V battery charger, an electric facility, using the combined response spectrum (CRS) that considered NRC RG 1.60, the UHS of the Uljin area, RG 1.60, and UHS. In addition, the chattering phenomenon of the relay was examined during the shaking table test because the battery charger must be able to maintain its original function before and after an earthquake.

2. Methods and Results

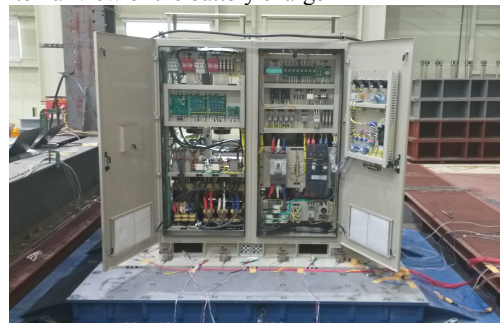
Most of the electric facilities used in nuclear power plants are installed in cabinets, and the malfunctioning of such electric facilities installed in electric cabinets may affect the safety of nuclear power plants. In this study, to verify the seismic performance of the battery charger, among electric facilities, a battery charger that is being supplied to nuclear power plants was used. Fig. 1 shows the battery charger installed on the shaking table, and Table I shows its specifications.

The floor response spectrum (FRS) was calculated using RG 1.60 and the time history analysis results for the UHS seismic wave of the Uljin area, and a CRS with

low- and high-frequency components was created. The response spectral ratios of RG 1.60, UHS, and CRS were adjusted based on PGA 0.2g, which is the criterion of a safe-shutdown earthquake (SSE), as shown in Fig. 2. Moreover, the fragility test was applied by gradually amplifying the response spectrum in Fig. 2, but the increase rate was linearly interpolated by referring to the high confidence and low probability of failure (HCLPF) and the zero period acceleration (ZPA) corresponding to the failure probability 10% interval. Table II shows the PGA and ZPA of the input ground motion in the shaking table test. Excitation was performed with a 5% input seismic wave damping ratio, a 1.0-60.0 Hz frequency range, a 30-second vibration duration, and a strong 20-second motion duration. Moreover, the input and output conditions (voltage) and the chattering of the relay were checked to examine the function of the battery charger during the excitation of each artificial seismic wave, as shown in Fig. 3.



(a) External view of the battery charger

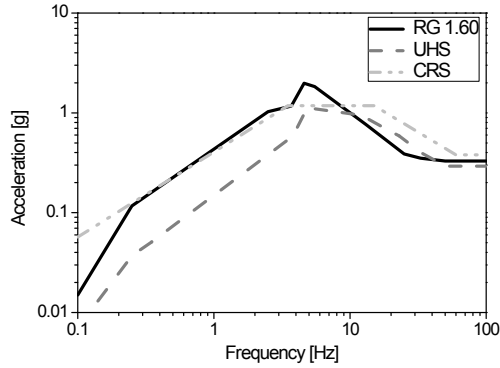


(b) Internal view of the battery charger

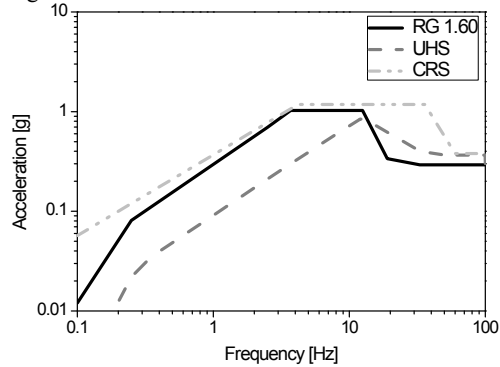
Fig. 1. Battery charger installed on the shaking table

Table I: Specifications of the battery charger

Model	Dimension (mm)			Weight (kg)
	Length	Width	Height	
DC125 V 600A	920	1,600	2,215	1,700



(a) Longitudinal and transverse direction



(b) Vertical direction

Fig. 2. Response spectrum used in the shaking table test

Table II: Input ground motions of the battery charger

Type	PGA (g)	ZPA (g)
SSE	0.2	0.38
HCLPF	0.47	0.893
Fragility 10%	0.75	1.425
Fragility 20%	0.91	1.729
Fragility 30%	1.05	1.995

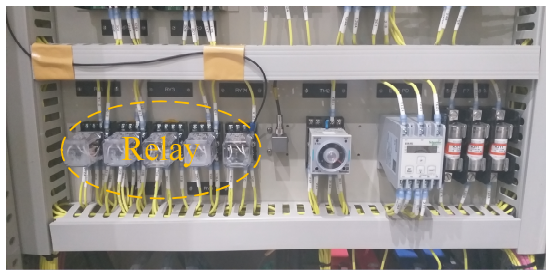


Fig. 3. Relay measurement location

Table III shows the results of the functional tests and visual inspections conducted in each seismic performance assessment test. A fracture occurred in the weld zone of the coil support when excitation was performed using a seismic wave with 10% fragility.

3. Conclusions

In this study, the seismic performance of the DC 125V battery charger, an electric facility, was assessed using NRC Regulatory Guideline 1.60 (RG 1.60), the uniform hazard spectrum (UHS) of the Uljin area, and

the combined response spectrum (CRS). As a result of the examination of the battery charger's function, chattering of the relay did not occur under the safe-shutdown earthquake (SSE) seismic wave, but it occurred under the 10% fragility excitation. In addition, a fracture occurred in the weld zone of the electric coil support when excitation was performed using a seismic wave with 10% fragility.

As the results were obtained from only one test and on one electric cabinet, further experimental studies on domestic nuclear power plants are required in the future.

Table III: Test result summary

Test No.	Seismic Wave	Results	
		Function	Inspection
1	UHS (X)	O.K.	O.K.
	UHS (Y)	O.K.	O.K.
	UHS (Z)	O.K.	O.K.
2	RG 1.60 (X)	O.K.	O.K.
	RG 1.60 (Y)	O.K.	O.K.
	RG 1.60 (Z)	O.K.	O.K.
3	CRS (X)	O.K.	O.K.
	CRS (Y)	O.K.	O.K.
	CRS (Z)	O.K.	O.K.
4	UHS (X, Y, Z),	O.K.	O.K.
5	RG 1.60 (X, Y, Z)	O.K.	O.K.
6	CRS (X), (Y), (Z)	O.K.	O.K.
7	HCLPF (X, Y, Z)	O.K.	O.K.
8	Fragility 10% (X, Y, Z)	Chattering	Fracture

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